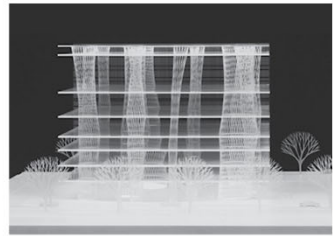


Tragwerksentwurf III

Structural Design III

Joseph Schwartz · Philippe Block



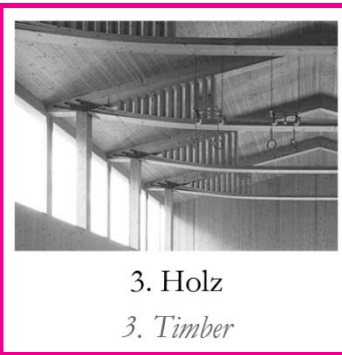
Architektur und Tragwerk
Architecture and Structure



1. Stahl
1. Steel



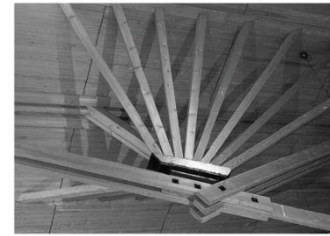
2. Stahlbeton
2. Reinforced concrete



3. Holz
3. Timber



4. Mauerwerk
4. Masonry



5. Konstruktionsdetails
5. Construction details

Tragwerksentwurf III *Structural Design III*

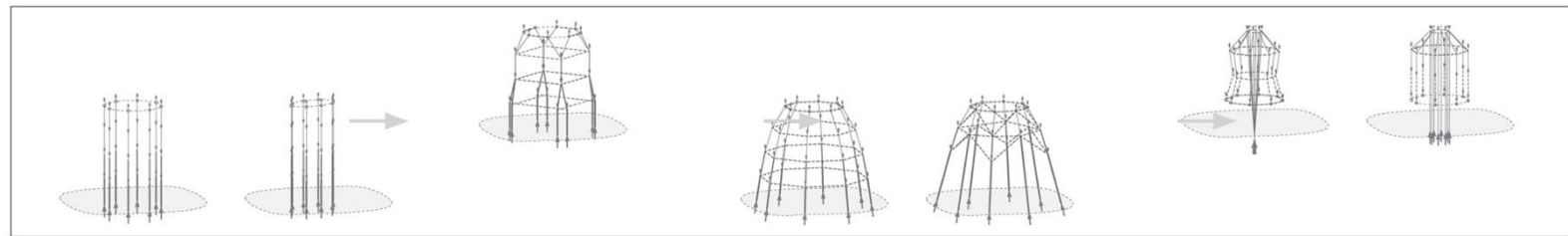
Tragwerksentwurf IV *Structural Design IV*



Entwerfen von Tragwerken I
Design of structures I



Entwerfen von Tragwerken II
Design of structures II



Entwurfsprojekt
Design project



Holz

Timber



Einführung

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Mechanische Eigenschaften

Mechanical Properties

Bautechnologie

Building Technologies

Fallstudie: Mehrzweckhalle Vrin

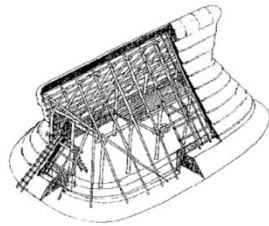
Case Study: Gym Vrin

Ausgewählte Projekte

Selected Projects

Steel	<u>IX century</u> : first cast iron structures built (China)	<u>1856</u> : Bessemer patent for steel mass production (H. Bessemer)
Concrete	<u>Around 300 BC</u> : the Romans start to build extensively using “opus caementicium”	<u>1849</u> : Reinforced concrete patent (J. Monier)

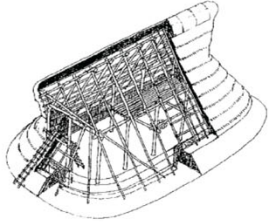
Timber has been widely used as a construction material since prehistoric times



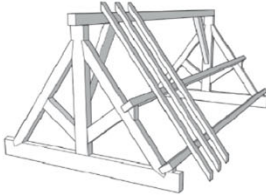
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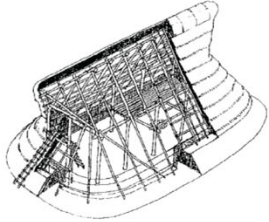
Around 100 BC: Introduction of timber roof trusses



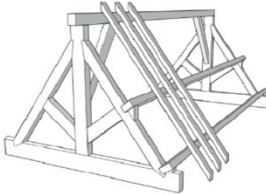
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Around 100 BC: Introduction of timber roof trusses



751 AD: Todai-ji Temple, Nara (JP)



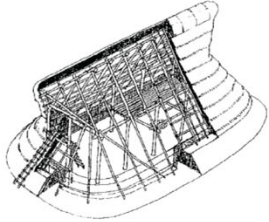
Timber



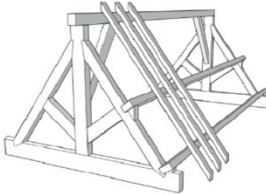
Todai-ji Temple, Nara, 751 AD

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Around 100 BC: Introduction of timber roof trusses



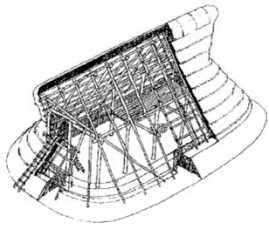
751 AD: Todai-ji Temple, Nara (JP)



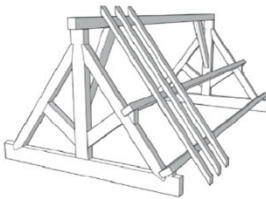
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Around 100 BC: Introduction of timber roof trusses



XV century: Half-timbered house (Fachwerkhaus)



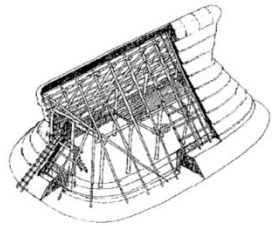
751 AD: Todai-ji Temple, Nara (JP)



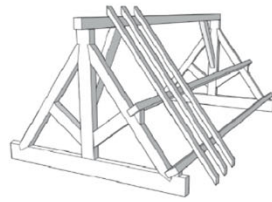
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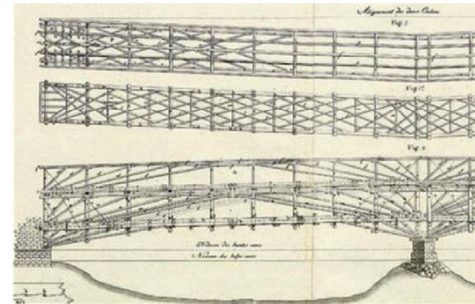
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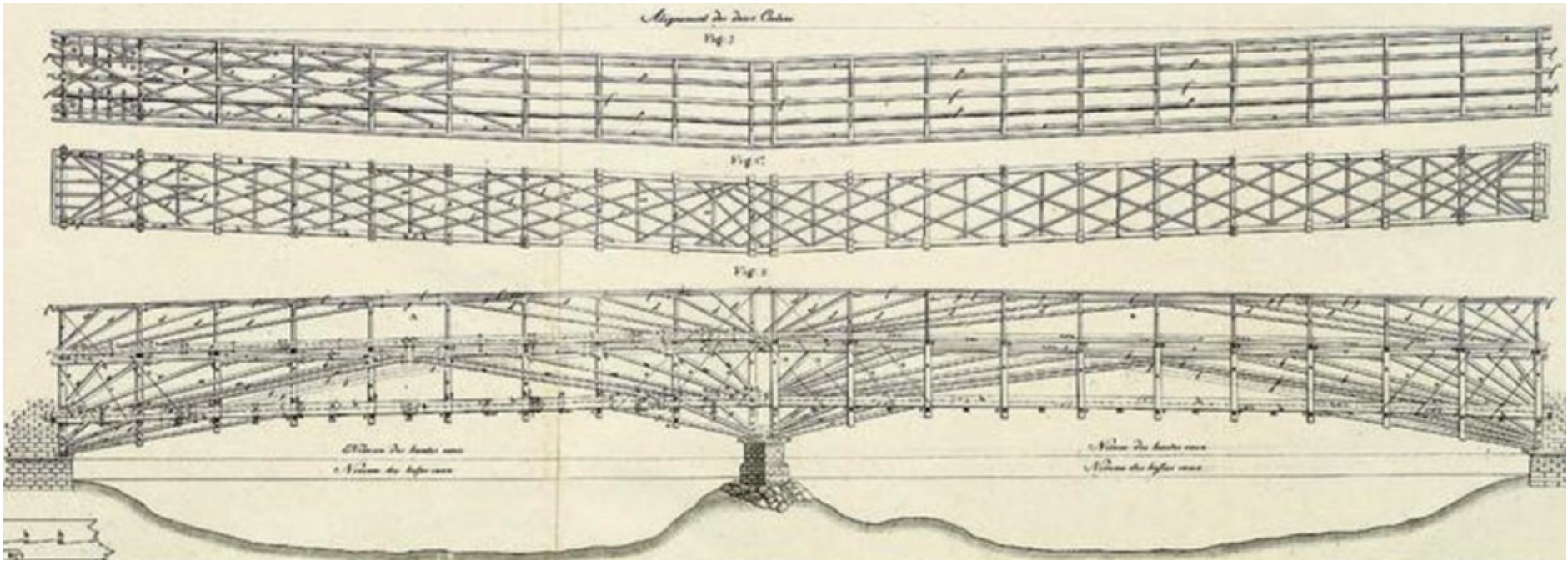
751 AD: Todai-ji Temple, Nara (JP)



1758: Schaffhausener Brücke (Grubenmann)



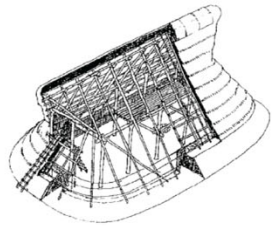
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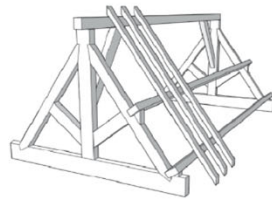
Schaffhausener Brücke, Schaffhausen, 1758, Hans Ulrich Grubenmann

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Around 100 BC: Introduction of timber roof trusses



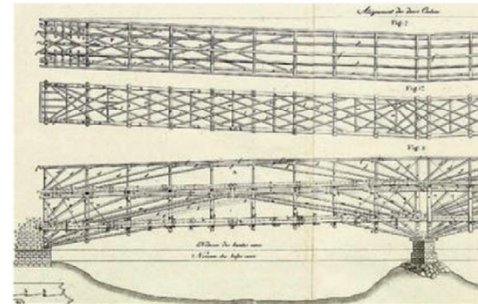
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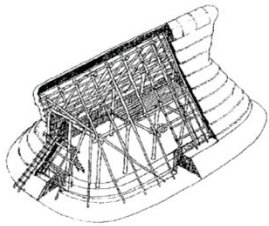


Timber

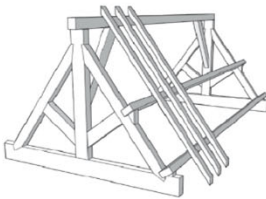
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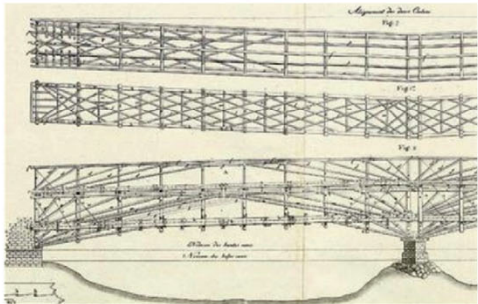
1817: Burr Truss



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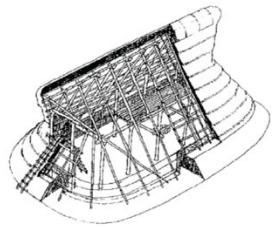


Timber

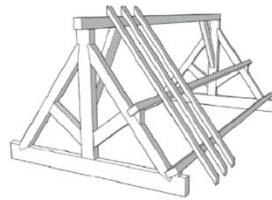
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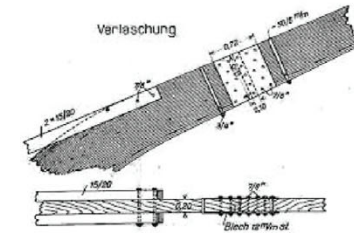
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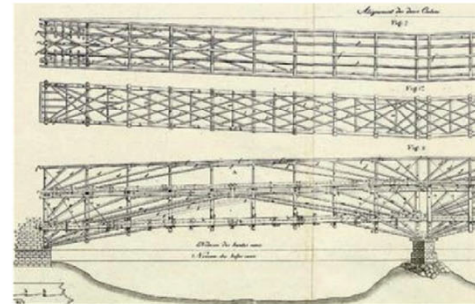
Around 1900: Development of glued, laminated timber (Glulam) technology



751 AD: Todai-ji Temple, Nara (JP)



1758: Schaffhausener Brücke (Grubenmann)



Timber

© B. Zöllig Söhne

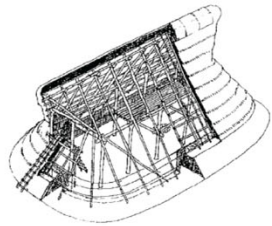


Reithalle Langensand, Luzern, 1932

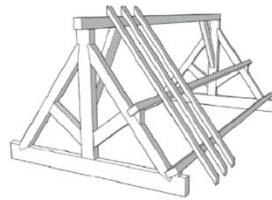
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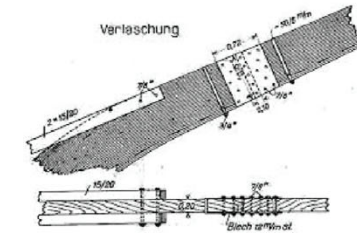
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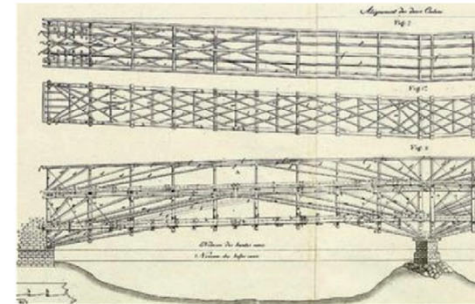
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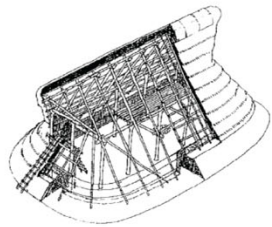


Timber

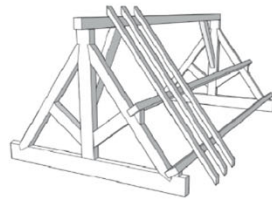
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Around 100 BC: Introduction of timber roof trusses



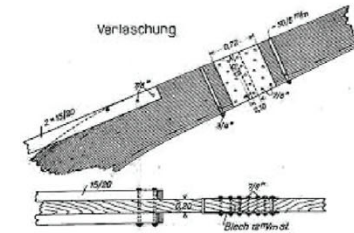
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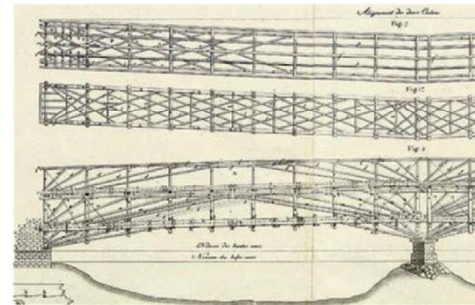
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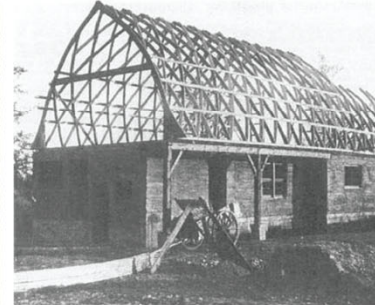
751 AD: Todai-ji Temple, Nara (JP)



1758: Schaffhausener Brücke (Grubenmann)



Around 1920: Zollinger Dach



Timber



1965: Smith House
(Meier)



Timber



Smith House, Connecticut, 1965, arch. Richard Meier & Partners Architects, eng. William Atlas



1965: Smith House
(Meier)



Timber



1965: Smith House
(Meier)



1975: Multihalle, Mannheim
(F. Otto, C. Mutschler, J. Langner)



Timber



© SAN Ingenieure

Multihalle, Mannheim, 1975, arch. Frei Otto, Carfield Mutschler, Joachim Langner, eng. BuroHappold



1965: Smith House
(Meier)



1975: Multihalle, Mannheim
(F. Otto, C. Mutschler, J. Langner)



Timber



1965: Smith House
(Meier)



1990: School of engineering
(Meili Peter)



1975: Multihalle, Mannheim
(F. Otto, C. Mutschler, J. Langner)



Timber



© Georg Aerni

Swiss School of Engineering for the Wood Industry, Biel, 1997, arch. Meili Peter Architekten



1965: Smith House
(Meier)



1990: School of engineering
(Meili Peter)



1950

1970

1990

2010

1975: Multihalle, Mannheim
(F. Otto, C. Mutschler, J. Langner)



Timber



1965: Smith House
(Meier)



1990: School of engineering
(Meili Peter)



1975: Multihalle, Mannheim
(F. Otto, C. Mutschler, J. Langner)



2000: EXPO Roof
(Herzog)



Timber



Expo Dach, Hanover, 2000, arch. Herzog & Partner, eng. IEZ Natterer GmbH



1965: Smith House
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1965: Smith House
(Meier)



1990: School of engineering
(Meili Peter)



1993: CLT panels
for buildings



1975: Multihalle, Mannheim
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(Herzog)



Timber



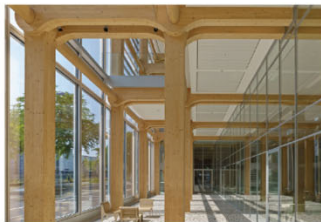
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(Meier)



1990: School of engineering
(Meili Peter)



1993: CLT panels
for buildings



2013: Tamedia Building
(Ban)



1975: Multihalle, Mannheim
(F. Otto, C. Mutschler, J. Langner)



2000: EXPO Roof
(Herzog)



Timber



Tamedia Office Building, Zürich, 2013, arch. Shigeru Ban



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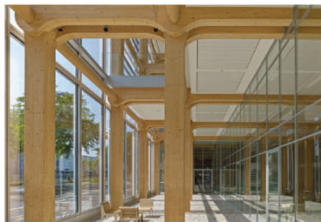
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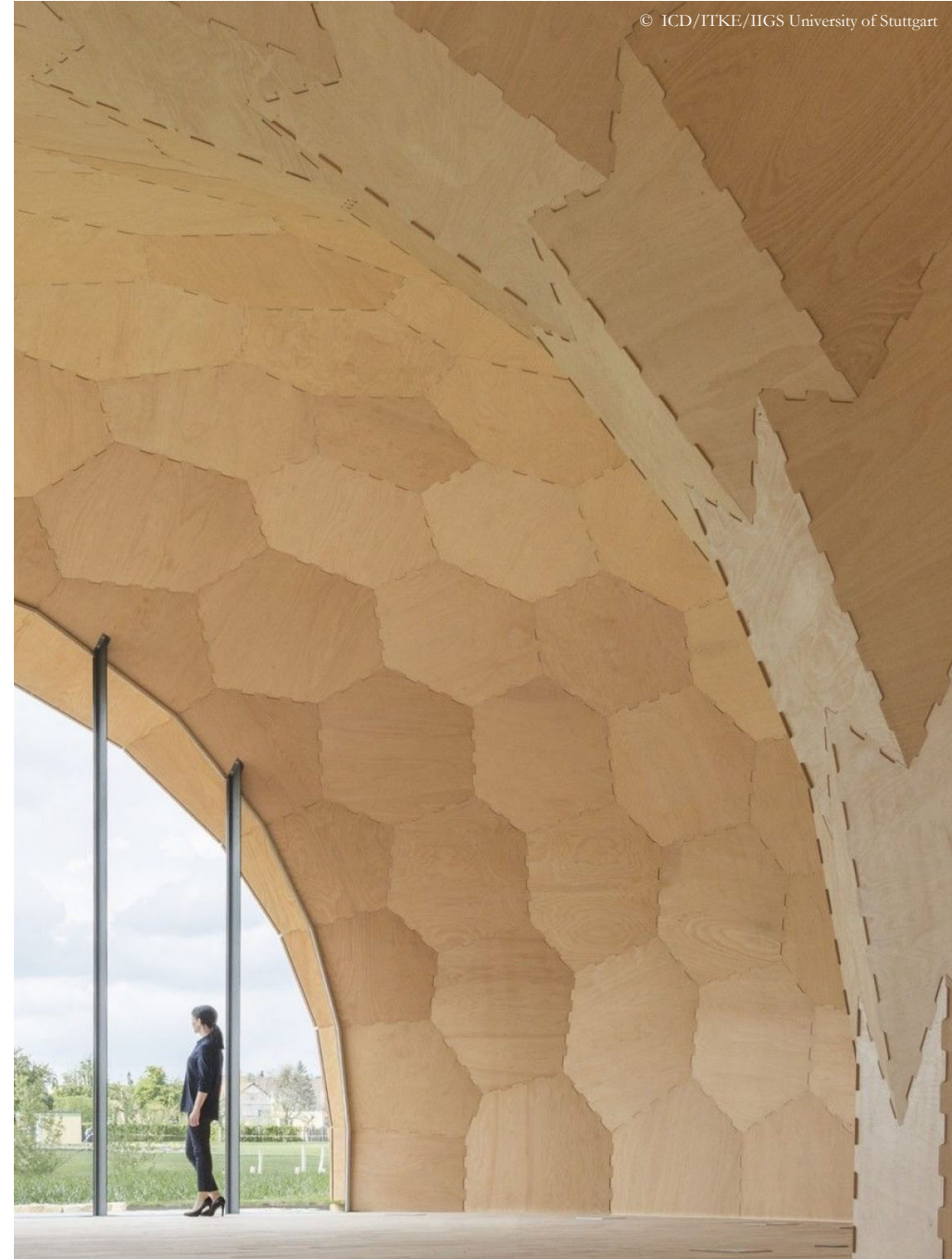
2000: EXPO Roof
(Herzog)



2014: Landesgartenschau Exhibition Hall
(ICD, ITDK, IIGS Stuttgart)



Timber



Landesgartenschau Exhibition Hall, Schwäbisch Gmünd, 2014, arch. ICD, eng. ITKE

Holz

Timber

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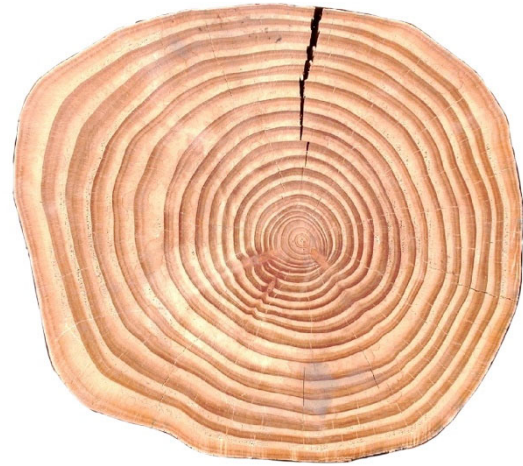
Ausgewählte Projekte

Selected Projects



Nadelholz - Douglasie

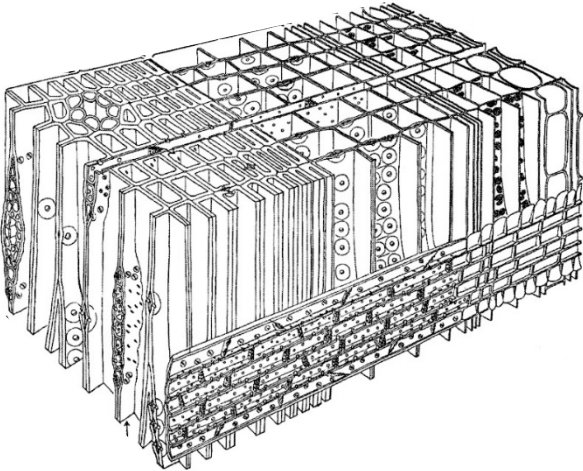
Softwood - Douglas fir



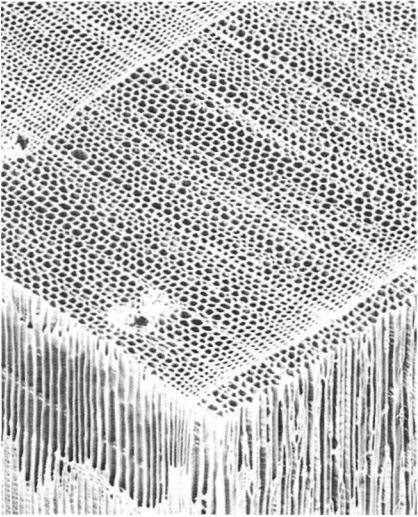
Laubholz - Eiche

Hardwood - Oak

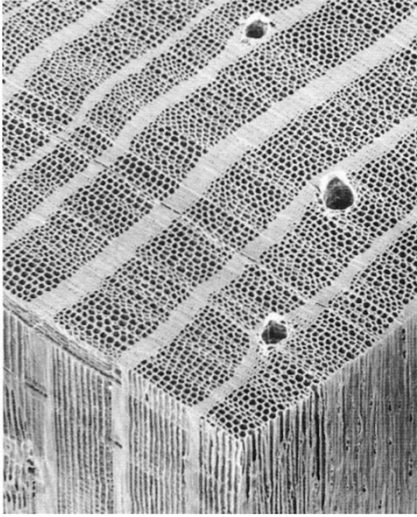




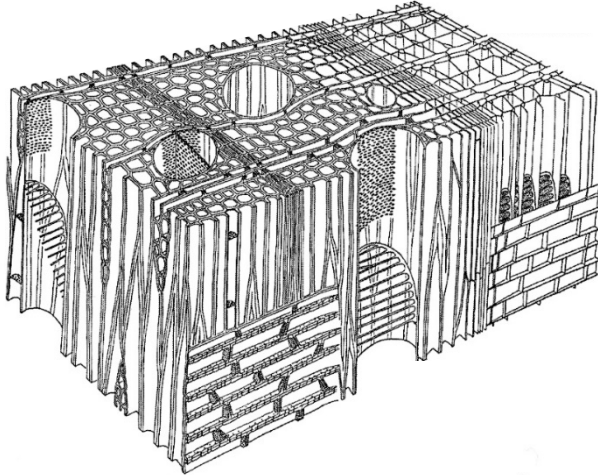
Coniferous wood (Nadelholz)



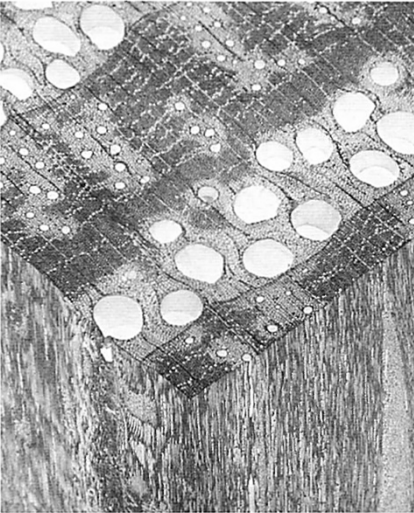
Weisskiefer - *White Pine*



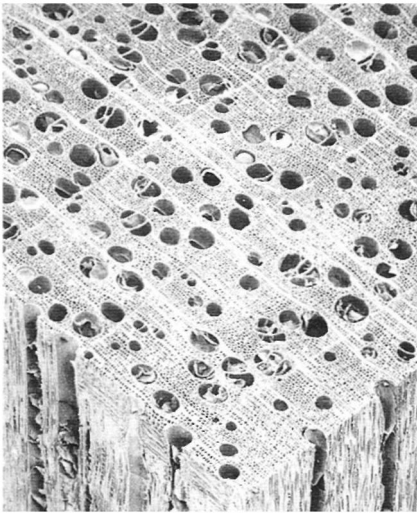
Gelbkiefer - *Yellow Pine*



Deciduous wood (Laubholz)



Rote Eiche - *Red Oak*



Schwarznuß - *Black Walnut*

Nadelholz - *Softwood*



Fichte - *Spruce*
(*Picea abies*)



(Weiss-)Tanne - *Fir*
(*Abies alba*)



Kiefer - *Pine*
(*Pinus sylvestric*)



Lärche - *Larch*
(*Larix decidua*)

Laubholz - *Hardwood*



Eiche - *Oak*
(*Quercus robur*)



Robinie - *Locust*
(*Robinia pseudoacacia*)



(Rot-)Buche - *Beech*
(*Fagus sylvatica*)



Ahorn - *Maple*
(*Acer pseudoplatanus*)





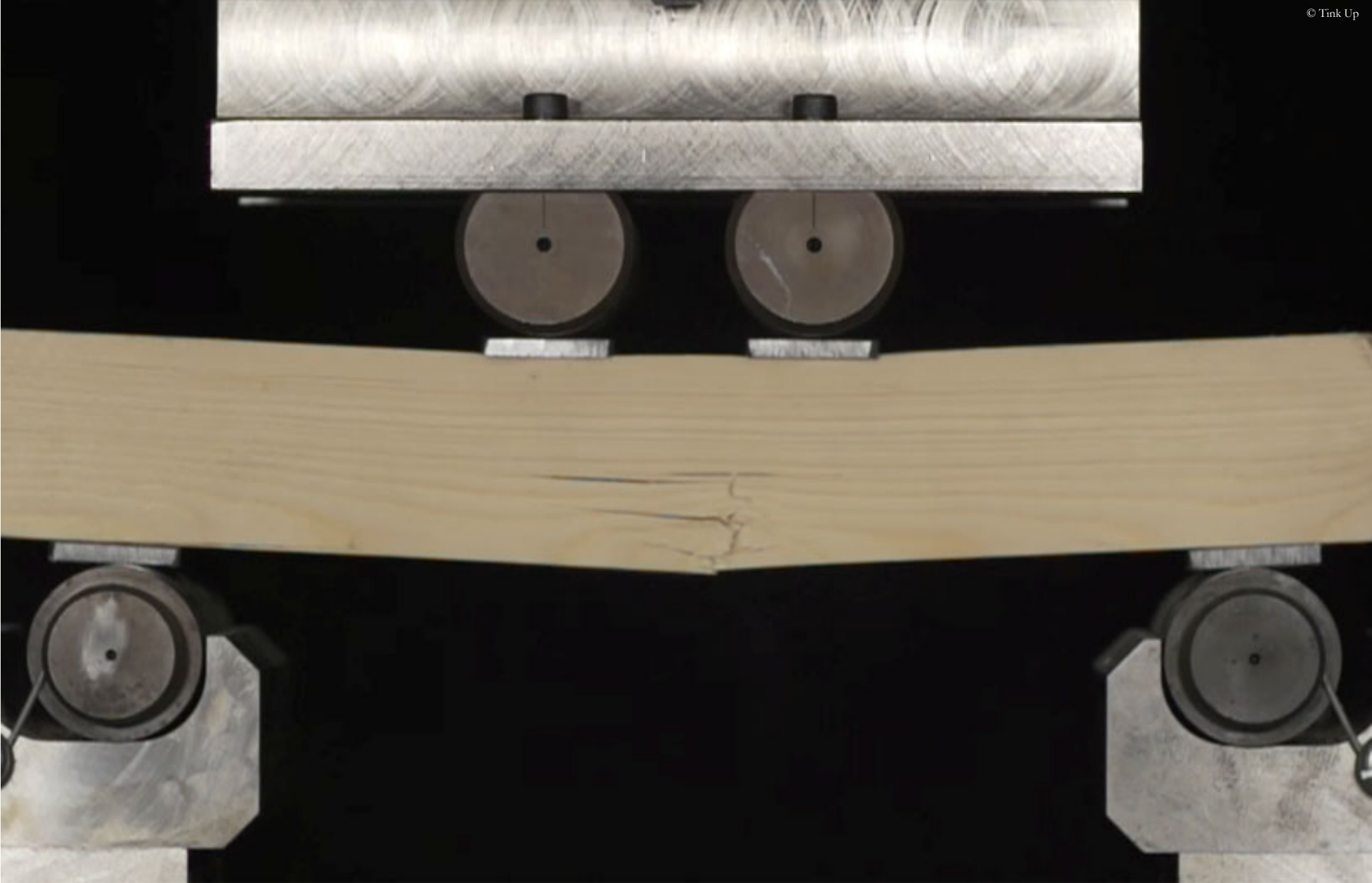
Druckversuch

Compression test



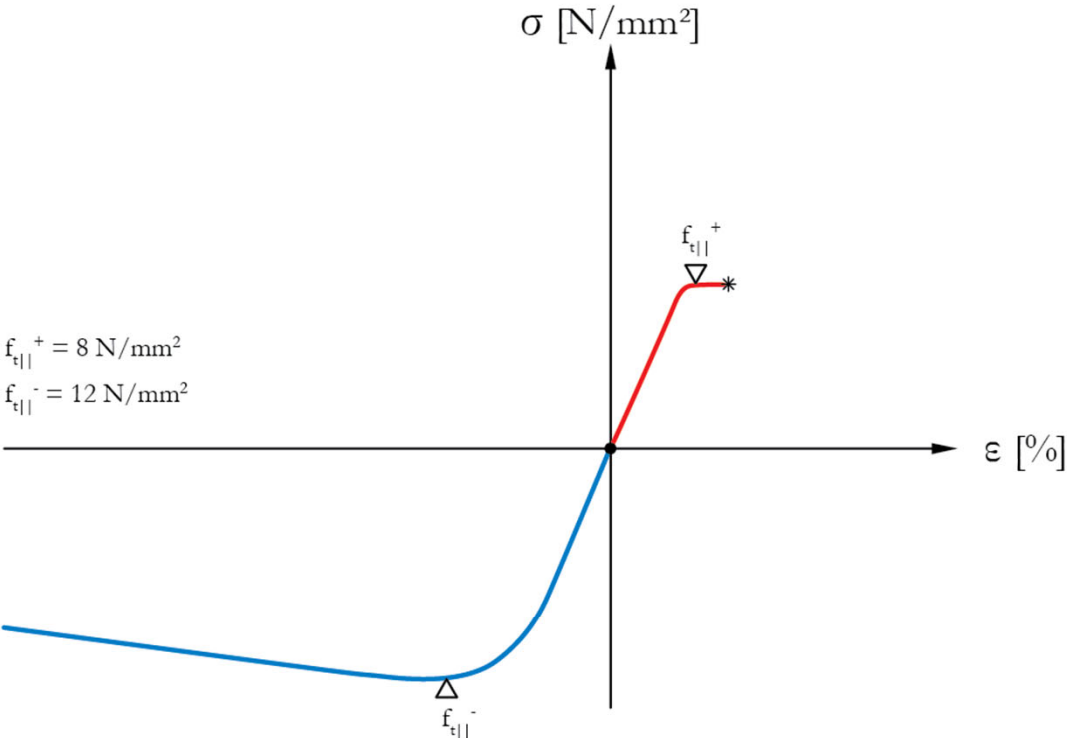
Biegeversuch

Bending test



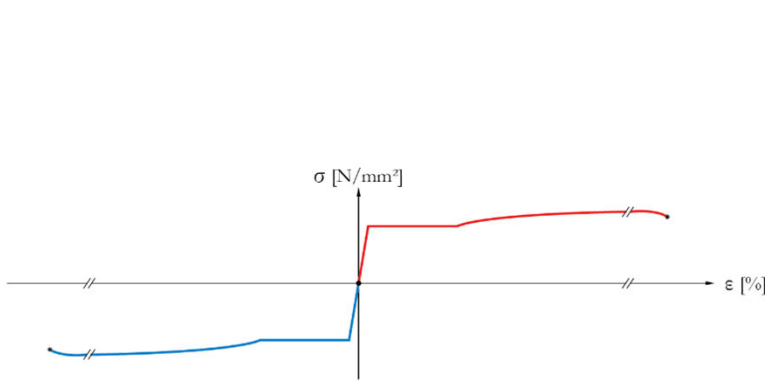
Biegeversuch

Bending test

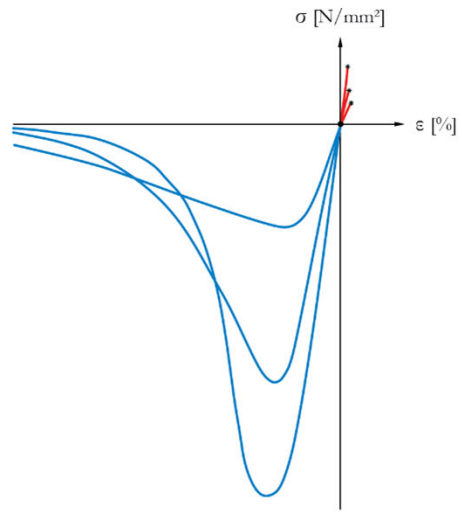


Holz (Tannenholz), Spannungs-Dehnungs-Diagramm

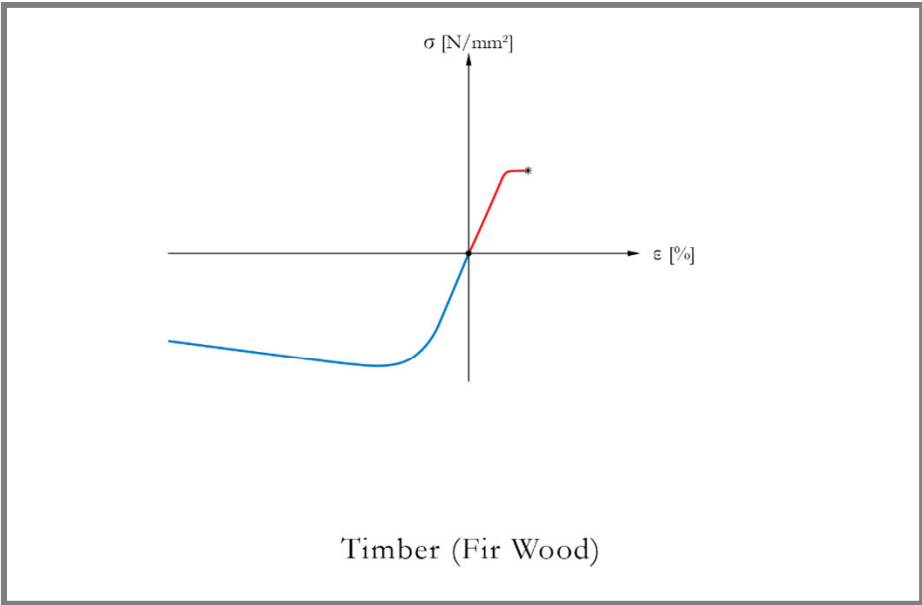
Timber (Fir wood), stress-strain diagram



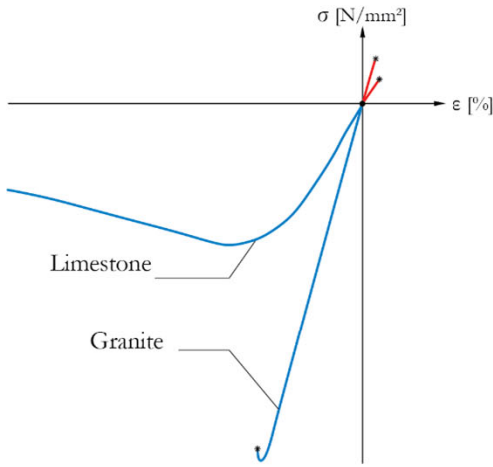
Steel (S235)



Concrete (Different Grades)



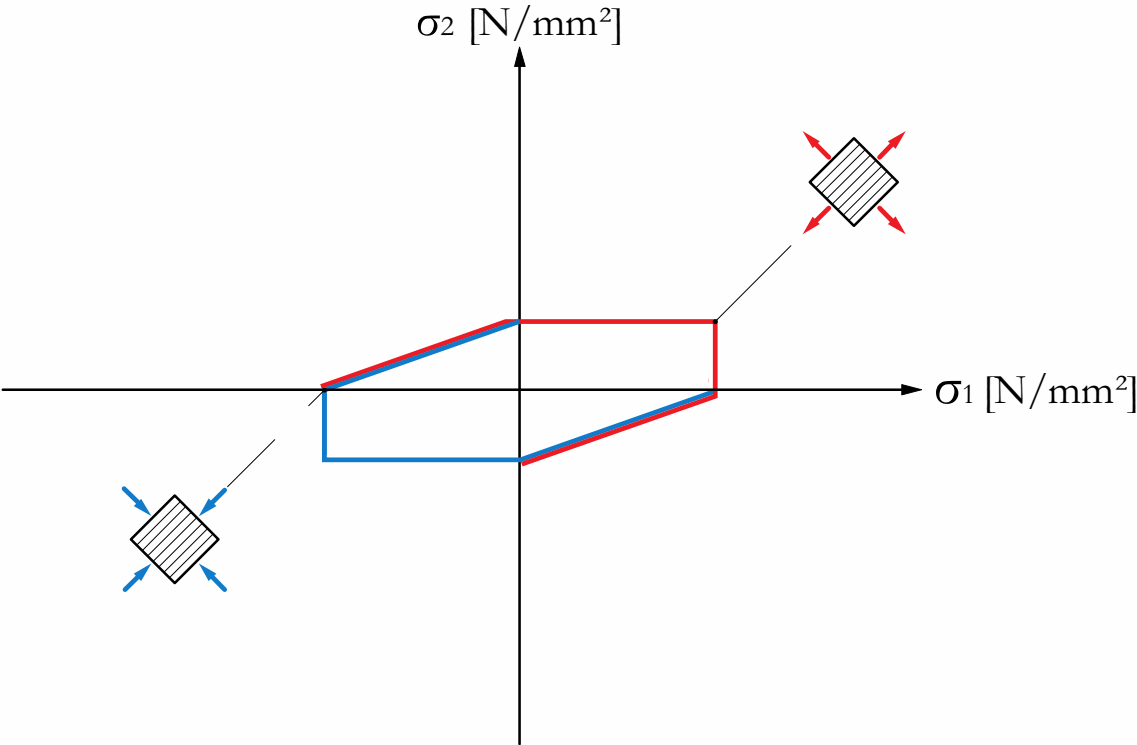
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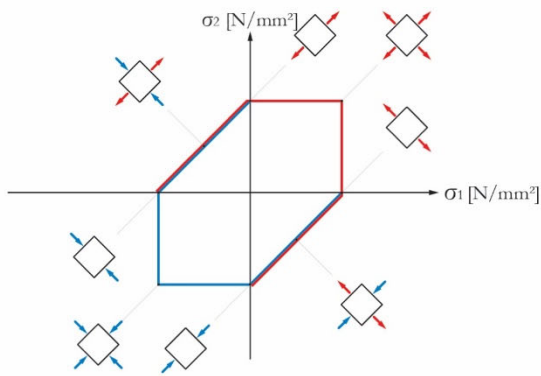


Masonry (Limestone & Granite)

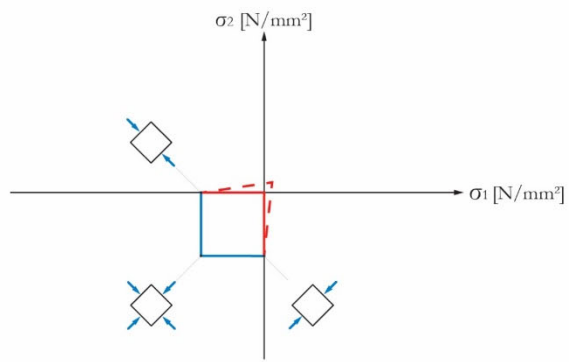
Spannungs-Dehnungs-Diagramme für die wichtigsten Baustoffe

Stress-strain diagrams for the main structural materials

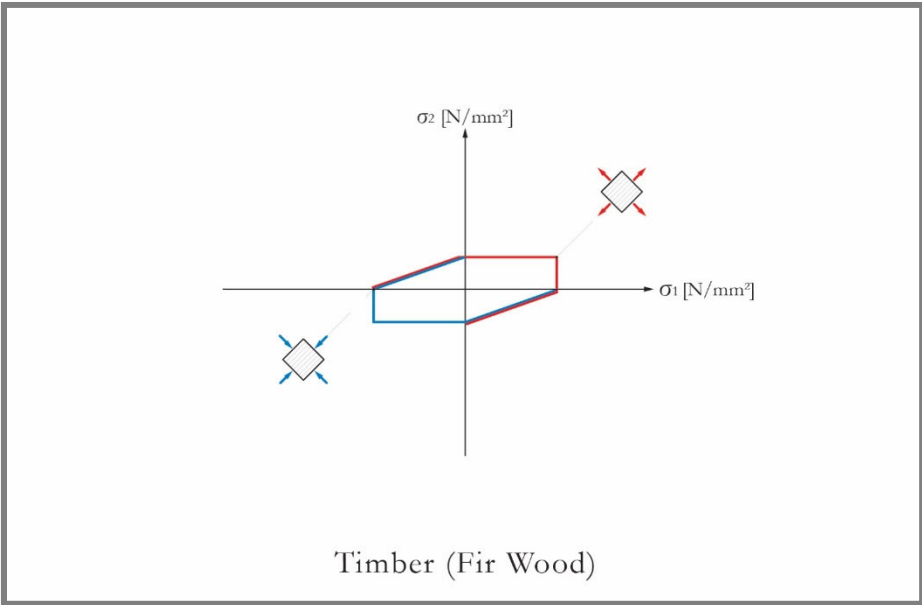




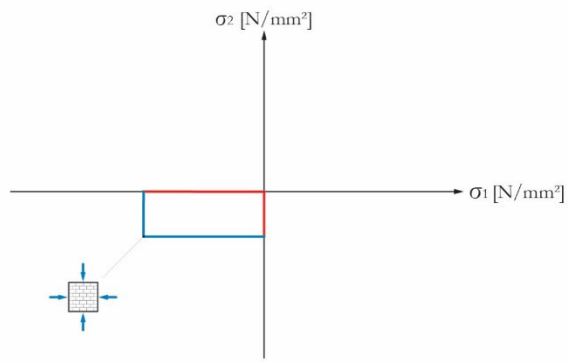
Steel (S235)



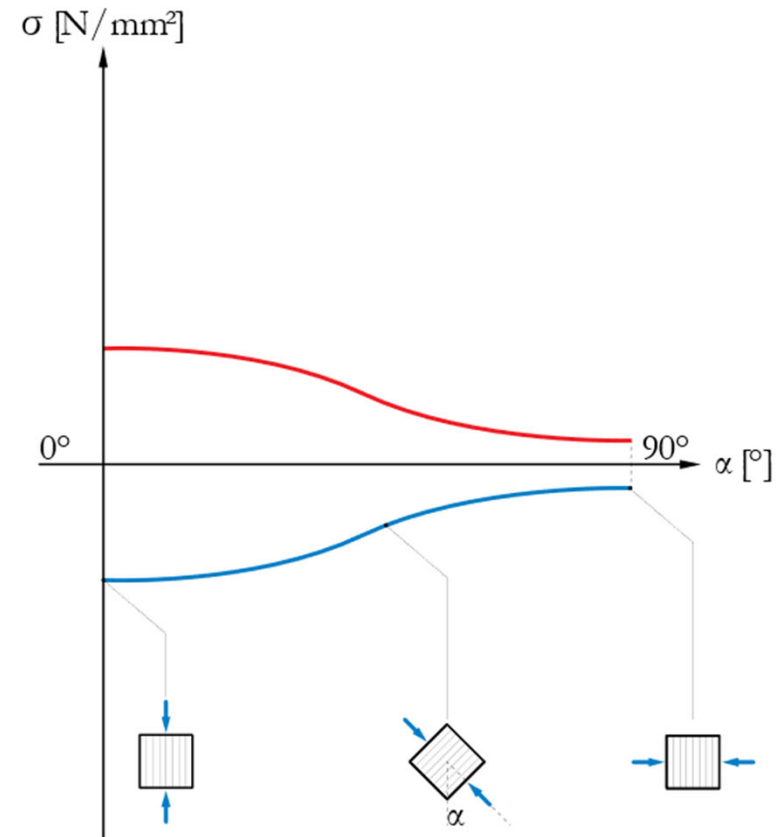
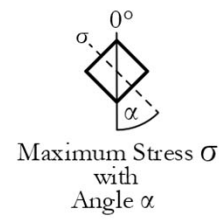
Concrete



Timber (Fir Wood)

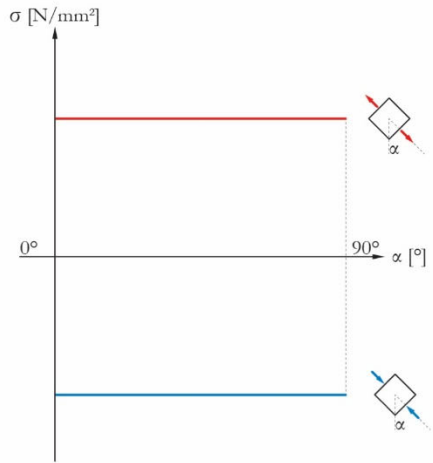
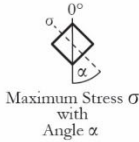


Masonry (Limestone)

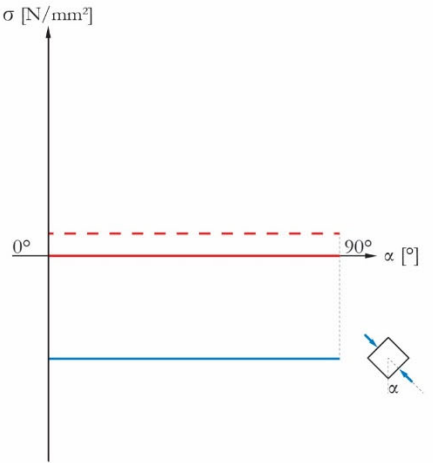


Holz (Tannenholz), Veränderung der Festigkeit in Abhängigkeit vom Spannungswinkel

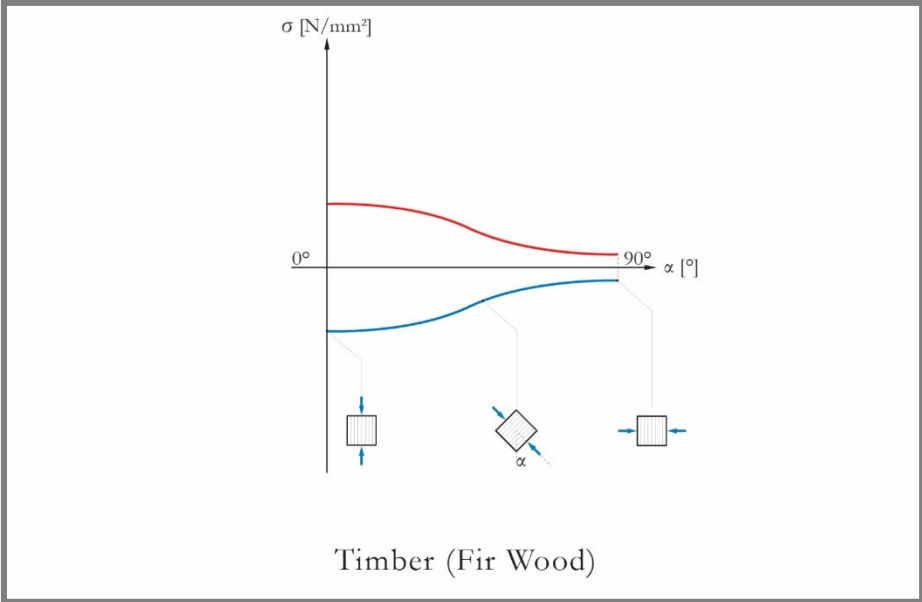
Timber (Fir wood), strength variation according to the stress angle



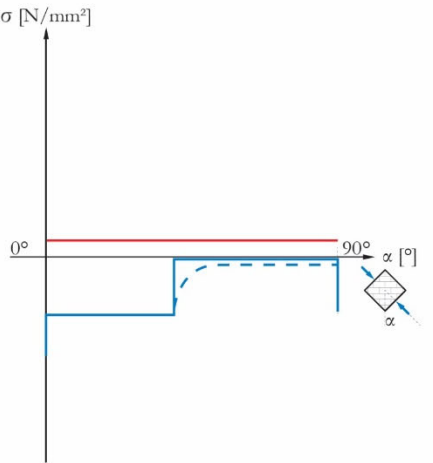
Steel (S235)



Concrete



Timber (Fir Wood)



Masonry (Limestone)

Veränderung der Festigkeit in Abhängigkeit vom Spannungswinkel

Strength variation according to the stress angle

Festigkeitsklassen				Nadelholz					Buche, Eiche
				C20	C24	C27	C35	C45	D30
Bemessungswerte									
Festigkeit	Zug parallel zur Faser	$f_{t\parallel,d}^+$	N/mm ²	7	8	9.5	14	18	10
	Druck parallel zur Faser	$f_{t\parallel,d}^-$	N/mm ²	11	12	13	17	18	13
	Zug senkrecht zur Faser	$f_{t\perp,d}^+$	N/mm ²	0.1	0.1	0.1	0.1	0.1	0.2
	Druck senkrecht zur Faser	$f_{t\perp,d}^-$	N/mm ²	1.7	1.8	1.9	2.0	2.2	5.3
	Zug /Druck 45 °	$f_{t\Delta,d}^+$ $f_{t\Delta,d}^-$	N/mm ²	1.5	1.5	1.5	1.8	1.8	2.0
Verformung	$E_{\parallel,mean}$ in Faserrichtung	$E_{t,mean}$ $E_{t\parallel,mean}^+$ $E_{t\parallel,mean}^-$	kN/mm ²	9.5	11	12	13	15	10
	$E_{\perp,mean}$ senkrecht zur Faser	$E_{t\perp,mean}^+$ $E_{t\perp,mean}^-$	kN/mm ²	0.3	0.3	0.3	0.4	0.4	0.6
Rohdichte		ρ_k	kg/m ³	330	350	370	400	440	530



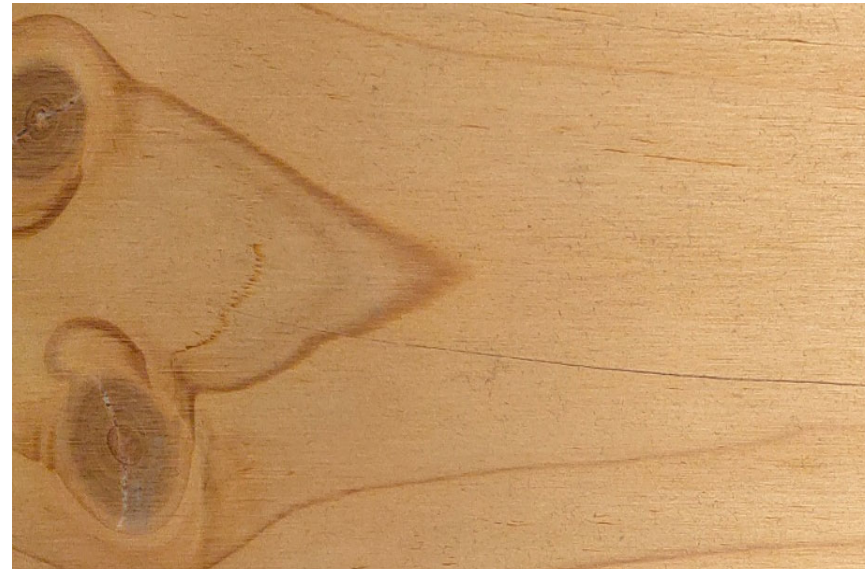
Beeinflusste Eigenschaft	Tragwiderstand		Steifigkeit	
	Feuchteklasse 2	Feuchteklasse 3	Feuchteklasse 2	Feuchteklasse 3
Baustoff				
Vollholz, Brettschichtholz, Furnierschichtholz, Sperrholz	0.80	0.60	0.90	0.75

Einfluss der Feuchtigkeit auf die Tragwiderstand und Steifigkeit

Influence of moisture on the load-bearing resistance and stiffness

Grade A Premium Quality	Grade N Normal Quality	Grade I Industrial Quality
----------------------------	---------------------------	-------------------------------

- Äste - *Branches*
- Dimension des Jahrringes - *Dimension of the growth ring*
- Verteilung der Fasern - *Distribution of the fibres*
- Harz - *Resin*
- Wachstum der Rinde - *Bark growth*
- Art des Schnittes - *Type of cut*
- Baumkante und Rinde - *Tree edge and bark*
- Reaktion Holz - *Reaction wood*
- Verfärbung - *Discoloration*
- Fäulnis - *Decay*
- Insektenbefall - *Insect infestation*
- Risse - *Cracks*
- Krümmung - *Curvature*
- Oberfläche - *Surface*



Merkmal	Erscheinungsklassen für Vollholz		
	A	N	I
Äste	mit kleinstem sichtbarem Durchmesser bis 2/5 der Abmessung der zugehörigen Querschnittsseite, aber höchstens 70 mm, zulässig mit grösstem sichtbarem Durchmesser bis 2/3 der Abmessung der zugehörigen Querschnittsseite zulässig	mit kleinstem sichtbarem Durchmesser bis 2/5 der Abmessung der zugehörigen Querschnittsseite zulässig	mit kleinstem sichtbarem Durchmesser bei C24 bis 2/5, bei C16 bis 3/5 der Abmessung der zugehörigen Querschnittsseite zulässig
- gesunde, festverwachsene Äste	zulässig	zulässig	zulässig
- andere Äste ¹⁾ und Astlöcher	mit grösstem sichtbarem Durchmesser bis 40 mm zulässig ²⁾	zulässig ²⁾	zulässig
mittlere Jahringbreite	bis 6 mm zulässig	bis 6 mm zulässig	bis 6 mm zulässig
Faserneigung	bis 12% zulässig	bis 12% zulässig	bis 12% zulässig
Harzgallen	bis 3 mm x 50 mm zulässig	bis 5 mm x 50 mm zulässig	zulässig
Rindeneinwuchs	nicht zulässig	nicht zulässig	zulässig
Schnittart	markfrei erforderlich	markdurchschnitten erforderlich	keine Anforderung
Baumkante und Rinde	nicht zulässig	nicht zulässig	Baumkante bis 1/4 der Abmessung der zugehörigen Querschnittsseite, parallel zu dieser Querschnittsseite gemessen, zulässig Rinde nicht zulässig
Reaktionsholz (Buchs)	bis 1/5 des Querschnittsumfanges zulässig	bis 2/5 des Querschnittsumfanges zulässig	bis 2/5 des Querschnittsumfanges zulässig
Verfärbungen			
- Bläue	nicht zulässig	bis 1/5 des Querschnittsumfanges zulässig	zulässig
- braune und rote Streifen	nicht zulässig	bis 1/5 des Querschnittsumfanges zulässig	bis 2/5 des Querschnittsumfanges zulässig
Fäule	nicht zulässig	nicht zulässig	nicht zulässig

Tabelle 4.1-2: Kriterien für die Erscheinungsklassierung von Vollholz aus Fichte und Tanne.

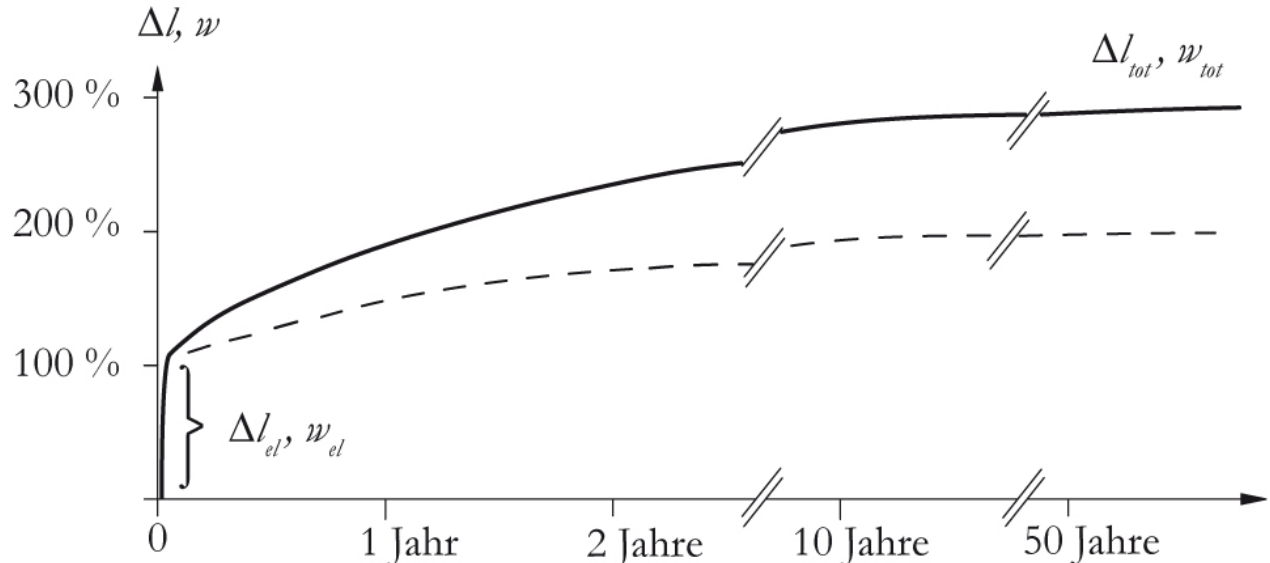
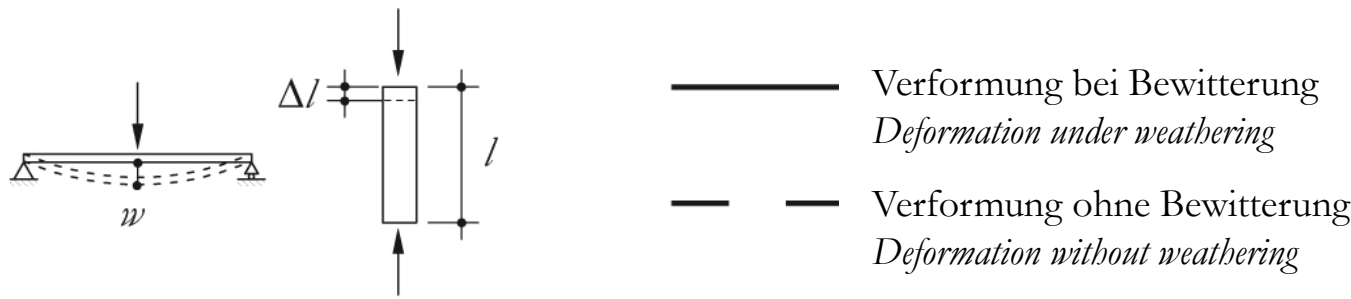
¹⁾ Teilweise oder nicht verwachsene Äste, angeschlagene Äste oder Astteile, Ausfalläste, schwarz- oder rindenumrandete Äste, Fauläste und schwarze Äste.
²⁾ Bei der Auslieferung zulässig. Bei sichtbar bleibenden Oberflächen von verbautem Vollholz sind andere Äste und Astlöcher mit grösstem sichtbarem Durchmesser über 20 mm auszuflicken.

Merkmal	Erscheinungsklassen für Vollholz		
	A	N	I
Insektenbefall	nicht zulässig	Frassgänge bis 2 mm Durchmesser bei inaktivem Insektenbefall zulässig	Frassgänge bis 2 mm Durchmesser bei inaktivem Insektenbefall zulässig
Risse			
- Schwindrisse	Rissbreite bis 3% der zugehörigen Querschnittsseite, jedoch nicht mehr als 6 mm, zulässig Ristiefe bis zur 0,5-fachen Abmessung der jeweiligen Querschnittsseite, parallel zu dieser Querschnittsseite gemessen, zulässig	Rissbreite bis 5% der zugehörigen Querschnittsseite, jedoch nicht mehr als 10 mm, zulässig Ristiefe bis zur 0,5-fachen Abmessung der jeweiligen Querschnittsseite, parallel zu dieser Querschnittsseite gemessen, zulässig	Ristiefe bis zur 0,5-fachen Abmessung der jeweiligen Querschnittsseite, parallel zu dieser Querschnittsseite gemessen, zulässig
- Endrisse	Risslänge bis zur 1-fachen Abmessung der grösseren Querschnittsseite zulässig	Risslänge bis zur 1-fachen Abmessung der grösseren Querschnittsseite zulässig	Risslänge bis zur 1,5-fachen Abmessung der grösseren Querschnittsseite zulässig
- übrige Risse	nicht zulässig	nicht zulässig	nicht zulässig
Krümmung			
- Verdrehung	bis 1 mm pro 25 mm Höhe auf 2 m zulässig	bis 1 mm pro 25 mm Höhe auf 2 m zulässig	bis 1 mm pro 25 mm Höhe auf 2 m zulässig
- Längskrümmung	bis 4 mm auf 2 m zulässig	bis 8 mm auf 2 m zulässig	bis 8 mm auf 2 m zulässig

Tabelle 4.1-2: Kriterien für die Erscheinungsklassierung von Vollholz aus Fichte und Tanne (Fortsetzung).

Visuelle Festigkeitssortierung (Quelle: Qualitätskriterien für Holz und Holzwerkstoffe im Bauwesen und Ausbau - Lignum)

Visual strength-grading (Source: Quality criteria for wood and wood-based materials in construction and finishing - Lignum)





Brettschichtholz (Leimholz)

Glued-laminated timber (Glulam)



Brettschichtholz (Glulam) - Druckprüfung

Glued-laminated timber (Glulam) - Compression test



Brettschichtholz (Glulam) - Druckprüfung

Glued-laminated timber (Glulam) - Compression test

Festigkeitsklassen				normales Brettschichtholz BSH				hochwertiges Brettschichtholz BSH	
				GL24k	GL24h	GL28k	GL28h	GL36k	GL36h
Bemessungswerte									
Festigkeit	Zug parallel zur Faser	$f_{t\parallel,d}^+$	N/mm ²	10	12	12	14	16	18
	Druck parallel zur Faser	$f_{t\parallel,d}^-$	N/mm ²	13	14.5	16	17	18	20.5
	Zug senkrecht zur Faser	$f_{t\perp,d}^+$	N/mm ²	0.15	0.15	0.15	0.15	0.15	0.15
	Druck senkrecht zur Faser	$f_{t\perp,d}^-$	N/mm ²	1.9	1.9	2.0	2.0	2.2	2.2
	Zug /Druck 45 °	$f_{t\Delta,d}^+$ $f_{t\Delta,d}^-$	N/mm ²	1.8	1.8	1.8	1.8	1.8	1.8
Verformung	$E_{\parallel,mean}$ in Faserrichtung	$E_{t,mean}$ $E_{t\parallel,mean}^+$ $E_{t\parallel,mean}^-$	kN/mm ²	11	11	12	12	14	14
	$E_{\perp,mean}$ senkrecht zur Faser	$E_{t\perp,mean}^+$ $E_{t\perp,mean}^-$	kN/mm ²	0.3	0.3	0.3	0.3	0.4	0.4
Rohdichte		ρ_k	kg/m ³	350	380	380	410	430	450



Holz

Timber

Einführung

Introduction

Mechanische Eigenschaften

Mechanical Properties

>>

Bautechnologie

Building Technologies

Fallstudie: Mehrzweckhalle Vrin

Case Study: Gym Vrin

Ausgewählte Projekte

Selected Projects



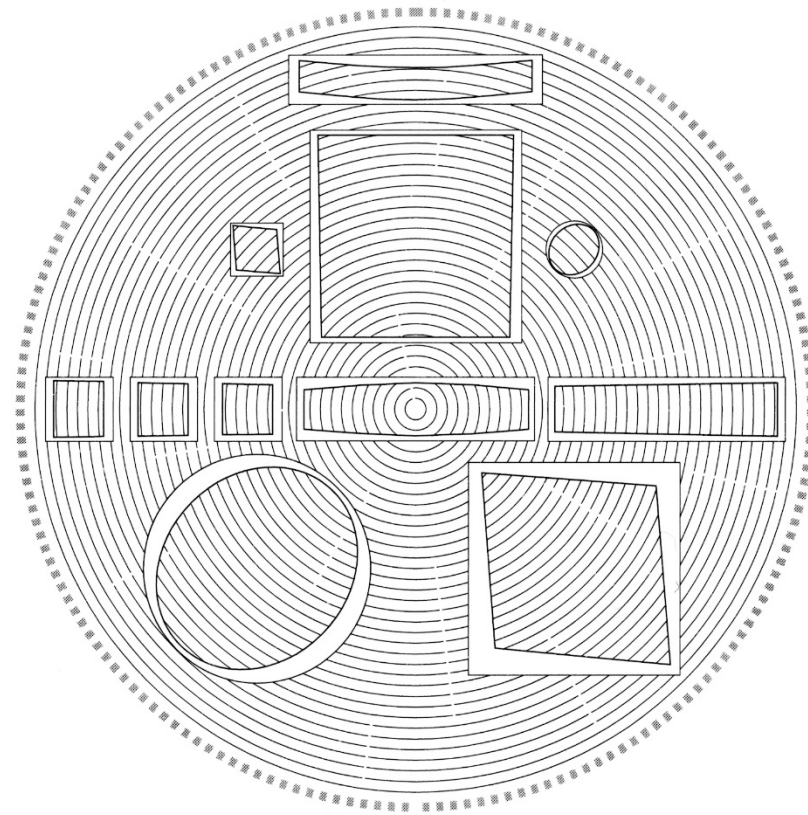


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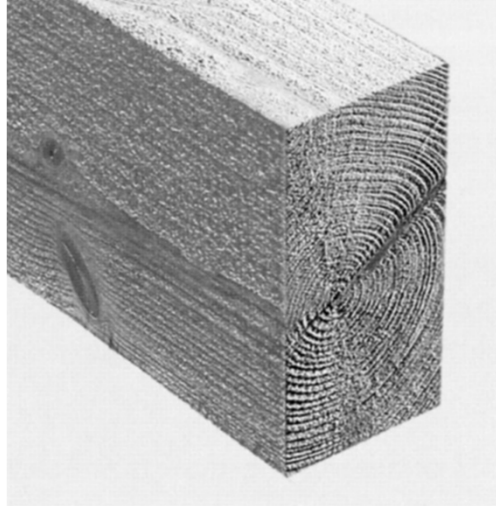
Verarbeitung von Holz
Processing timber



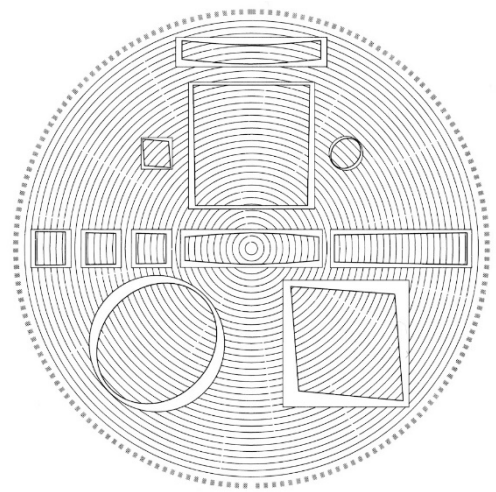
Unterschiedliche Ausrichtung der Schnitte in Bezug auf die Jahrringe des Holzes

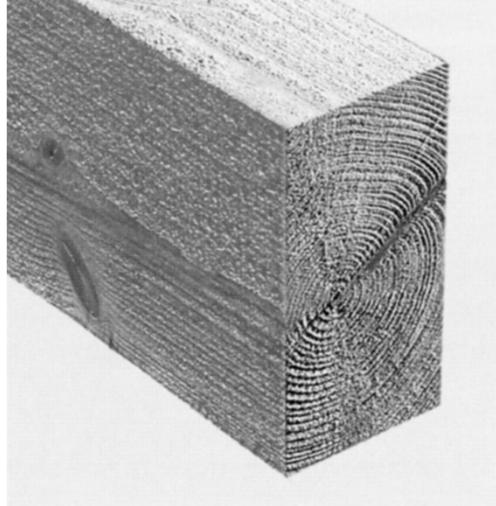
Different orientation of cuts with respect to wood growth rings

	Stärke d bzw. Höhe b	Breite b	Einheitliche Abmessungen $b \times d$ bzw. $b \times b$	Länge
Latte	$d \leq 40$ mm	$b < 80$ mm	$b = 75/80 / 100 / 115 / 120 / 125 / 140 / 150 / 160 / 175$ mm ungehobelt: $d = 16 / 18 / 22 / 24 / 28 / 38 / 44 / 48 / 50 / 63 / 70 / 75$ mm gehobelt: $d = 13.5 / 15.5 / 19.5 / 25.5 / 35.5 / 41.5 / 45.5$ mm	$1.5 \leq \leq 6$ m $\Delta = 250$ bzw. 300 mm
Brett	$d \leq 40$ mm	$b \geq 80$ mm		
Bohle	$d > 40$ mm	$b > 30 d$		
Kantholz	$h \leq 3 b$	$b > 40$ mm	60 x 60 / 80 / 120 mm 80 x 100 / 120 / 160 mm 100 x 100 / 120 / 160 mm 120 x 120 / 140 / 160 / 200 / 240 mm 140 x 140 / 160 mm 160 x 160 / 180 / 200 mm 180 x 220 mm 200 x 200 / 240 mm	≤ 16 m
Konstruktions- Vollholz KVH	$d \leq 120$ mm	$b < 240$ mm	60 x 120 / 140 160 / 180 / 200 / 240 mm 80 x 120 / 140 160 / 200 / 240 mm 100 x 120 / 200 mm 120 x 120 / 200 / 240 mm	≤ 5 m massiv ≤ 14 m keilverzinkt
Massiv Holz			wie Kantholz	≤ 13 m

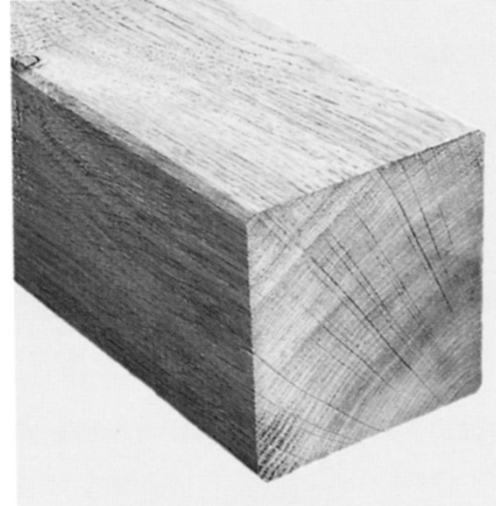


Nadelholz– *Softwood*

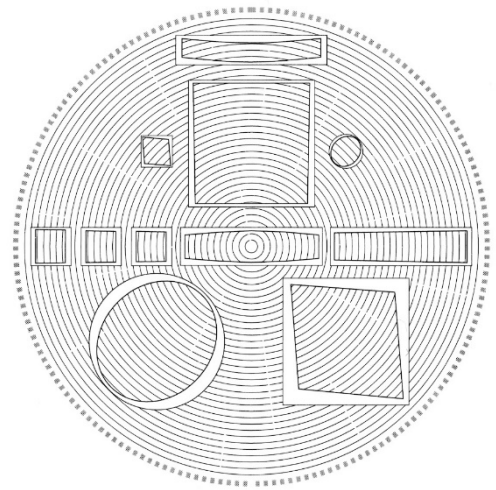


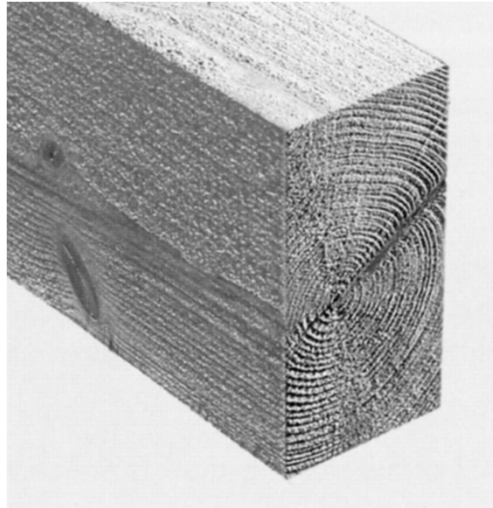


Nadelholz – *Softwood*

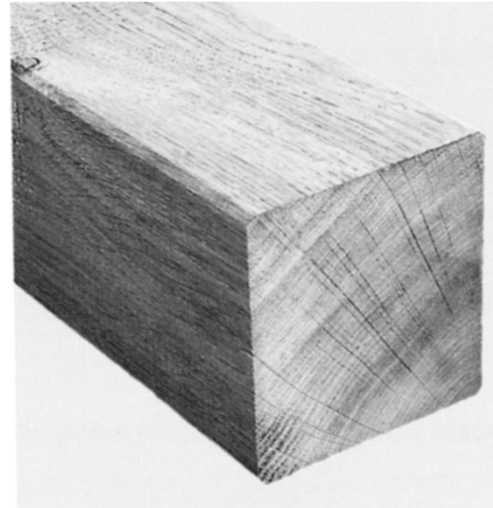


Laubholz – *Hardwood*





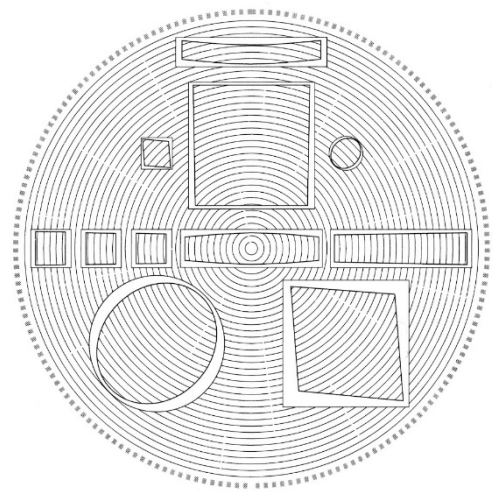
Nadelholz – *Softwood*

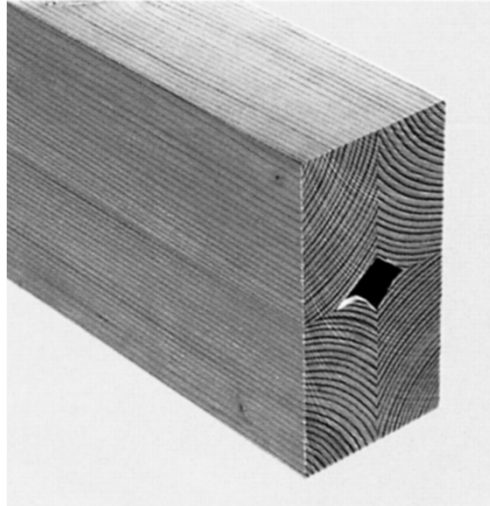


Laubholz – *Hardwood*

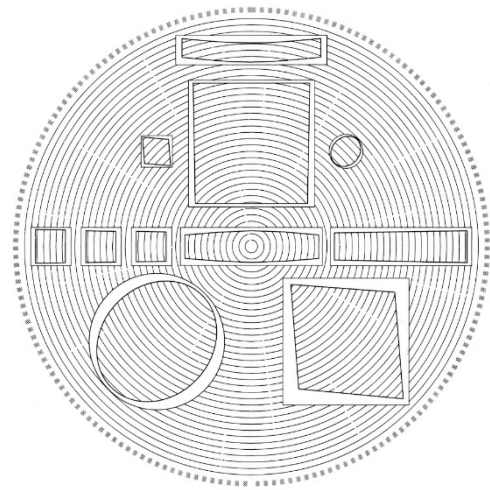


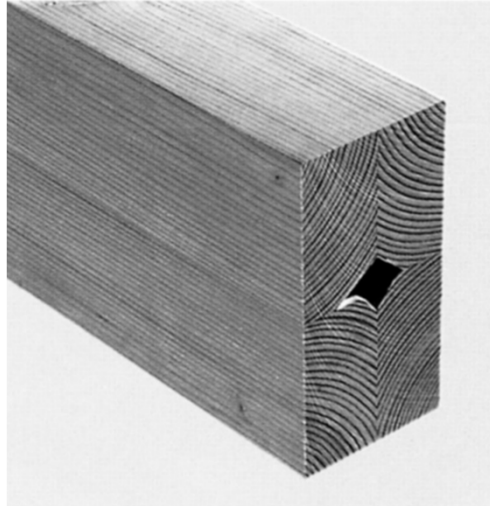
Blockholz – *Inner core*



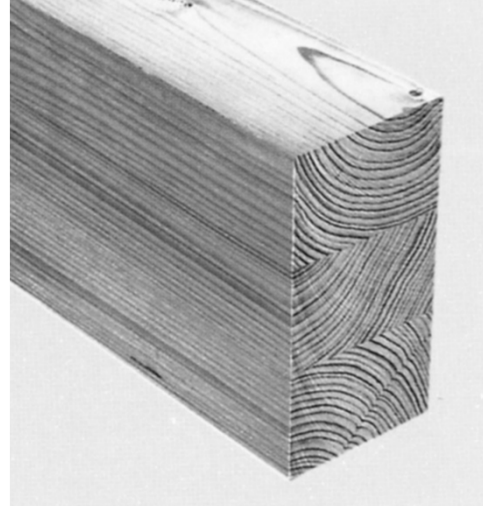


Kreuzbalken - *Composite timber beam*

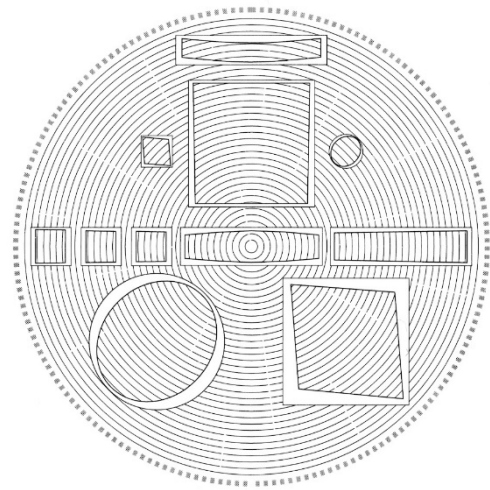


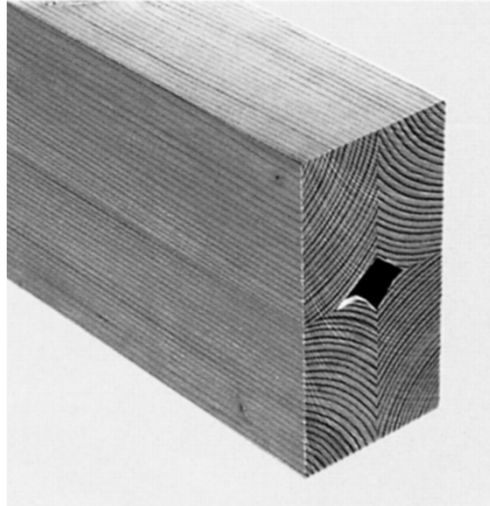


Kreuzbalken - *Composite timber beam*

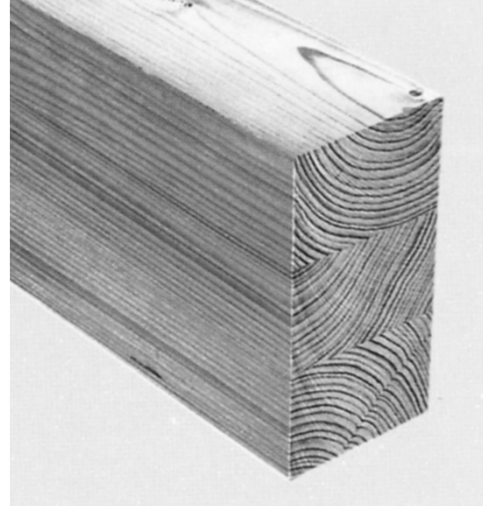


Duo-/Triobeam

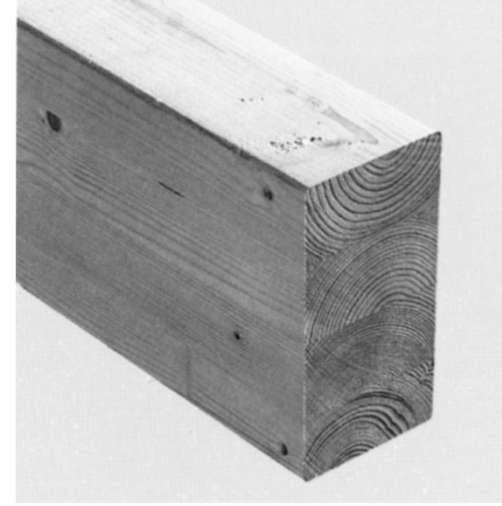




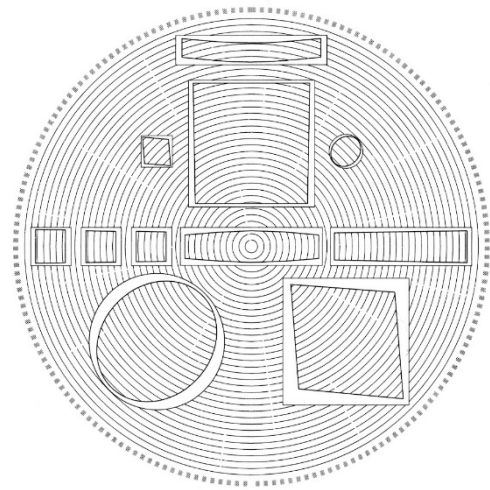
Kreuzbalken - *Composite timber beam*



Duo-/Triobeam



Brettschichtholz BSH - *Glulam*





© Rubner Holzbau

Brettschichtholz (Leimholz)
Glued-laminated (Glulam) timber



Brettschichtholz (Leimholz)
Glued-laminated (Glulam) timber



Brettschichtholz (Leimholz)
Glued-laminated (Glulam) timber



© Jack Hobhouse

Freemen's School Swimming Pool, Surrey, 2017, arch. Hawikins/Brown



© Fausto Franzosi

Asilo Nido, Guastalla, 2015, arch. Mario Cucinella Architects



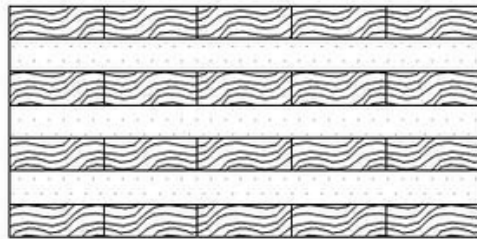
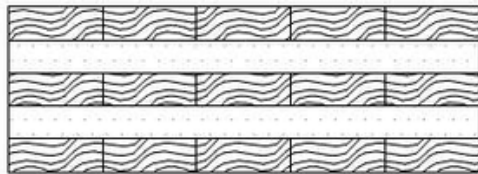
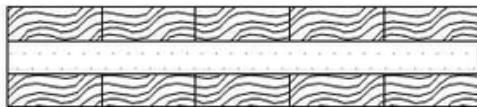
© Michel Denancé

Jérôme Seydoux - Pathé Foundation, Paris, 2014, arch. Renzo Piano Building Workshop, eng. VP Green



Brettsper Holz (CLT)

Cross-laminated timber (CLT)



3 LAYERS



5 LAYERS



7 LAYERS



Urbach Tower, Urbach, 2019, arch. ICD, eng. ITKE



© IDC/ITKE

Urbach Tower, Urbach, 2019, arch. ICD, eng. ITKE



Nichttragende Holzplatten
Non-structural timber panels



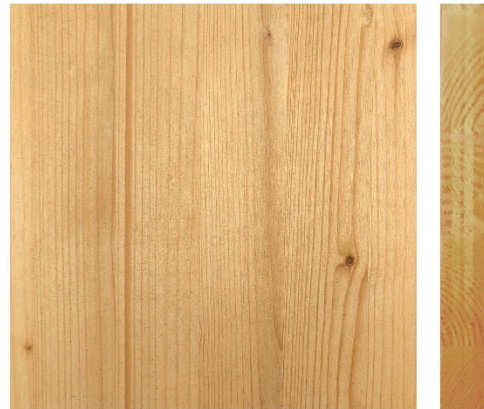
Furnierschnittholz
Veneer Lumber



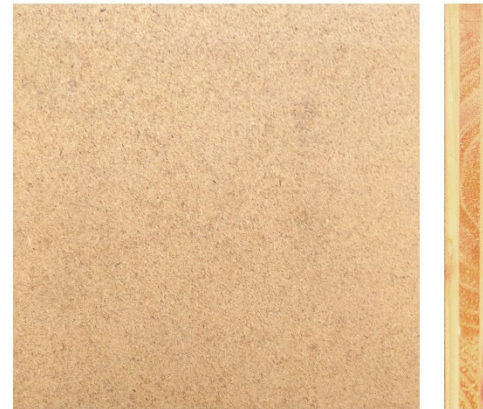
Furniersperrholz
Veneer Plywood



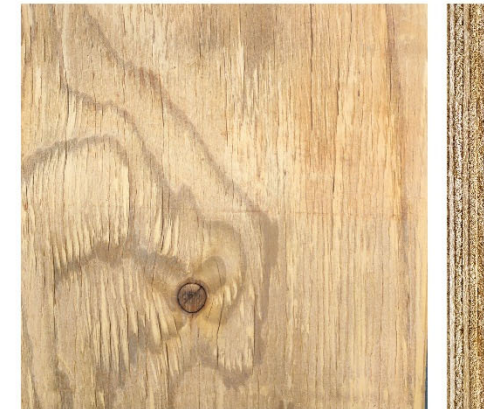
Sandwich-Paneel
Sandwich Panel



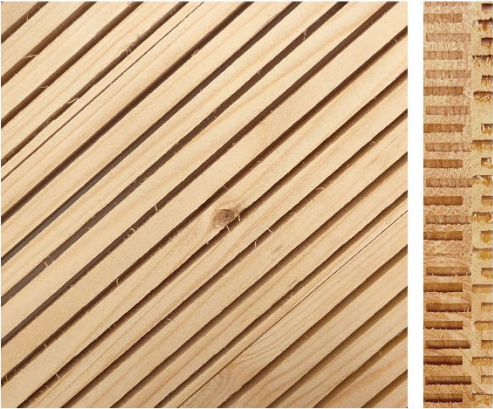
Einschichtige Massivholzplatte
Single Ply Solid Wood Panel



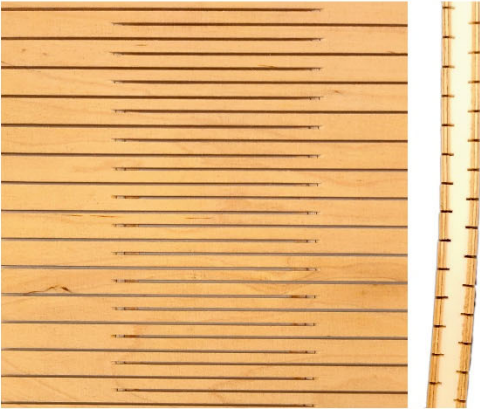
Mehrschichtige Vollsperrholzplatte
Multilayered Solid Plywood Panel



Sandwich-Paneel
Sandwich Panel



DendroLight
DendroLight



Flexibler Verbundwerkstoff
Flexible Composite Material



Leichte Platte
Lightweight Panel



OSB
OSB



Spanplatte
Chipboard



MDF
MDF



OSB-Platten als Aussteifungselemente

OSB panels used as stiffening elements



Holz-zu-Holz-Verbindungen
Timber-to-Timber connections



Butchery, Vrin (Graubünden), 1998 arch. Gion A. Caminada



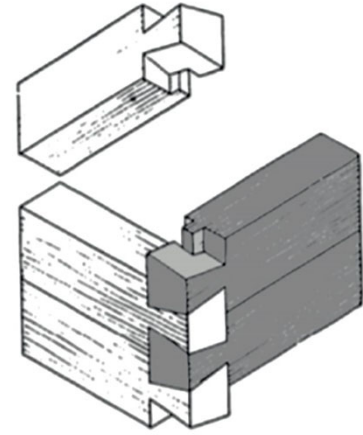
FEST
FIXED
(Timbered roof structures)



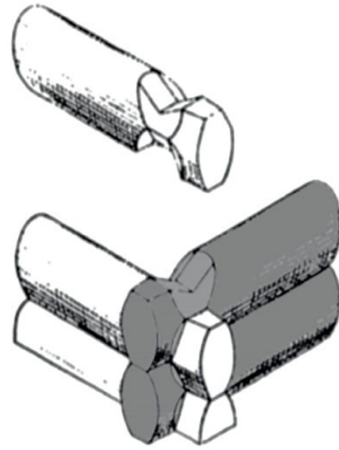
DREHGELENK
SWIVEL JOINT
(Tamedia Office Building, Zürich)



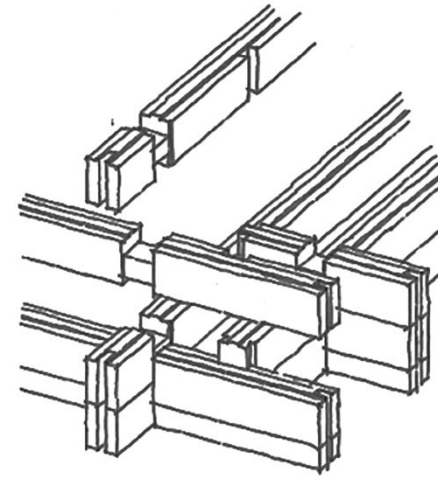
GESPALTET
STACKED
(Log cabins)



SCHWALBENSCHWANZ
DOVETAIL
(Singular)



KERBE
NOTCH
(Singular wall)

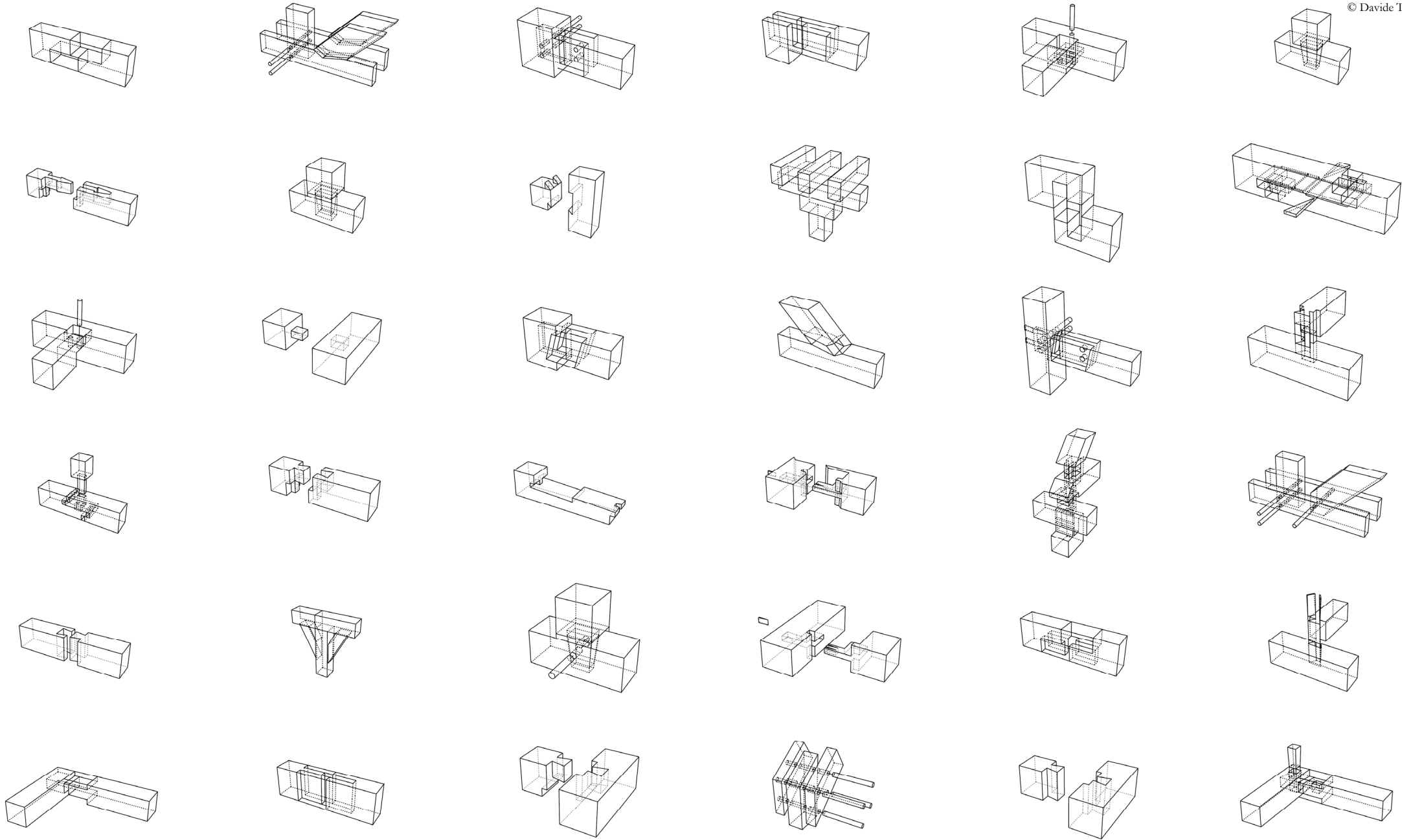


KERBE
NOTCH
(Double Walls)



Danjo Garan Temple, Koyasan, 9th century

© Davide Tanadini



Japanische Holz-zu-Holz-Verbindungen
Japanese Timber-to-Timber Connections



Holz-Stahl-Verbindungen
Timber-to-Steel Connections



WINKEL
ANGLE



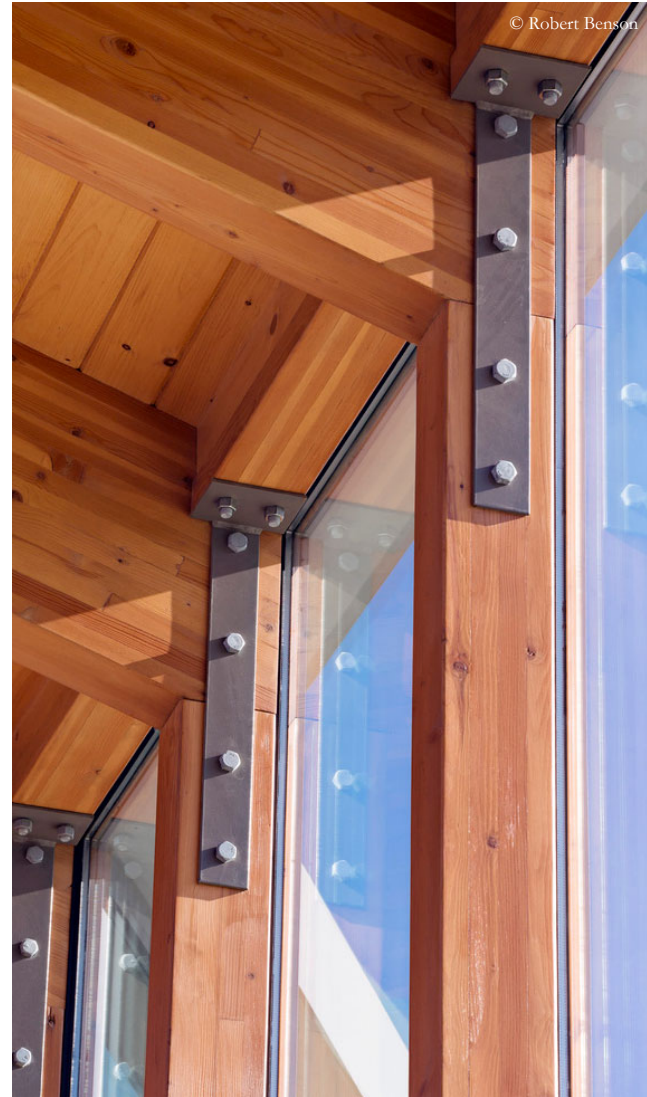
PLATTE
PLATE



BUCHSE
SOCKET



GEBOLZT
BOLTED
(OWT Timber Bolts)



VERSCHRAUB
SCREWED
(IMS, Lakeville)



EINGELEGT
INLAID
(Oak Framed House)



© OZCO

GEBOLZT
BOLTED
(OWT Timber Bolts)



© Nigel Young / Foster & Partners

VERSCHRAUBT
SCREWED
(Canary Wharf Station, London)



© Hiroyuki Hirai

EINGELEGT
INLAID
(Nine Bridges County Club, Jeju)



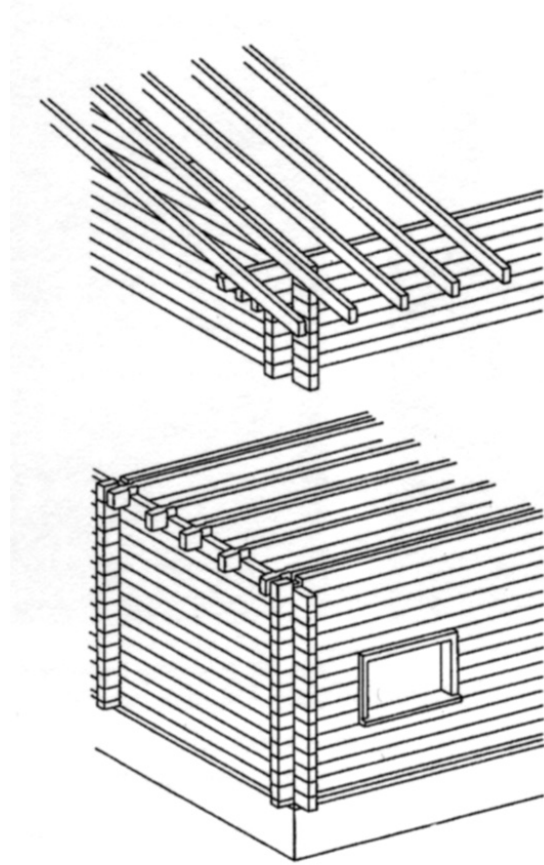
VERSCHRAUBT
SCREWED



WINKEL
ANGLE



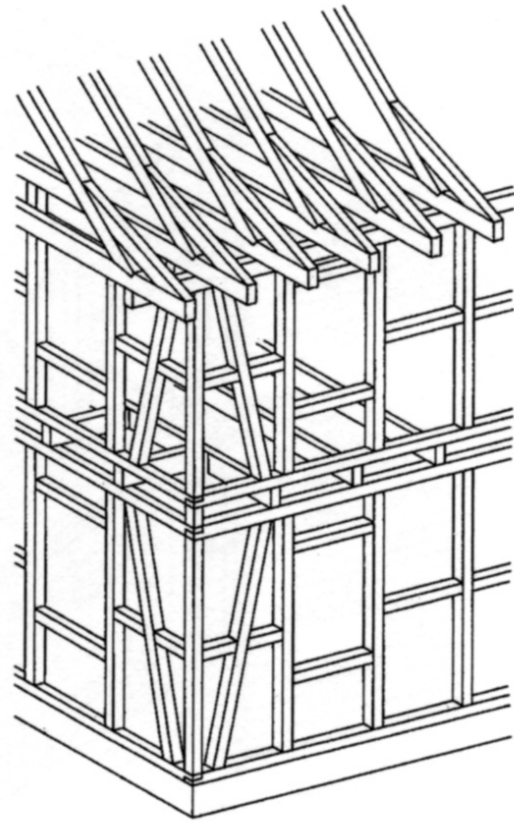
MODULAR
MODULAR



Blockbau, Strickbau
Log cabin



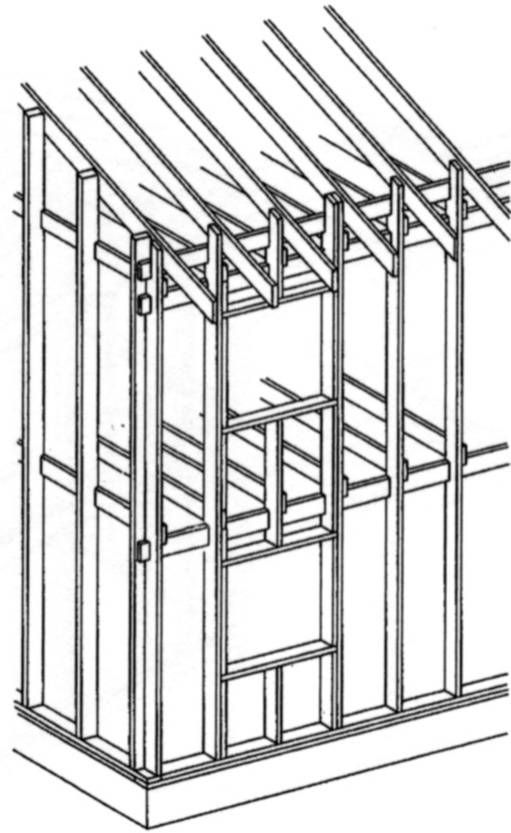
Residential building, Jenaz, 2003, P. Zumthor



Traditioneller Fachwerksbau- bzw. Riegelbau
Half-timbered building



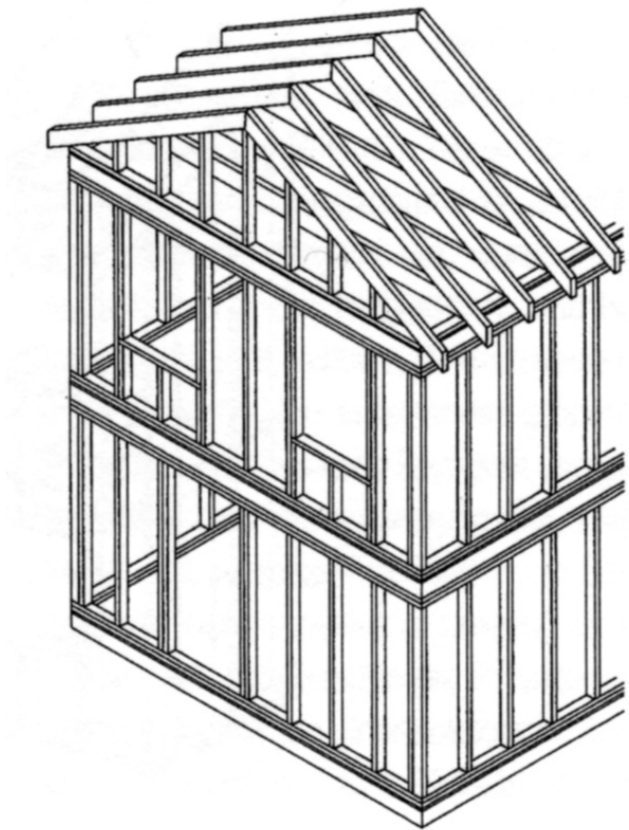
Unfinished "Riegelhaus"



Ständerbau
Balloon Frame



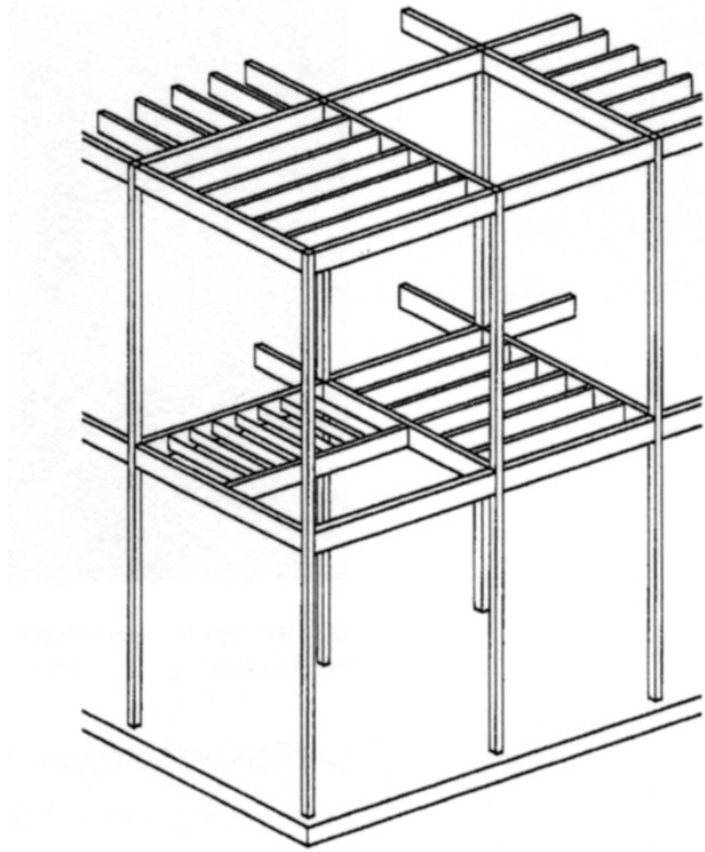
Vacation home, Maggiatal, 1998, R. Briccola



Rahmenbau
Platform Frame



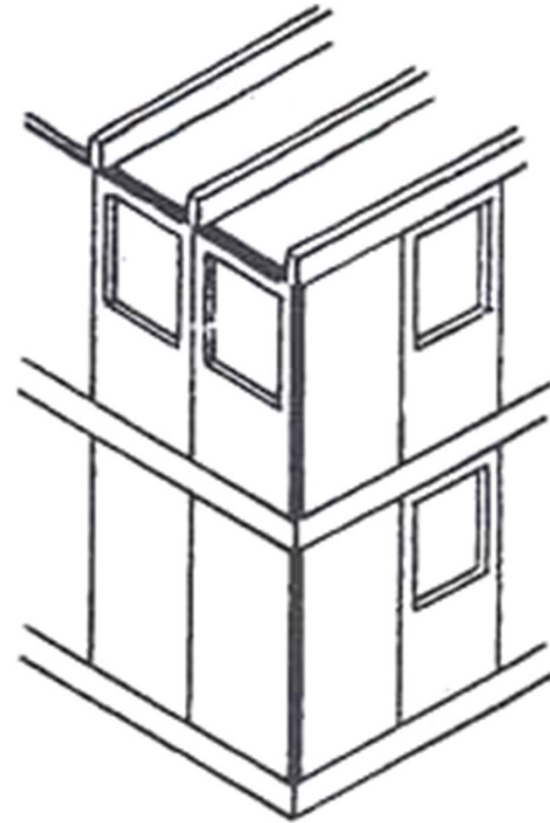
Apartment building Smith, Connecticut, 1968, Richard Meier



Skelettbau
Skeleton construction



Jugenddorf, Cieux, 1985, R. Schweizer



Tafelbau
Panel construction



Bearth-Canidas House, Sumvitg, 1998, Bearth and Deplazes





NATÜRLICH
NATURAL
(Protection with surface charring)



BESCHICHTET
COATED
(Fire coating)



UMHÜLLT
ENCASING
(Wood as protective layer)



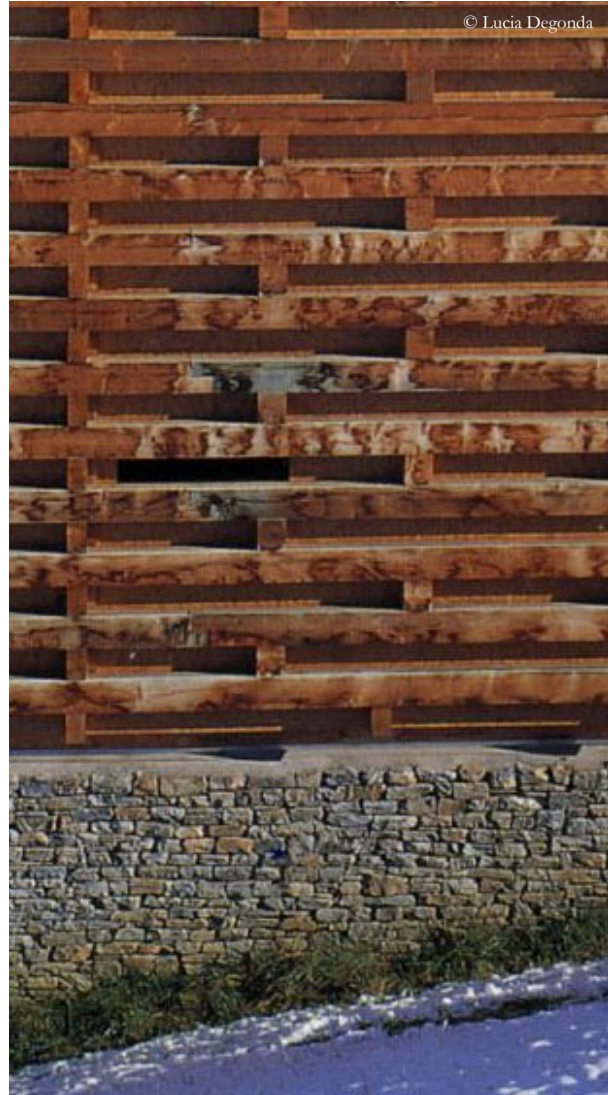
WASSERSCHADEN
WATER DAMAGE
(Fowing water)



WASSERSCHADEN
WATER DAMAGE
(High relative moisture)



TROCKENFÄULE
DRY ROT
(Fungal decay)



SOCKEL
BASE
(Butcher, Sum Vitg)



PLATTE
PLATE
(Wooden Bridge Museum, Yusuvara)



PUNKTUELL
PUNCTUAL
Wind Eaves Pavilion (Taiwan)

Holz

Timber

Einführung

Introduction

Mechanische Eigenschaften

Mechanical Properties

Bautechnologie

Building Technologies

>>

Fallstudie: Mehrzweckhalle Vrin

Case Study: Gym Vrin

Ausgewählte Projekte

Selected Projects

Multipurpose Hall Vrin

Vrin (Graubünden), 1996

Architect: Gion A. Caminada

Engineer: Jürg Conzett





„The use of wood as a building material was a logical decision, since the municipality of Vrin has ample stocks of fir wood. (...)

Extraordinary in this timber construction are in particular the large spans, which were to be bridged in favor of the multi-purpose hall. In this respect, the influence of the civil engineer Jürg Conzett was of great importance, because the novel roof construction in wood is due to his ingenuity.

The result is a binder construction as an under-stretched system. Five laminated wooden slats of 24 mm thickness serve as tie rods. This construction method makes the entire roof space visible, and contributes significantly to the generous spatial effect. „

Architecture





Gym Vrin, Vrin, 1996, arch. Gion A. Caminada, eng. Jürg Conzett



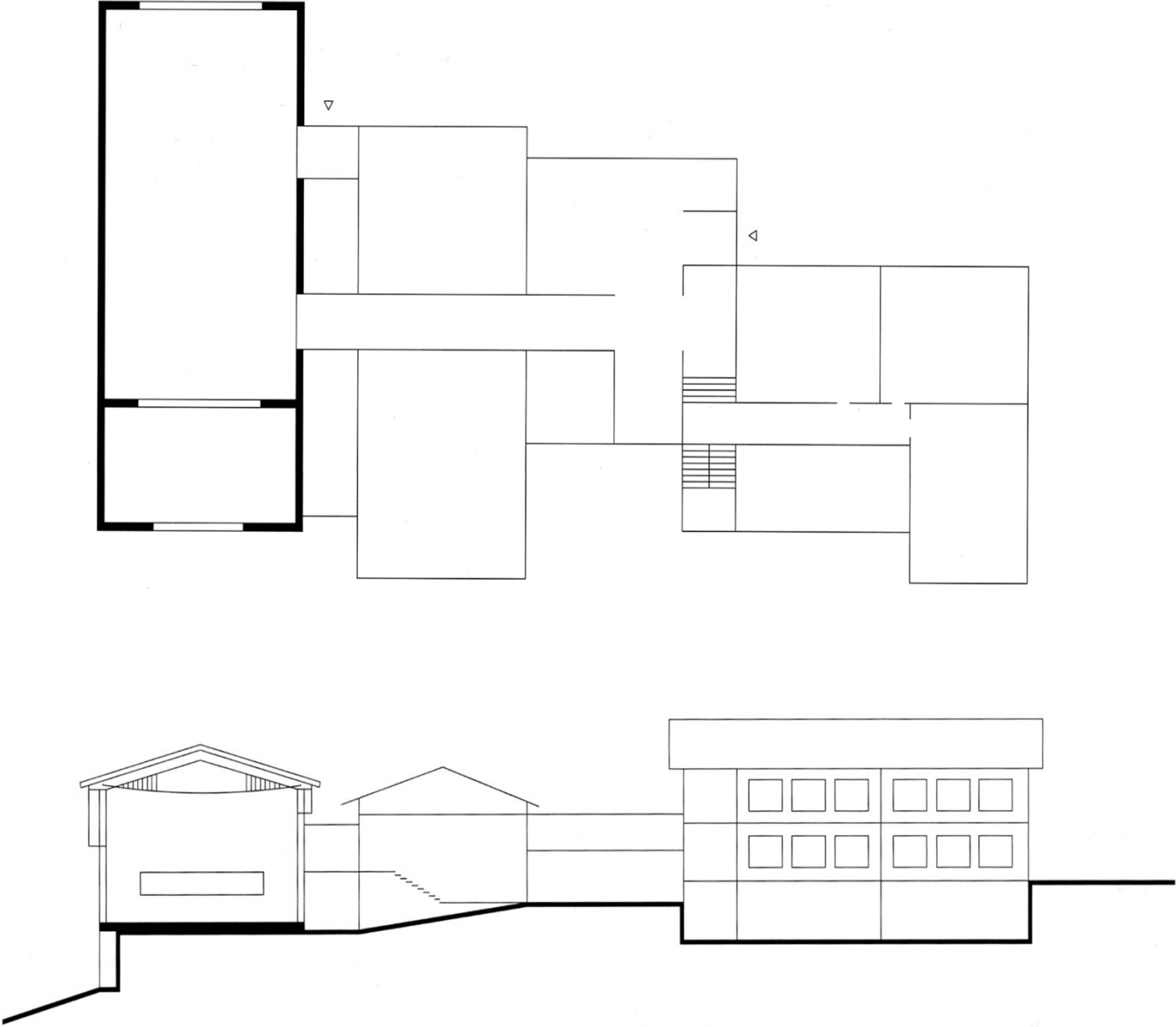


„The guiding principle of architecture [...] is „difference“. This difference arises from the distinctive relevance of the site. An „elemental“ building works towards this and strives to create an added value to the local life. The core idea is to create spaces that are directly related to people that inhabit them.,,

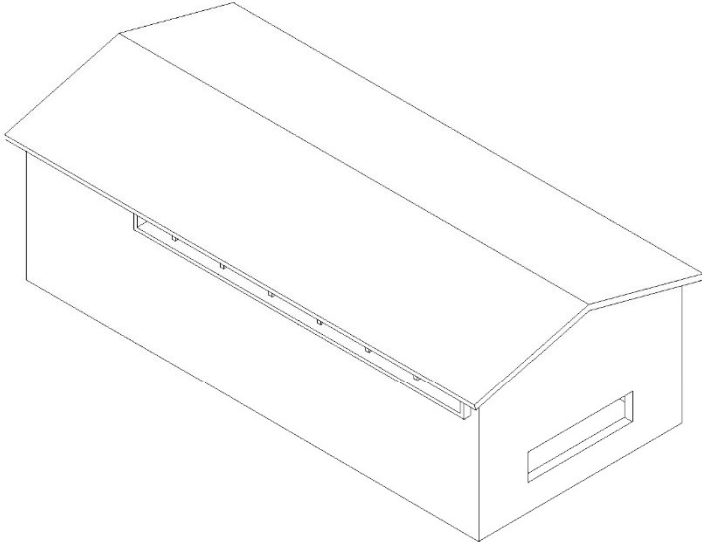
Gion A. Caminada



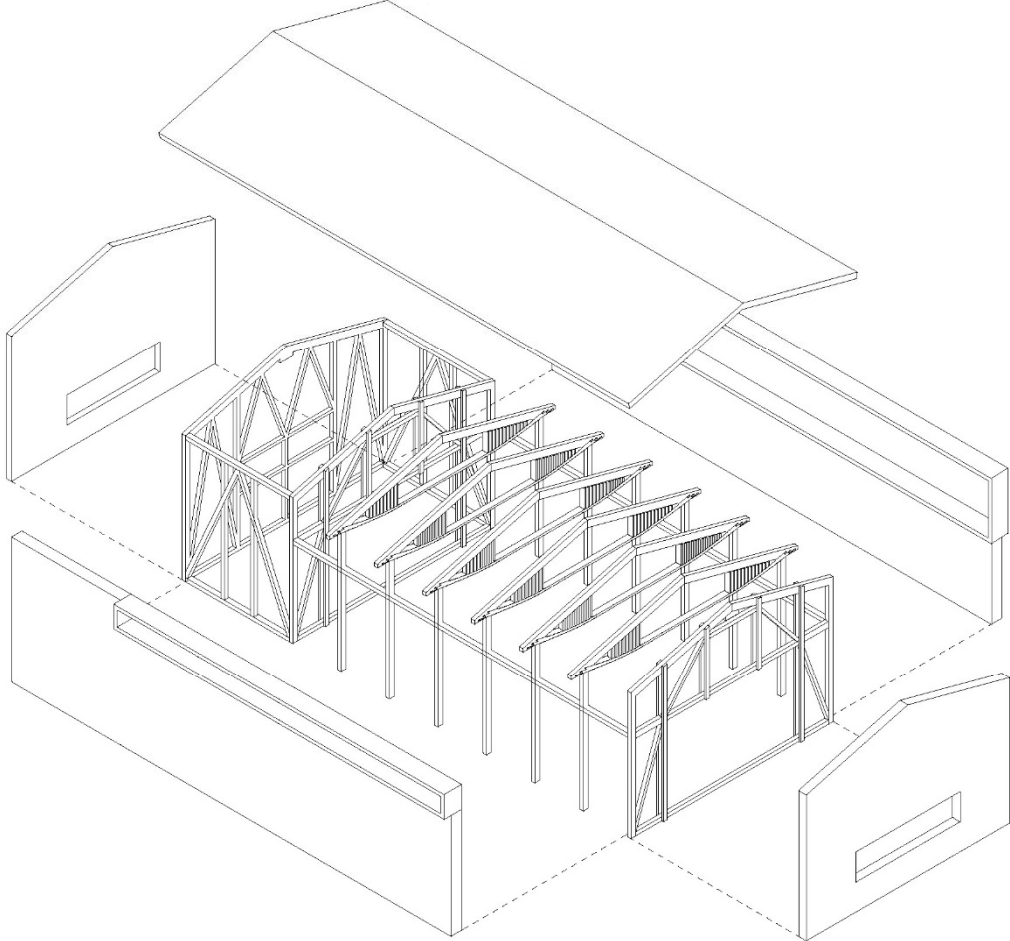
Case Study: Gym Vrin

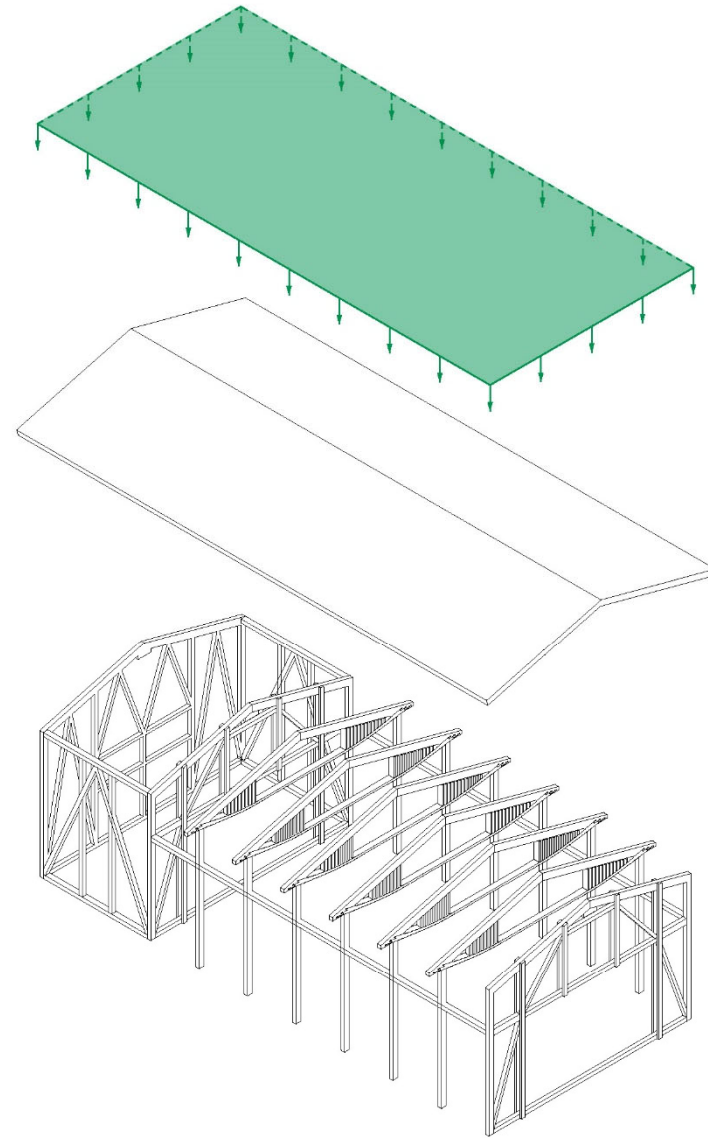


Case Study: Gym Vrin



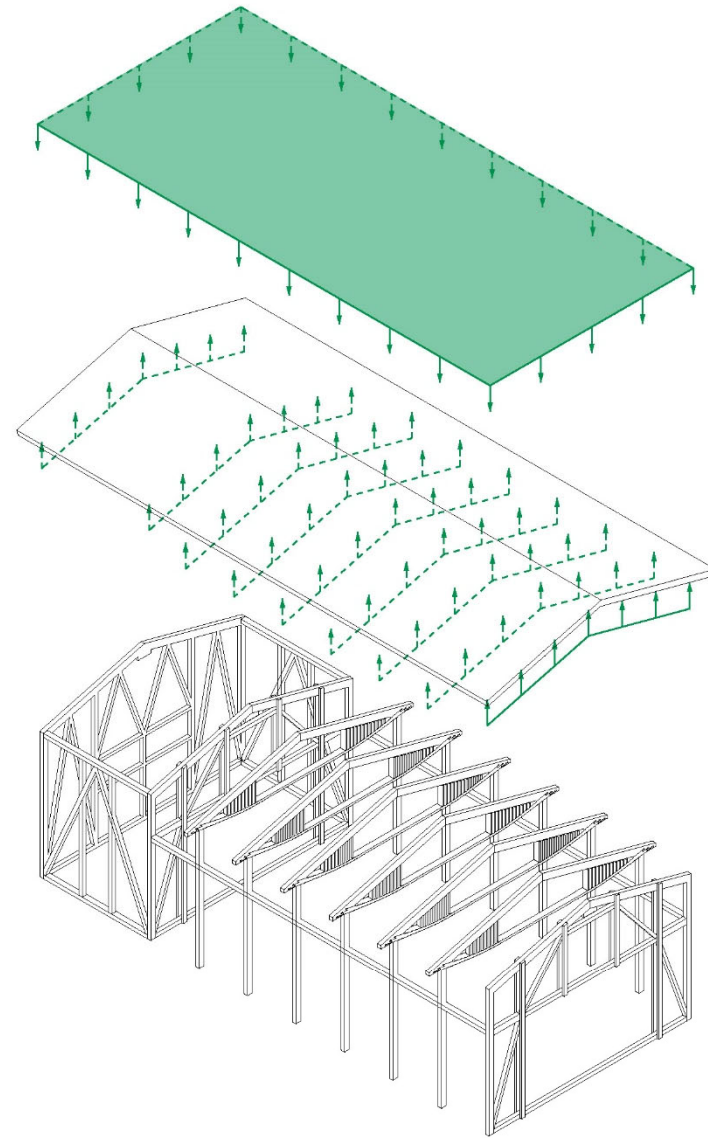
Case Study: Gym Vrin





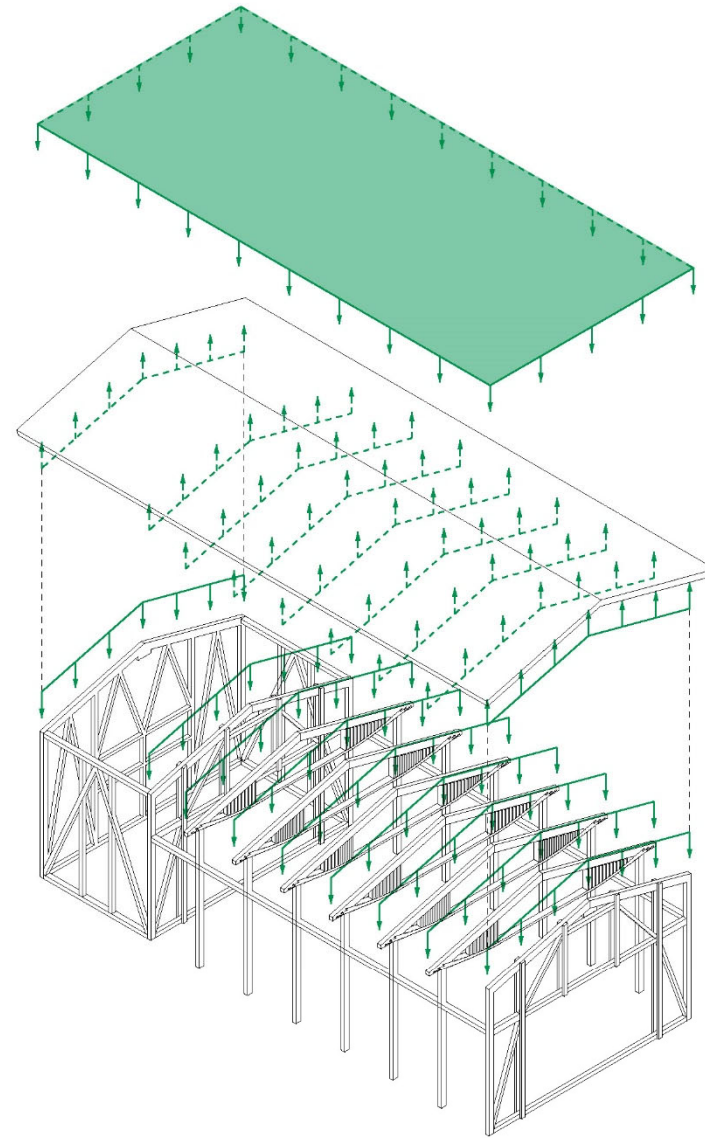
Vertikale Lasten

Vertical loads



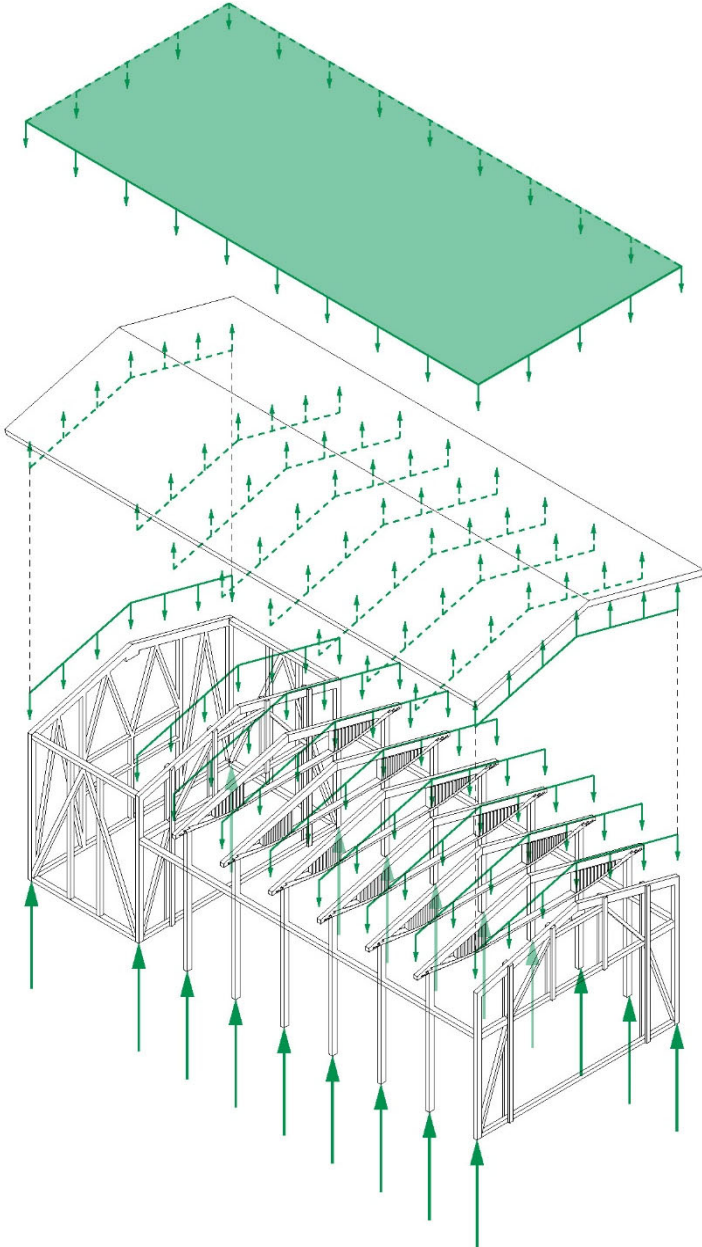
Vertikale Lasten

Vertical loads



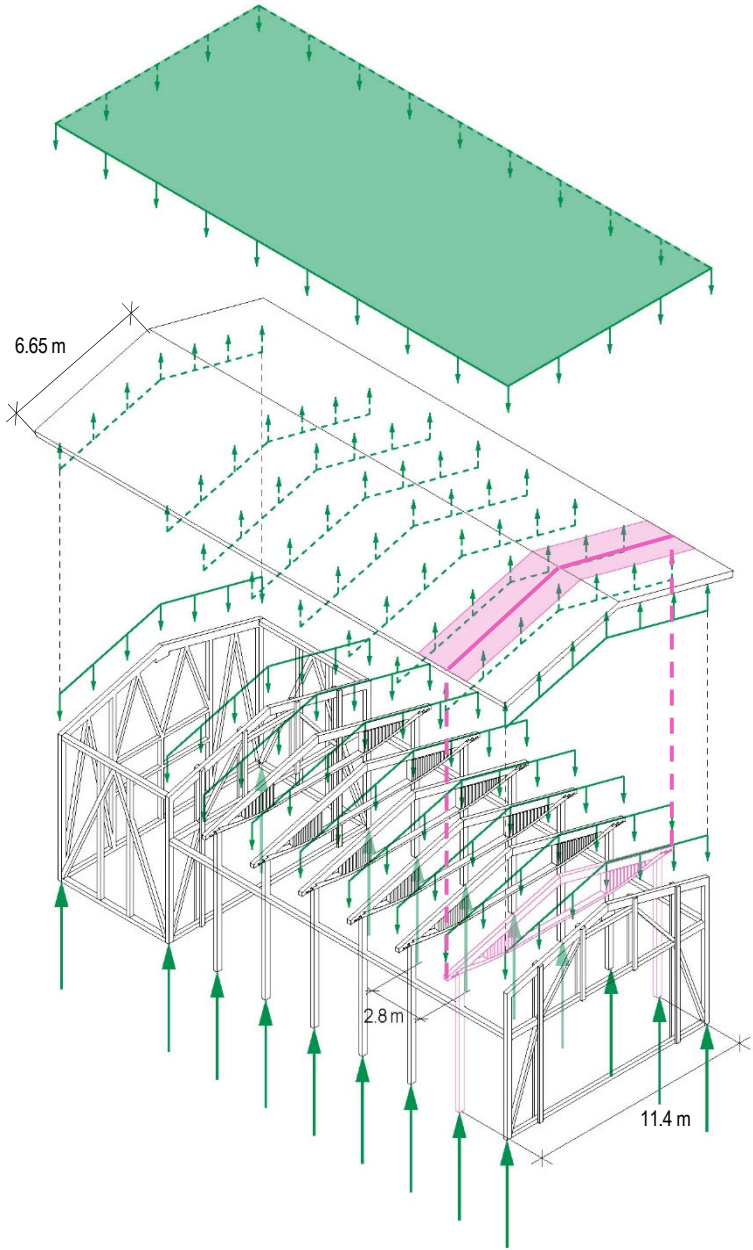
Vertikale Lasten

Vertical loads



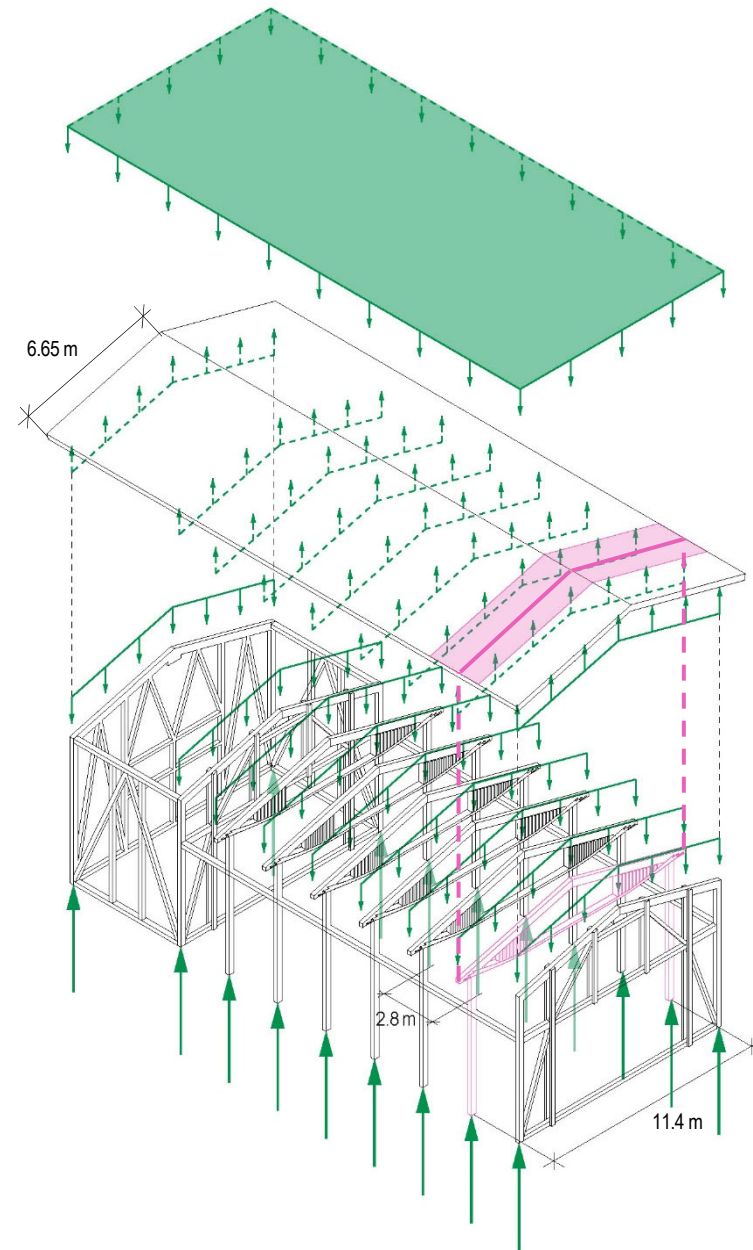
Vertikale Lasten

Vertical loads



Vertikale Lasten

Vertical loads



Timber (Fir)
 $\rho = 5 \text{ kN/m}^3$

Calculation of loads

Dead loads

Roof tributary area of one arch-cable: $2.8 \text{ m} \cdot 13.3 \text{ m} = 37.25 \text{ m}^2$

$$G_{\text{slab}} = \text{Roof sheeting} + \text{Planks} = 0.5 \text{ kN/m}^2 \cdot 37.25 \text{ m}^2 = 18.62 \text{ kN}$$

$$G_{\text{beam}} = 1.7 \text{ m}^3 \cdot 5 \text{ kN/m}^3 = 8.5 \text{ kN}$$

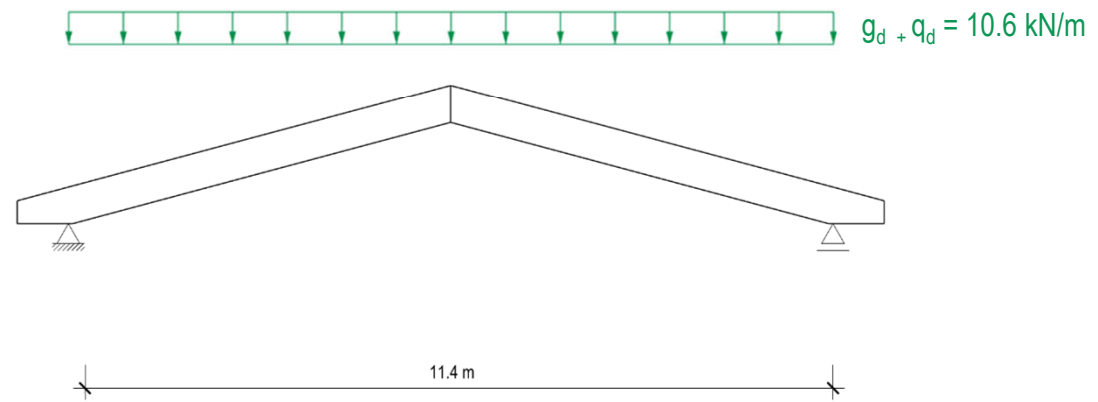
Live loads (snow)

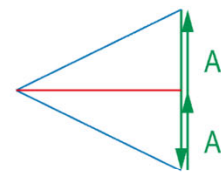
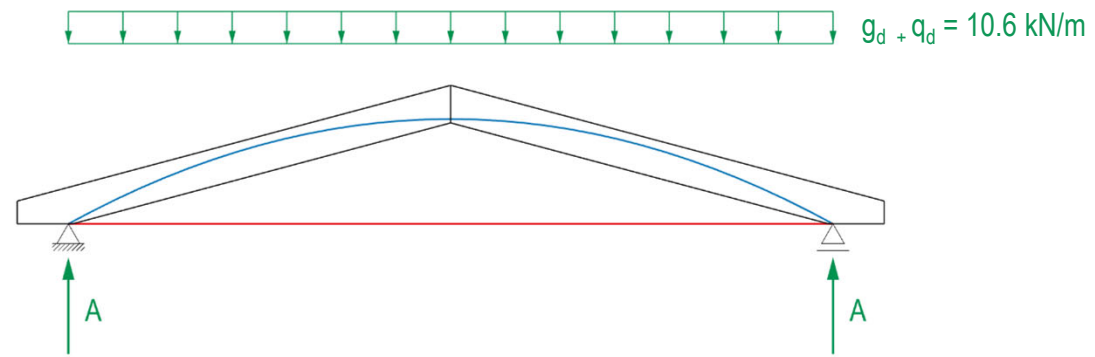
$$Q_{\text{snow}} = 1.5 \text{ kN/m}^2 \cdot 37.25 \text{ m}^2 = 55.87 \text{ kN}$$

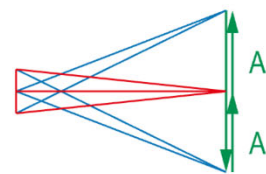
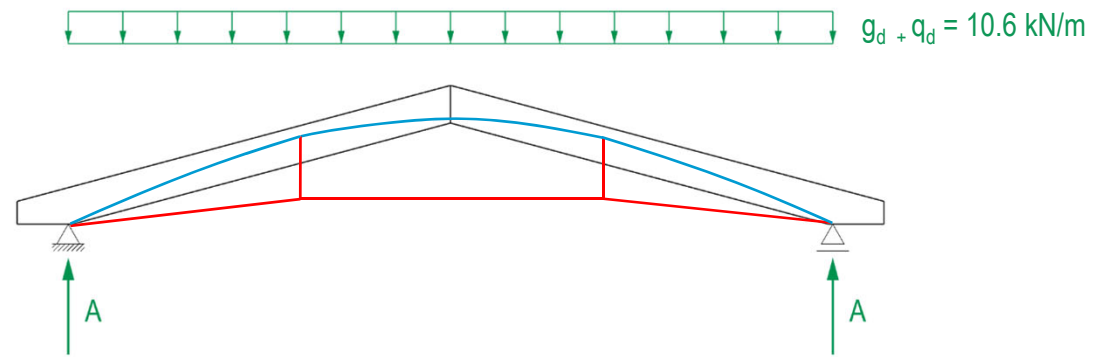
Total design load

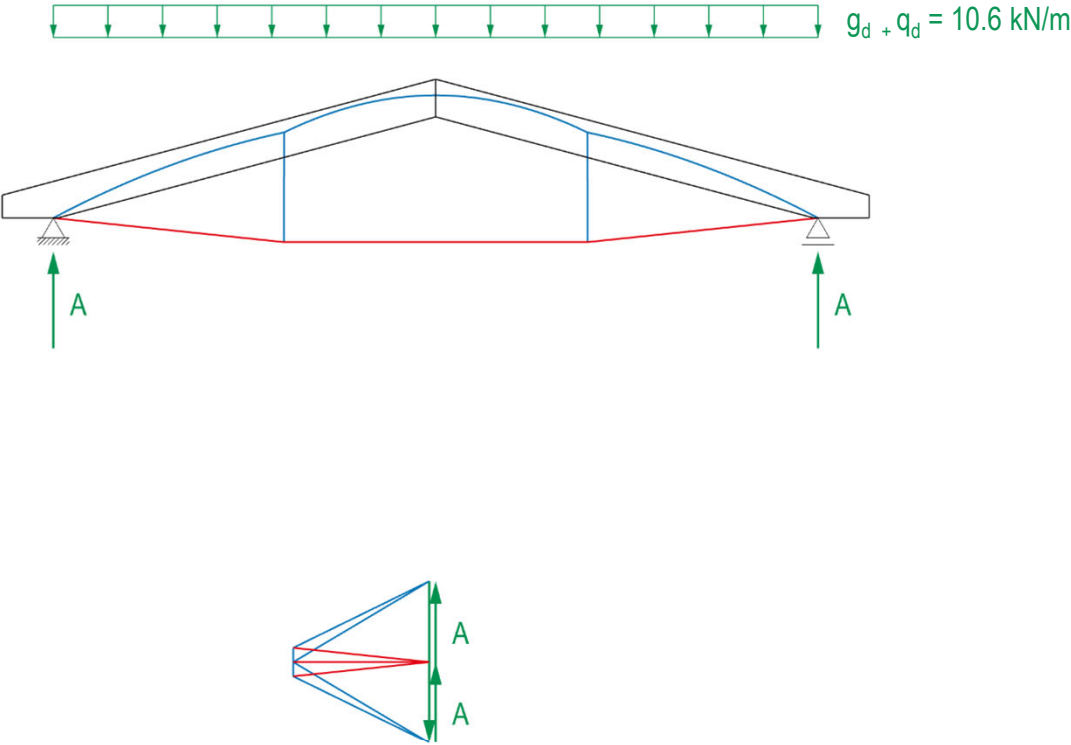
$$G_d + Q_d = 1.35 \cdot (18.62 \text{ kN} + 8.5 \text{ kN}) + 1.5 \cdot 55.87 \text{ kN} = 120.42 \text{ kN}$$

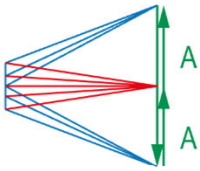
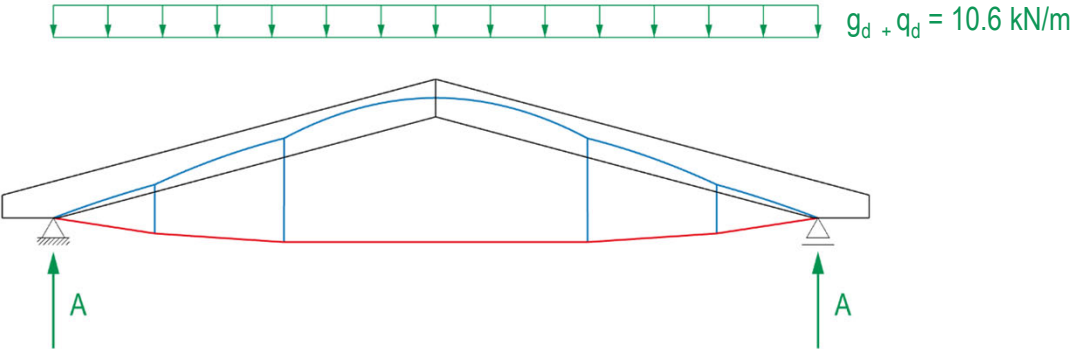
$$g_d + q_d = 120.42 \text{ kN} / 11.4 \text{ m} \approx 10.6 \text{ kN/m}$$

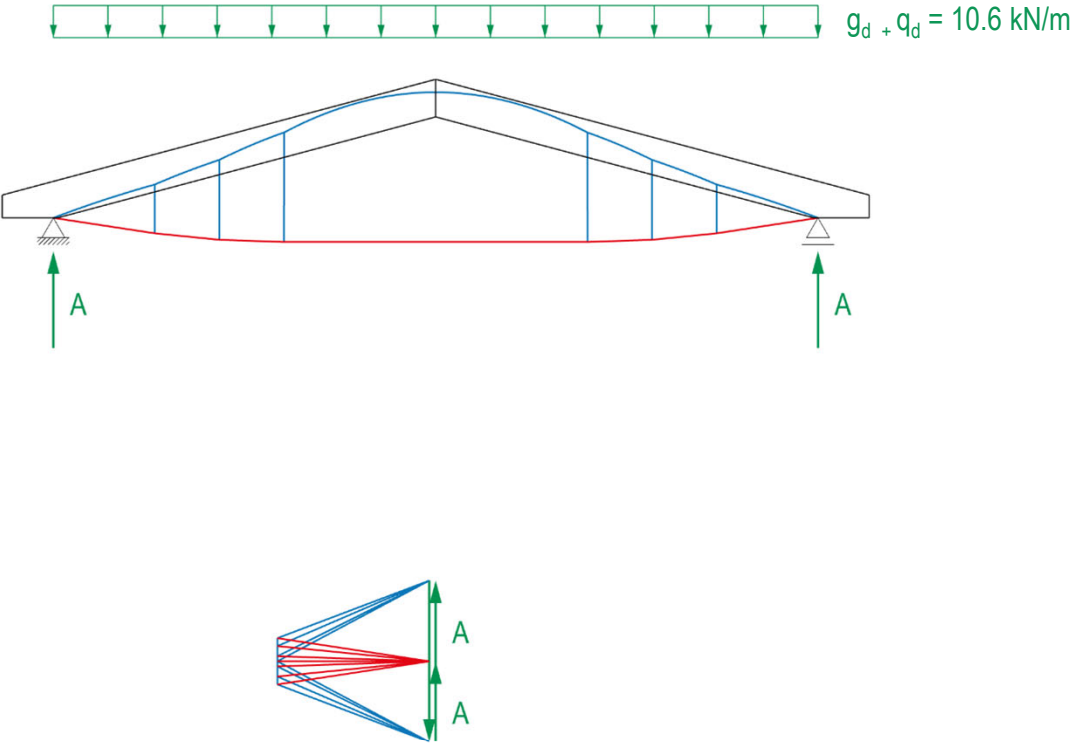


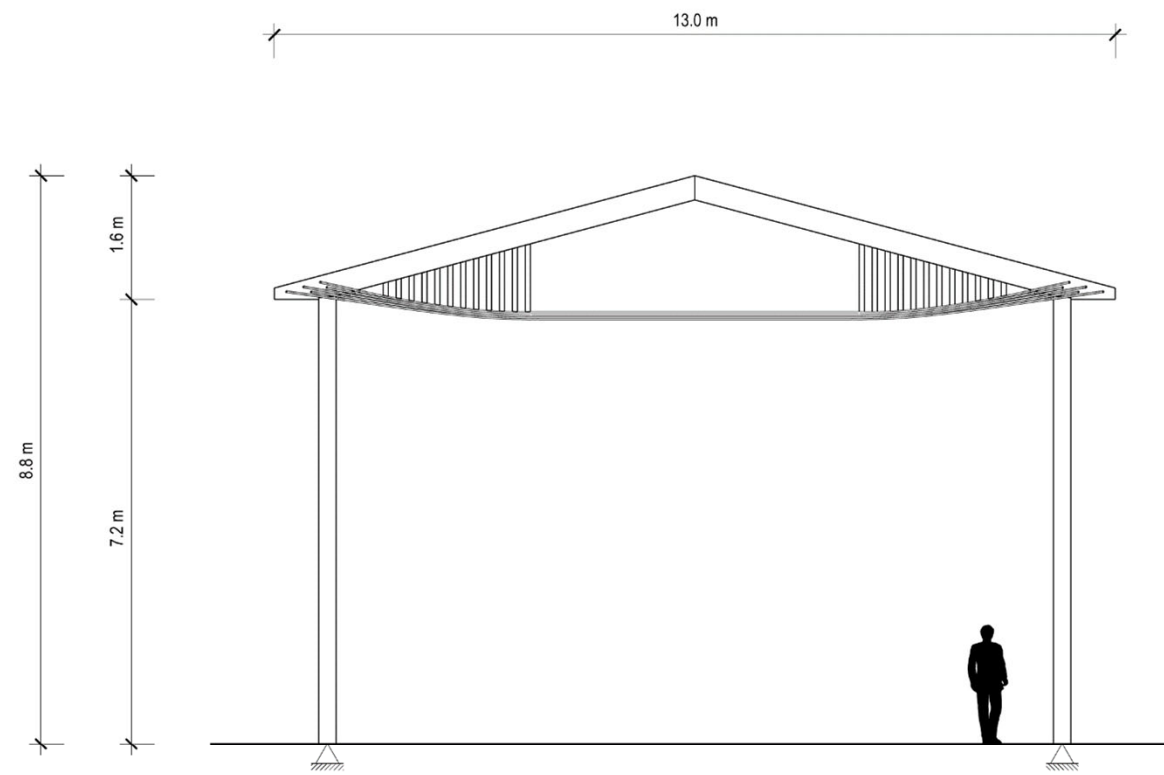








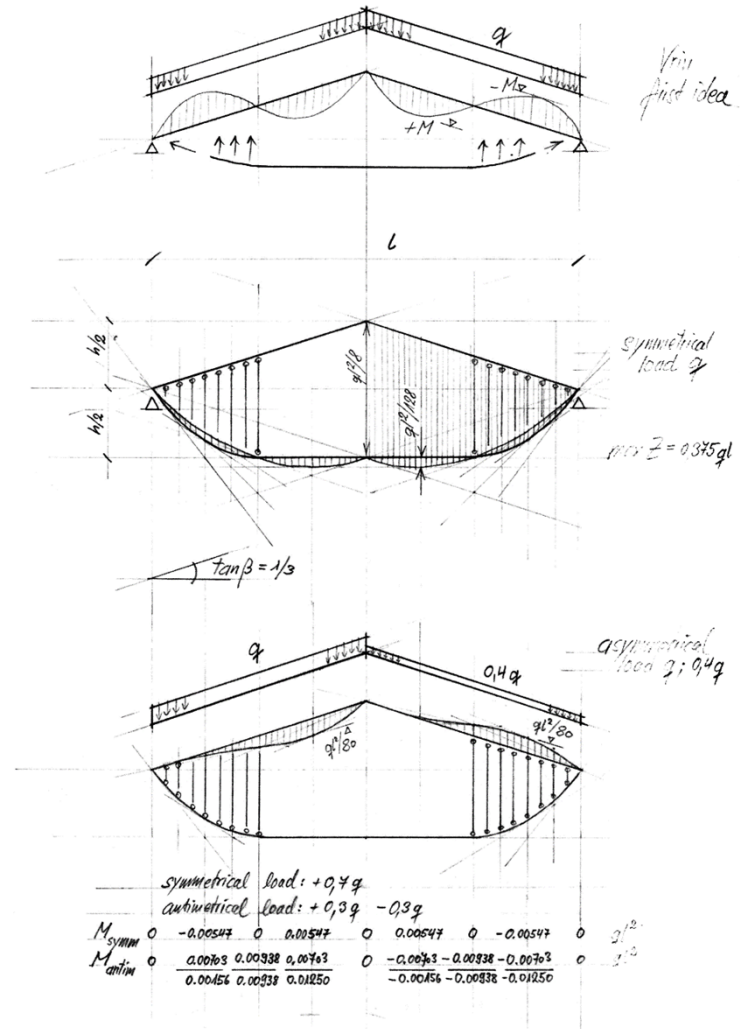
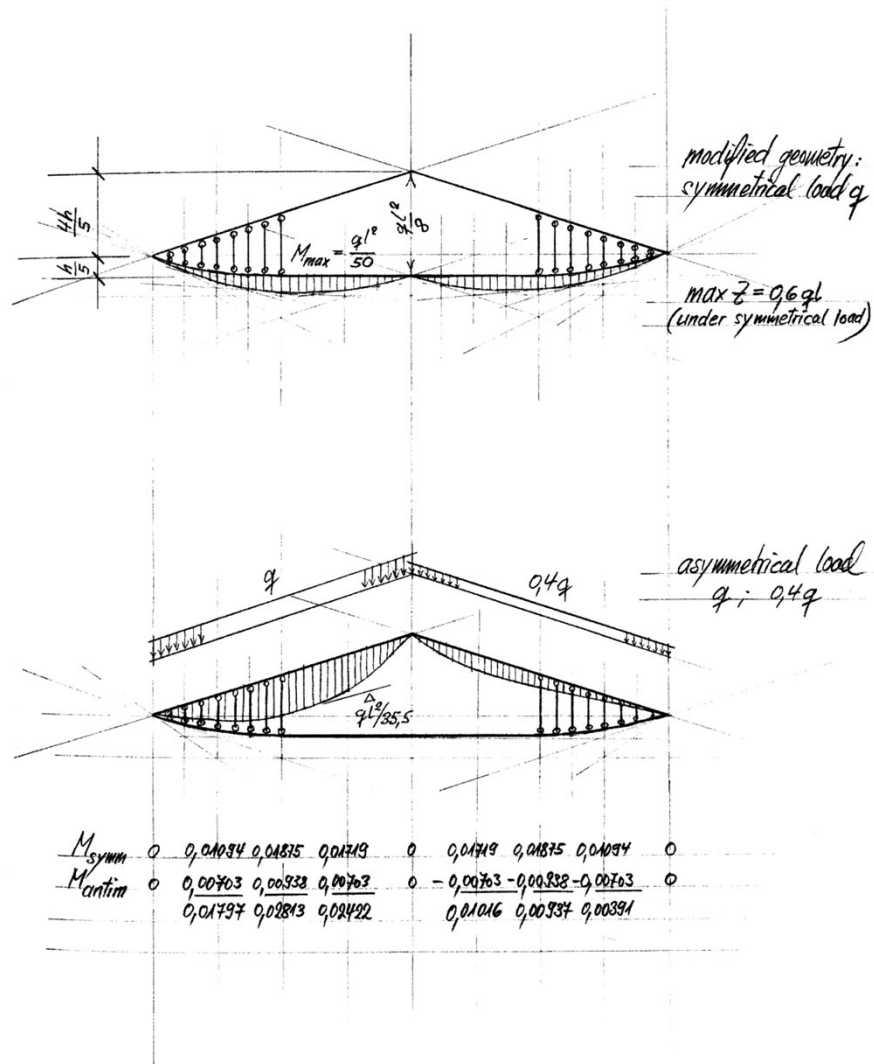




Vertikale Lasten

Vertical loads

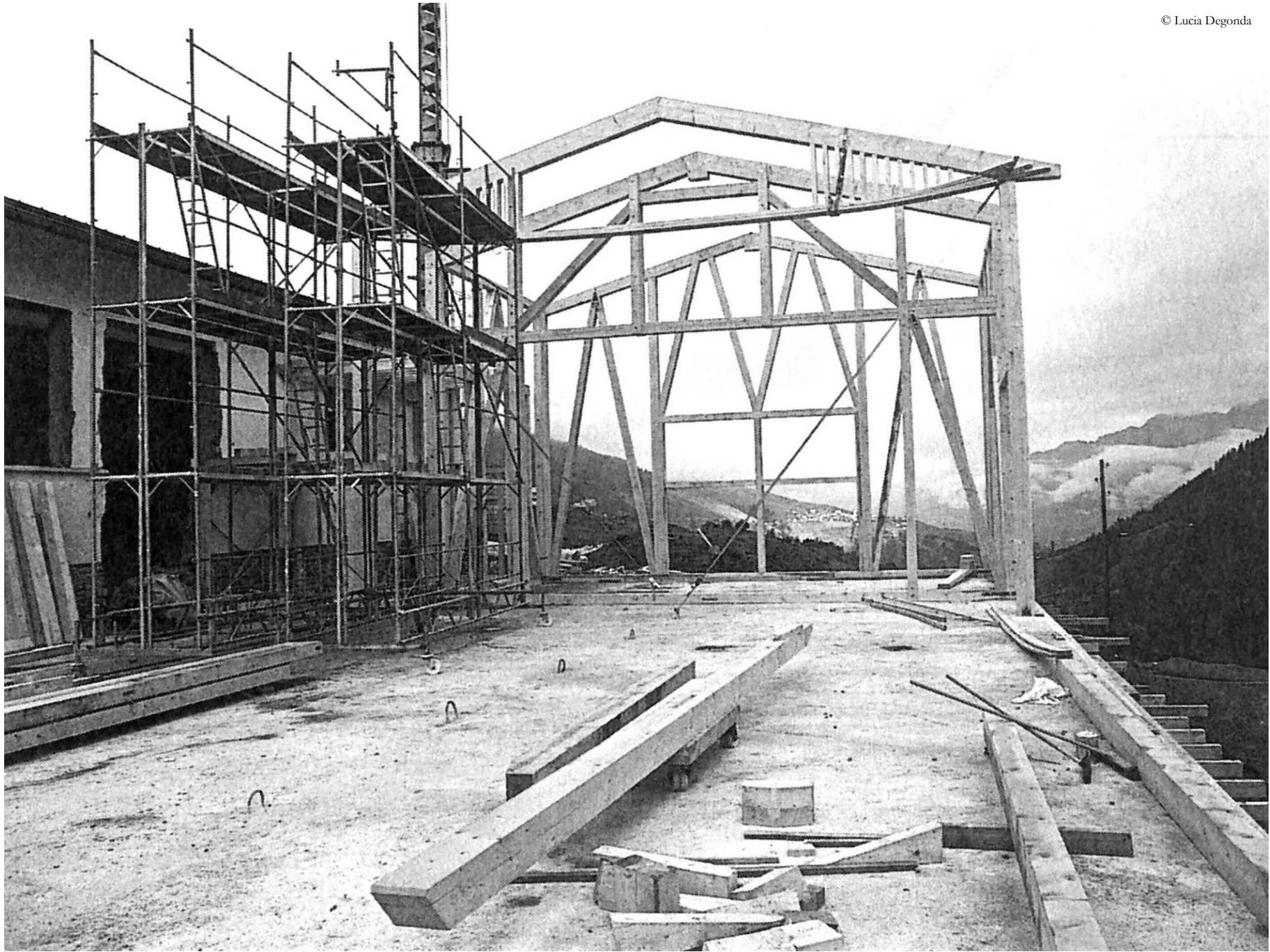
Case Study: Gym Vrin



Vertikale Lasten

Vertical loads

© Lucia Degonda





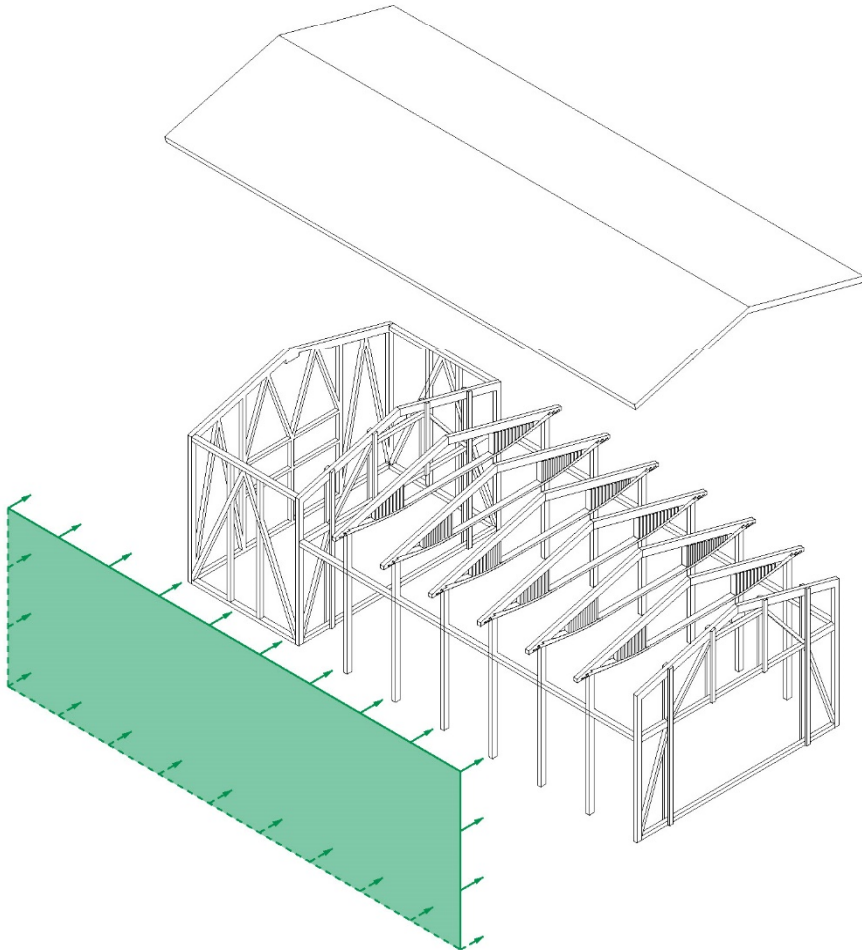
© Lucia Degonda



Horizontal Loads

Wind

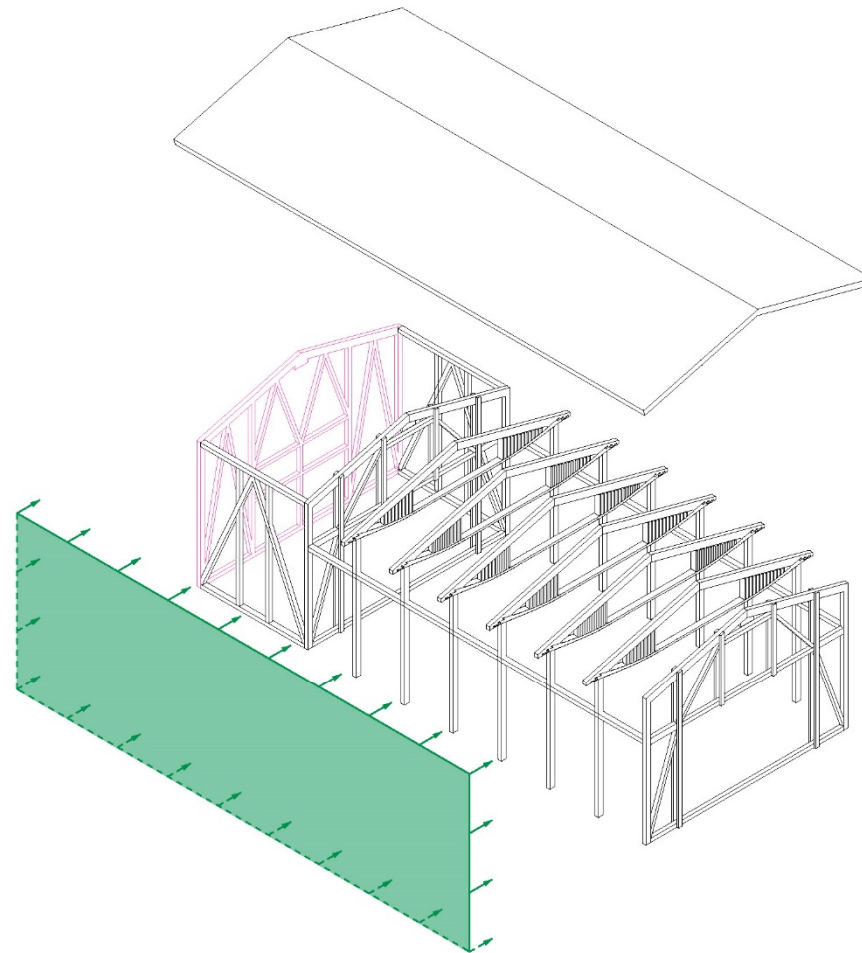
$$q_{wind} = 1.0 \text{ kN/m}^2$$



Horizontal Loads

Wind

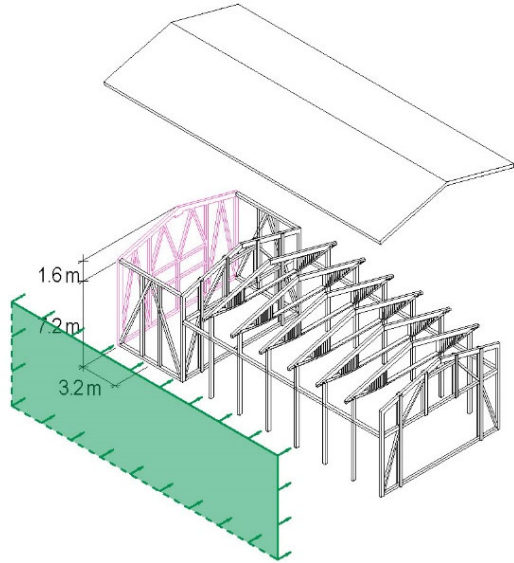
$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$



Horizontale Lasten

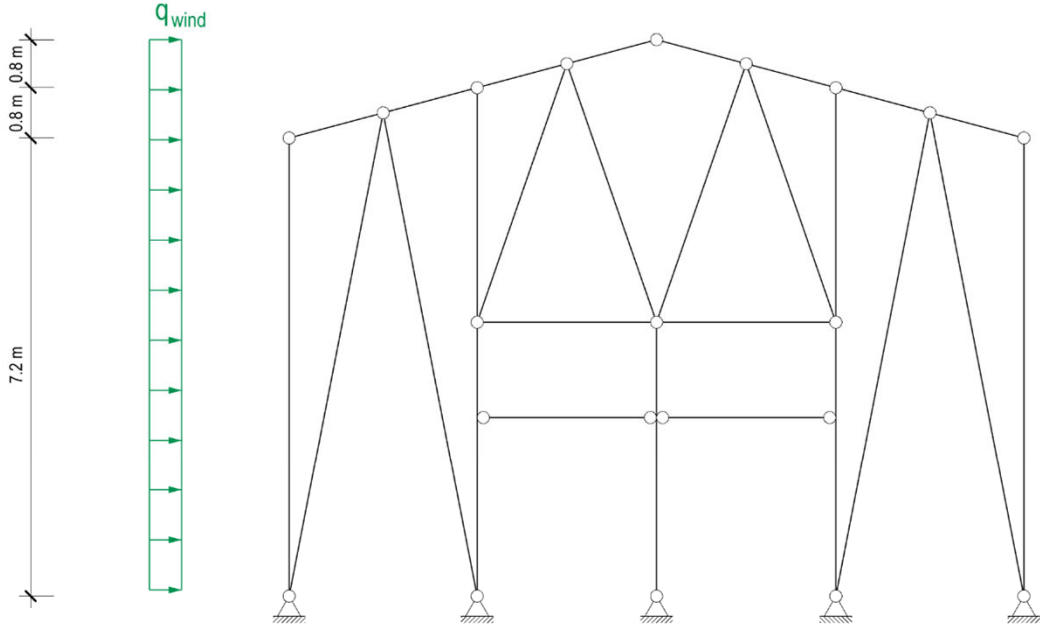
Horizontal loads

Case Study: Gym Vrin



Horizontal Loads

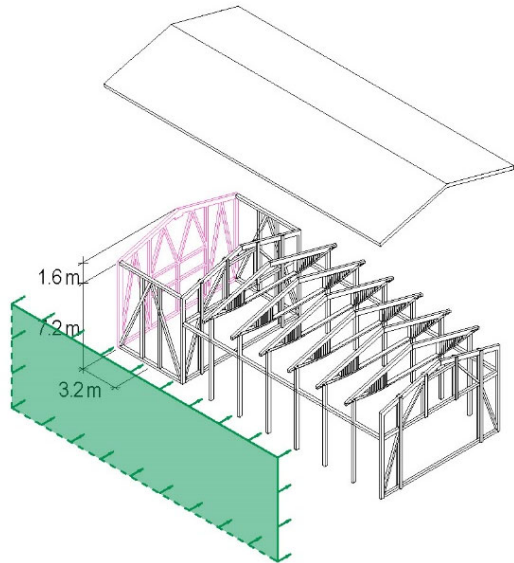
Wind
 $q_{wind} = 1.0 \text{ kN/m}^2$



Horizontale Lasten

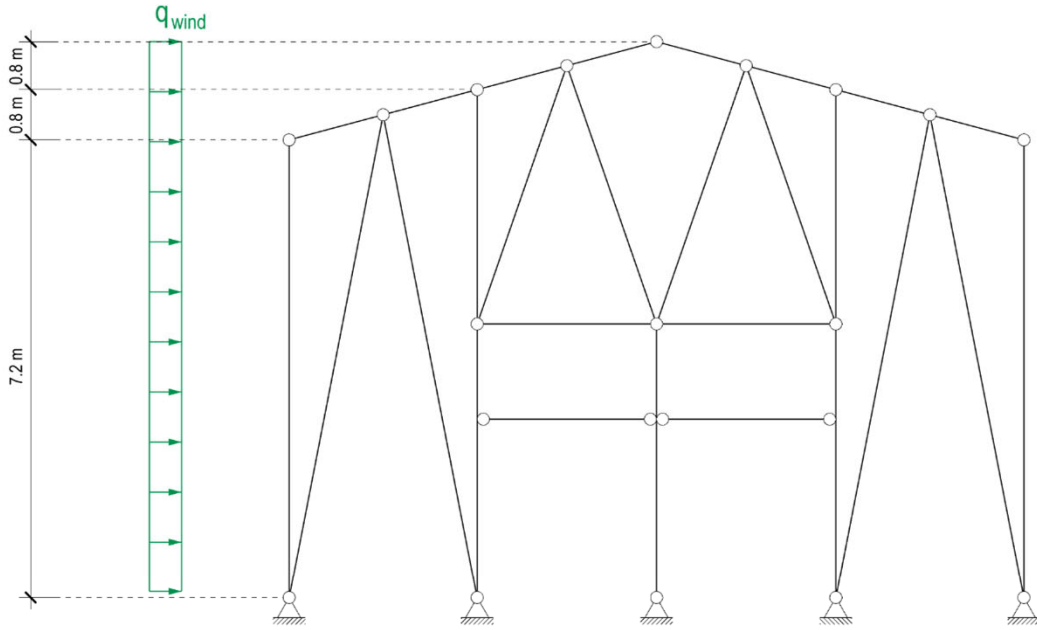
Horizontal loads

Case Study: Gym Vrin



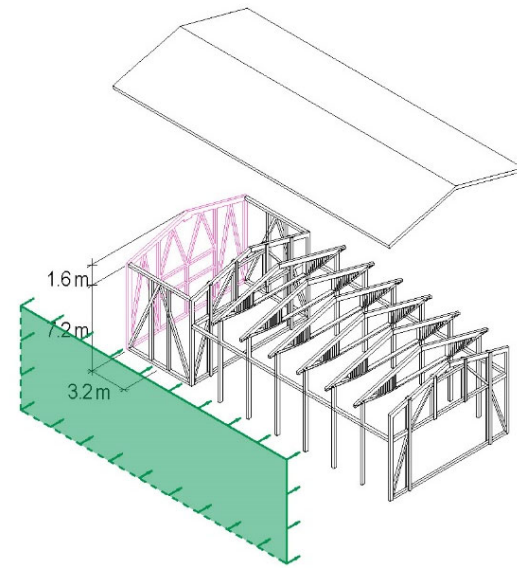
Horizontal Loads

Wind
 $q_{wind} = 1.0 \text{ kN/m}^2$



Horizontale Lasten

Horizontal loads



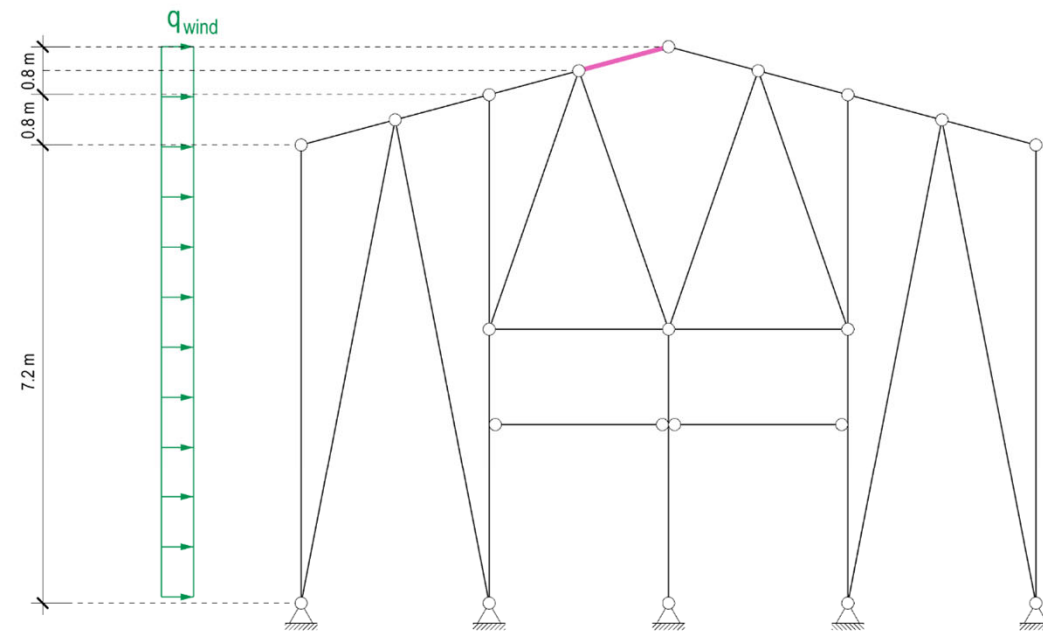
Horizontal Loads

Wind

$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$

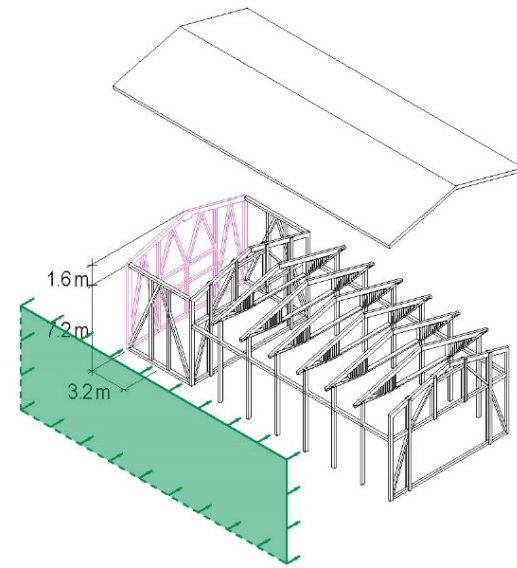
Tributary Areas

$$A_1 = (3.2 \text{ m} \cdot 0.8 \text{ m})/2 = 1.3 \text{ m}^2$$



Horizontale Lasten

Horizontal loads



Horizontal Loads

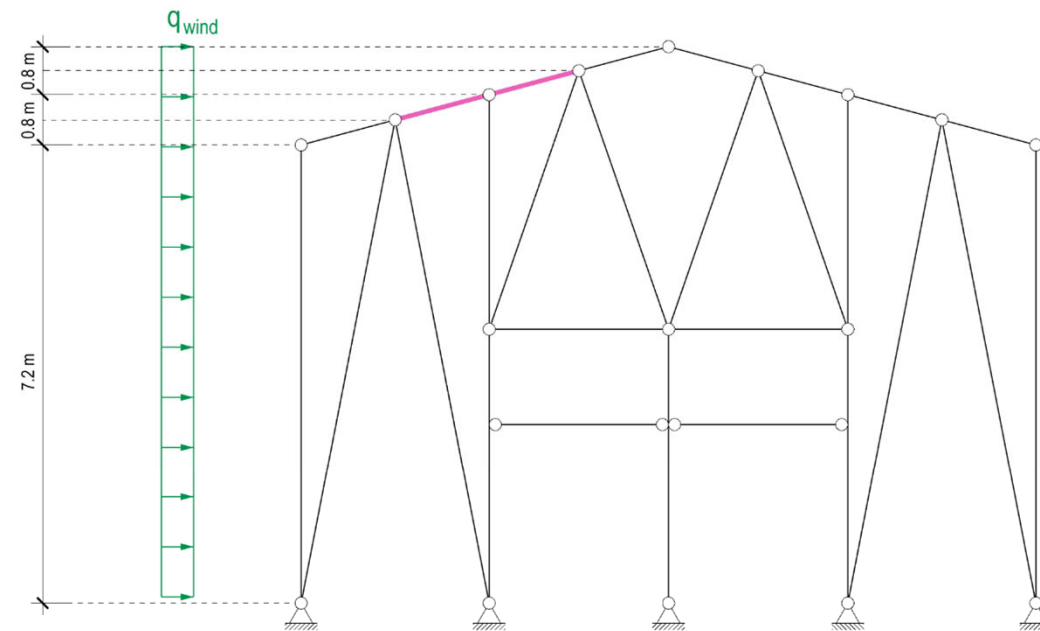
Wind

$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$

Tributary Areas

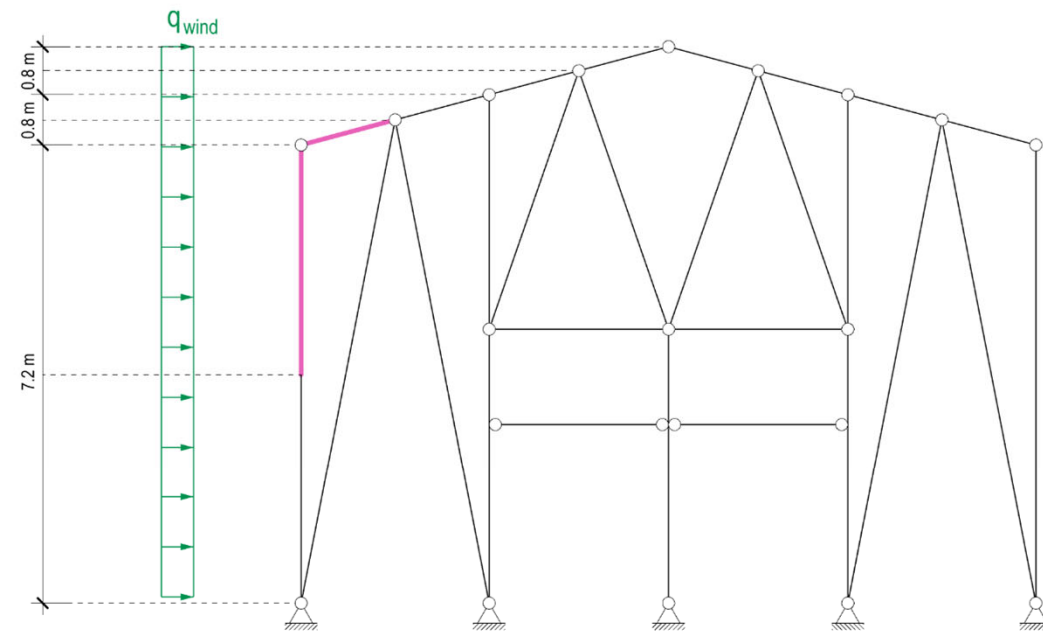
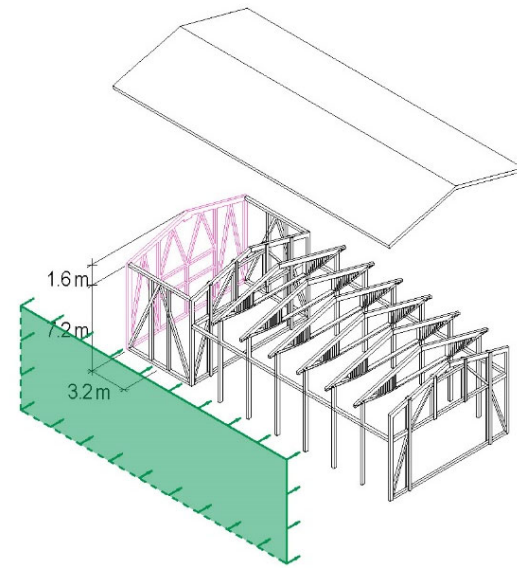
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Horizontale Lasten

Horizontal loads



Horizontal Loads

Wind

$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$

Tributary Areas

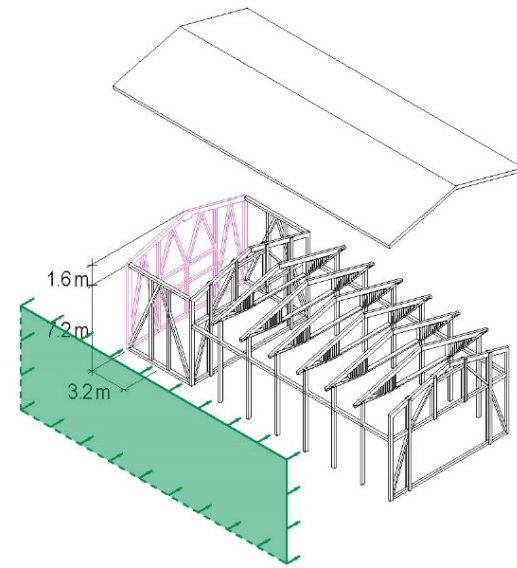
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$$A_3 = (3.2 \text{ m} \cdot (0.8 \text{ m} + 7.2 \text{ m}))/2 = 12.8 \text{ m}^2$$

Horizontale Lasten

Horizontal loads



Horizontal Loads

Wind

$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$

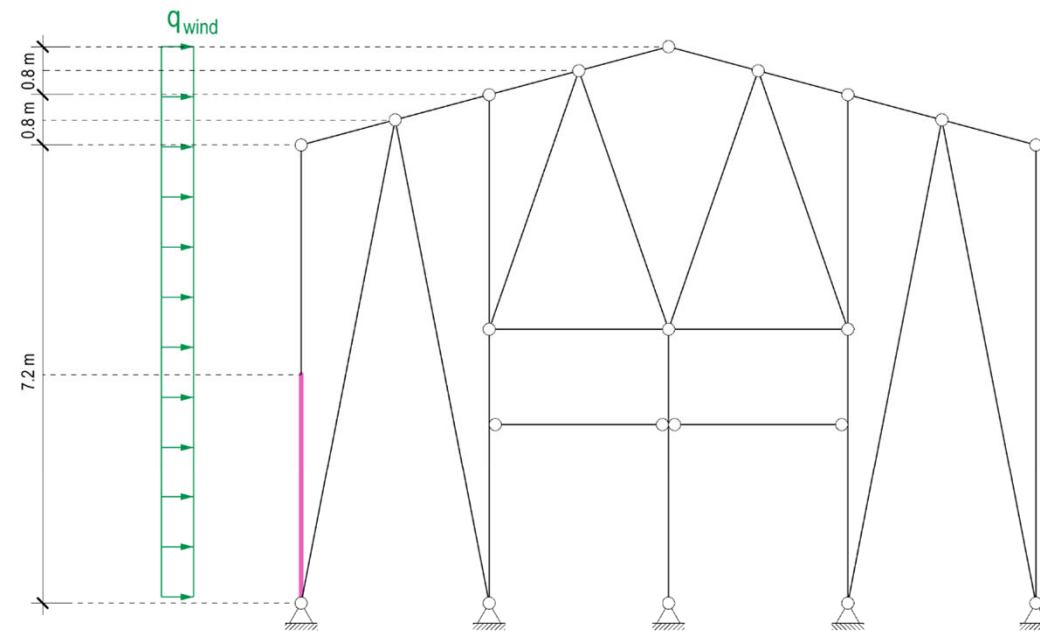
Tributary Areas

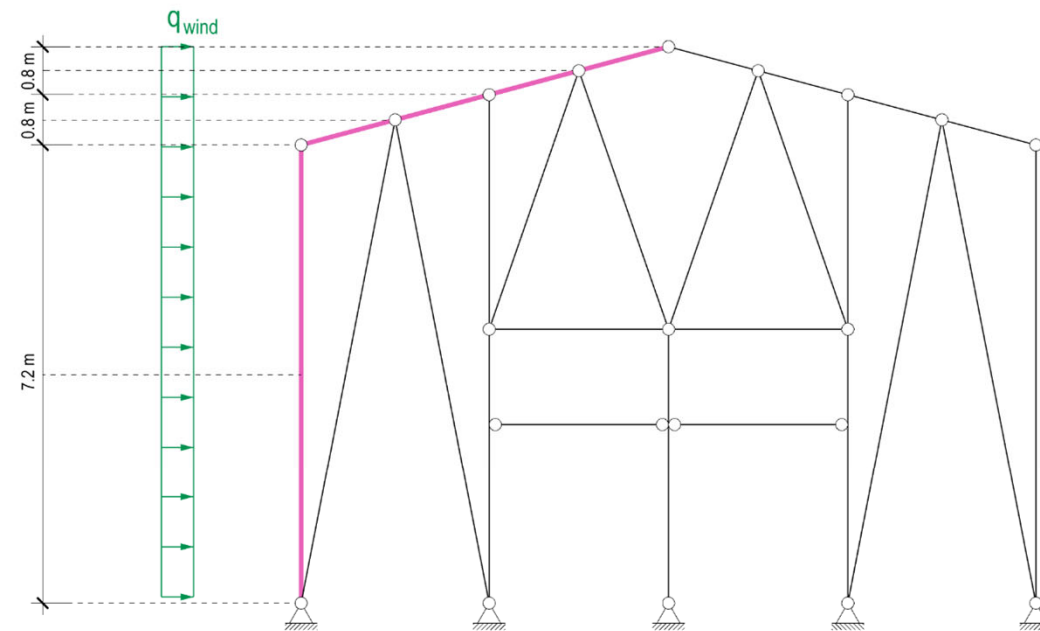
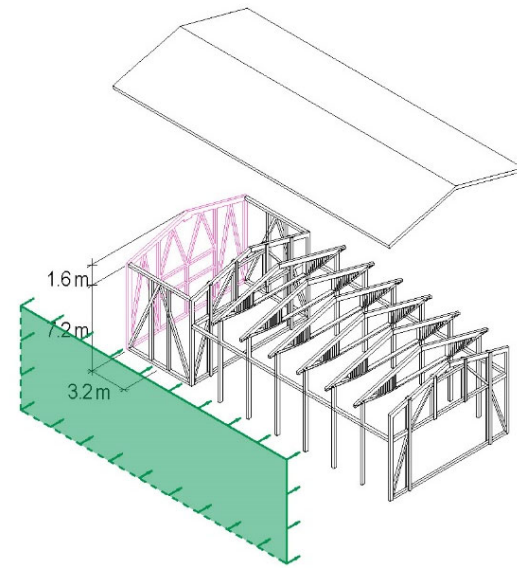
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$$A_3 = (3.2 \text{ m} \cdot (0.8 \text{ m} + 7.2 \text{ m}))/2 = 12.8 \text{ m}^2$$

$$A_4 = (3.2 \text{ m} \cdot 7.2 \text{ m})/2 = 11.5 \text{ m}^2$$





Horizontal Loads

Wind

$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$

Tributary Areas

$$A_1 = (3.2 \text{ m} \cdot 0.8 \text{ m})/2 = 1.3 \text{ m}^2$$

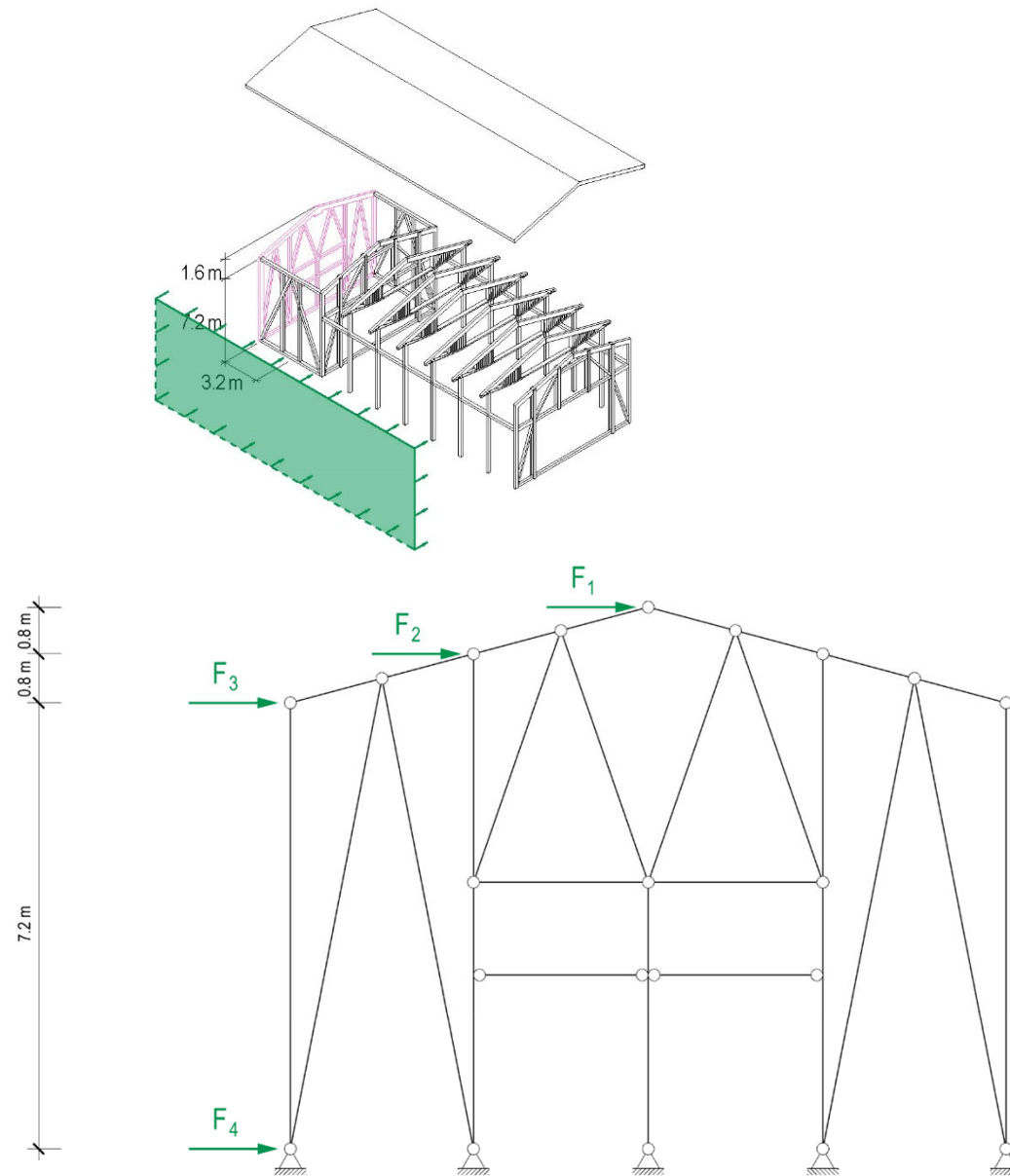
$$A_2 = (3.2 \text{ m} \cdot (0.8 \text{ m} + 0.8 \text{ m}))/2 = 2.6 \text{ m}^2$$

$$A_3 = (3.2 \text{ m} \cdot (0.8 \text{ m} + 7.2 \text{ m}))/2 = 12.8 \text{ m}^2$$

$$A_4 = (3.2 \text{ m} \cdot 7.2 \text{ m})/2 = 11.5 \text{ m}^2$$

Horizontale Lasten

Horizontal loads



Horizontal Loads

Wind

$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$

Tributary Areas

$$A_1 = (3.2 \text{ m} \cdot 0.8 \text{ m})/2 = 1.3 \text{ m}^2$$

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$$A_4 = (3.2 \text{ m} \cdot 7.2 \text{ m})/2 = 11.5 \text{ m}^2$$

Wind Forces

$$F_1 = q_{\text{wind}} \cdot A_1 = 1.3 \text{ kN}$$

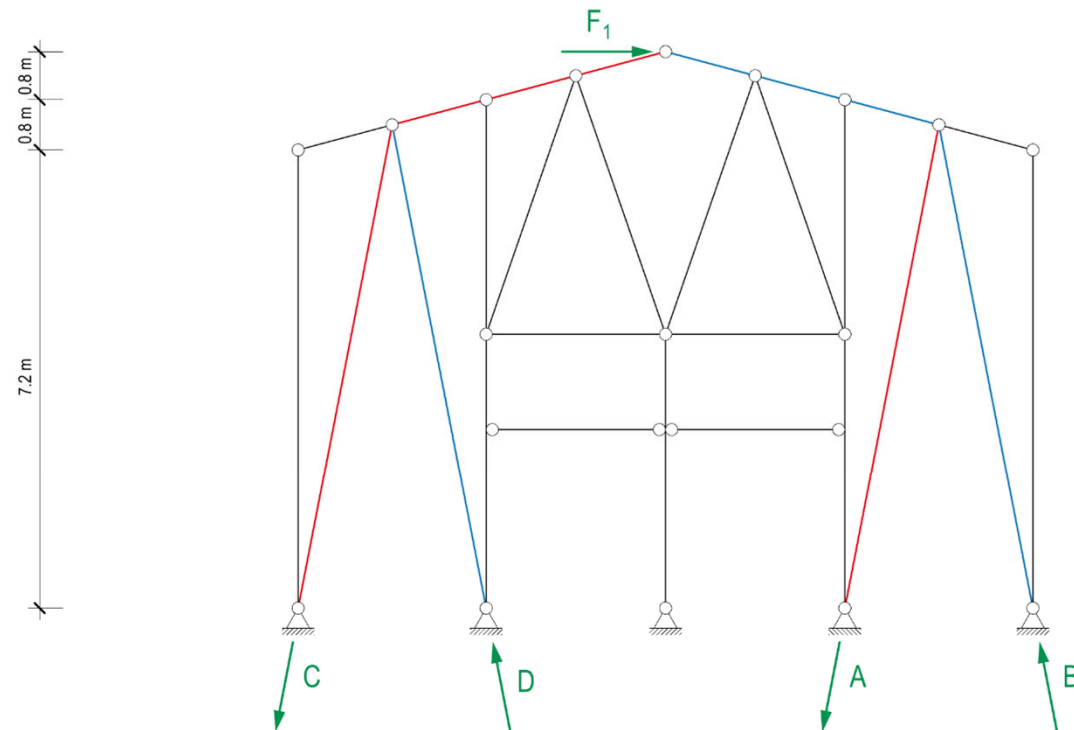
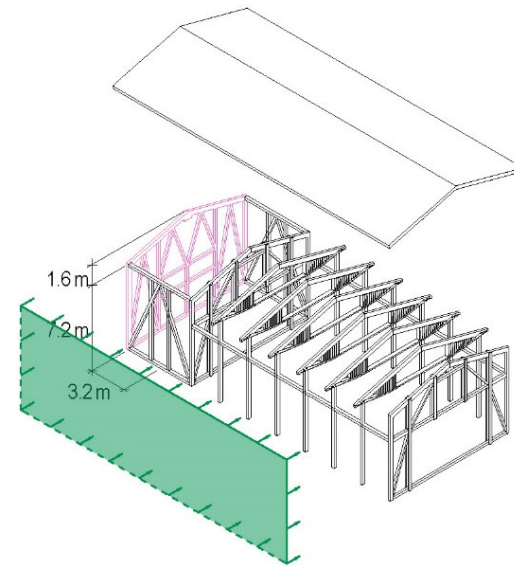
$$F_2 = q_{\text{wind}} \cdot A_2 = 2.6 \text{ kN}$$

$$F_3 = q_{\text{wind}} \cdot A_3 = 12.8 \text{ kN}$$

$$F_4 = q_{\text{wind}} \cdot A_4 = 11.5 \text{ kN}$$

Horizontale Lasten

Horizontal loads



Horizontal Loads

Wind

$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$

Tributary Areas

$$A_1 = (3.2 \text{ m} \cdot 0.8 \text{ m})/2 = 1.3 \text{ m}^2$$

$$A_2 = (3.2 \text{ m} \cdot (0.8 \text{ m} + 0.8 \text{ m}))/2 = 2.6 \text{ m}^2$$

$$A_3 = (3.2 \text{ m} \cdot (0.8 \text{ m} + 7.2 \text{ m}))/2 = 12.8 \text{ m}^2$$

$$A_4 = (3.2 \text{ m} \cdot 7.2 \text{ m})/2 = 11.5 \text{ m}^2$$

Wind Forces

$$F_1 = q_{\text{wind}} \cdot A_1 = 1.3 \text{ kN}$$

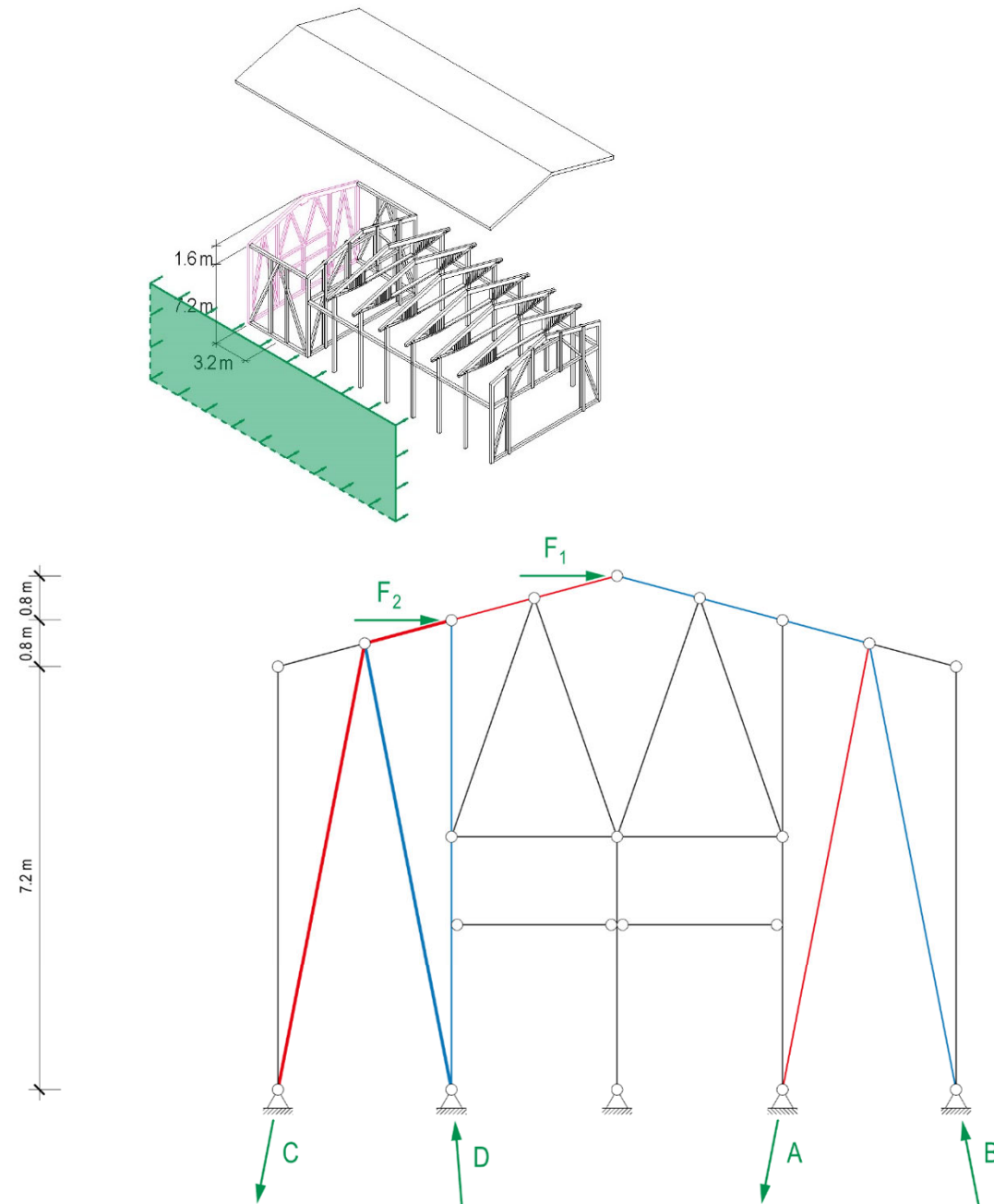
$$F_2 = q_{\text{wind}} \cdot A_2 = 2.6 \text{ kN}$$

$$F_3 = q_{\text{wind}} \cdot A_3 = 12.8 \text{ kN}$$

$$F_4 = q_{\text{wind}} \cdot A_4 = 11.5 \text{ kN}$$

Horizontale Lasten

Horizontal loads



Horizontal Loads

Wind

$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$

Tributary Areas

$$A_1 = (3.2 \text{ m} \cdot 0.8 \text{ m})/2 = 1.3 \text{ m}^2$$

$$A_2 = (3.2 \text{ m} \cdot (0.8 \text{ m} + 0.8 \text{ m}))/2 = 2.6 \text{ m}^2$$

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$$A_4 = (3.2 \text{ m} \cdot 7.2 \text{ m})/2 = 11.5 \text{ m}^2$$

Wind Forces

$$F_1 = q_{\text{wind}} \cdot A_1 = 1.3 \text{ kN}$$

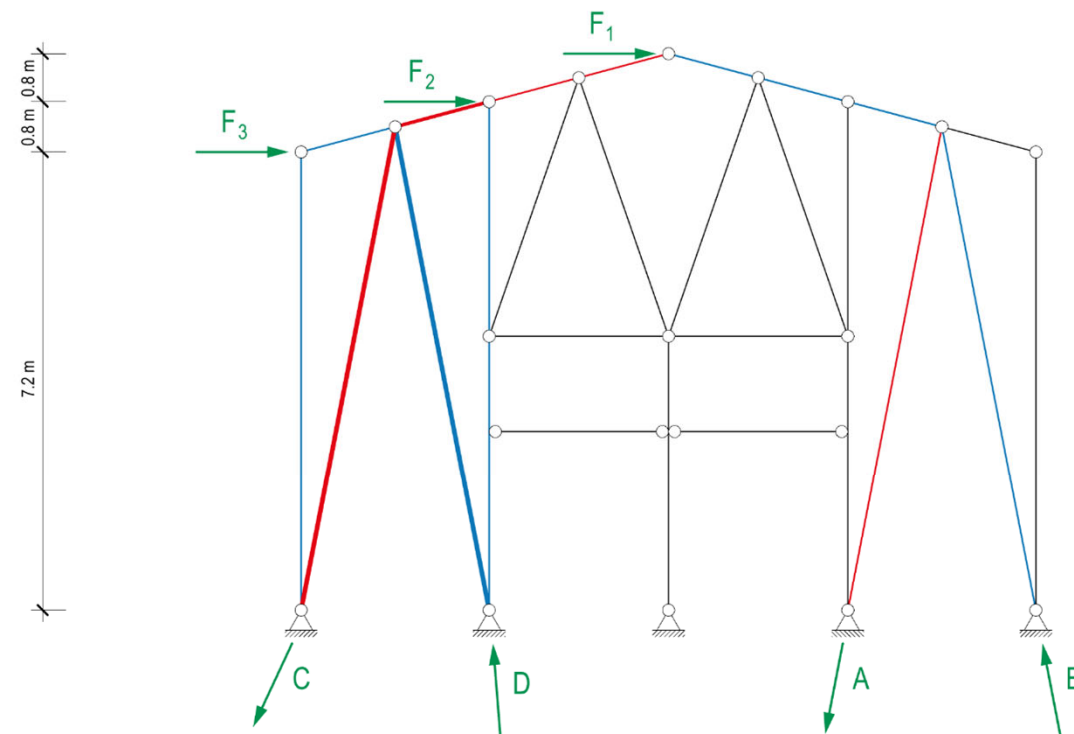
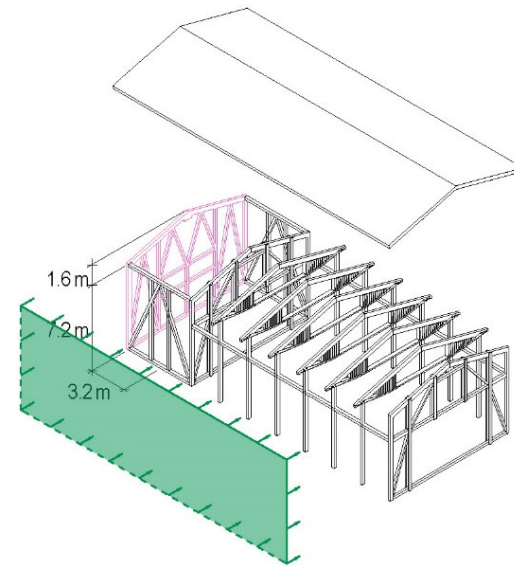
$$F_2 = q_{\text{wind}} \cdot A_2 = 2.6 \text{ kN}$$

$$F_3 = q_{\text{wind}} \cdot A_3 = 12.8 \text{ kN}$$

$$F_4 = q_{\text{wind}} \cdot A_4 = 11.5 \text{ kN}$$

Horizontale Lasten

Horizontal loads



Horizontal Loads

Wind

$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$

Tributary Areas

$$A_1 = (3.2 \text{ m} \cdot 0.8 \text{ m})/2 = 1.3 \text{ m}^2$$

$$A_2 = (3.2 \text{ m} \cdot (0.8 \text{ m} + 0.8 \text{ m}))/2 = 2.6 \text{ m}^2$$

$$A_3 = (3.2 \text{ m} \cdot (0.8 \text{ m} + 7.2 \text{ m}))/2 = 12.8 \text{ m}^2$$

$$A_4 = (3.2 \text{ m} \cdot 7.2 \text{ m})/2 = 11.5 \text{ m}^2$$

Wind Forces

$$F_1 = q_{\text{wind}} \cdot A_1 = 1.3 \text{ kN}$$

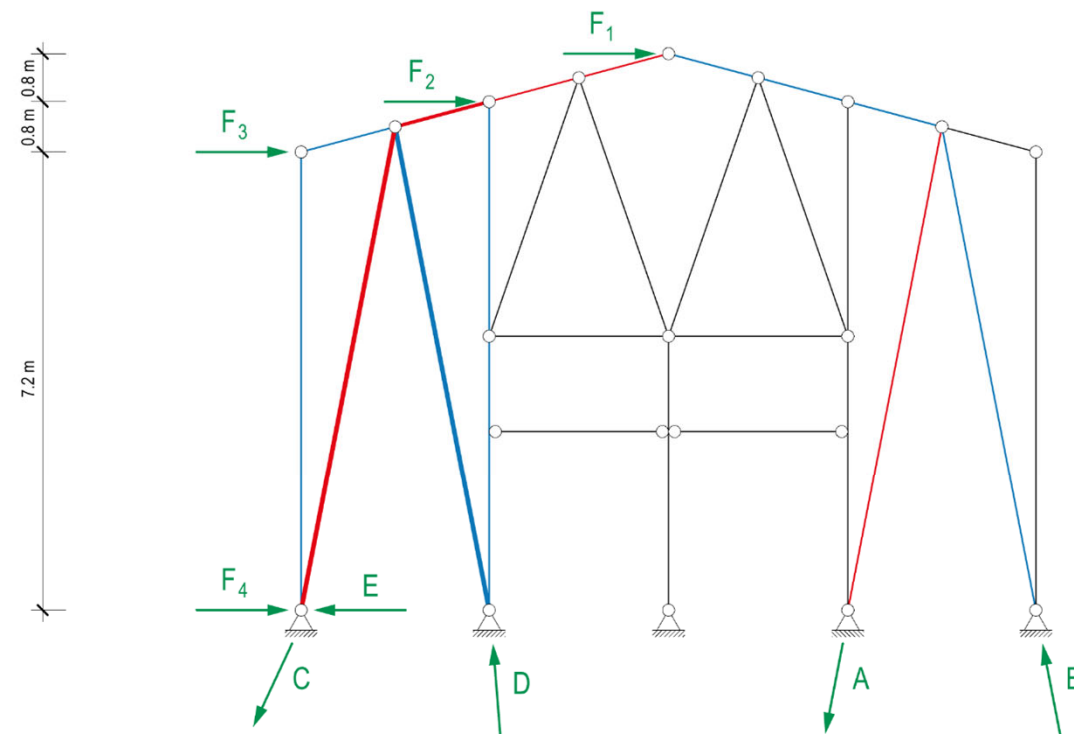
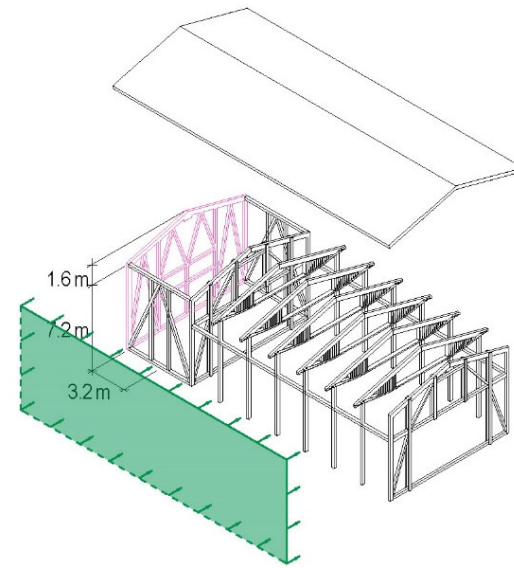
$$F_2 = q_{\text{wind}} \cdot A_2 = 2.6 \text{ kN}$$

$$F_3 = q_{\text{wind}} \cdot A_3 = 12.8 \text{ kN}$$

$$F_4 = q_{\text{wind}} \cdot A_4 = 11.5 \text{ kN}$$

Horizontale Lasten

Horizontal loads



Horizontal Loads

Wind

$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$

Tributary Areas

$$A_1 = (3.2 \text{ m} \cdot 0.8 \text{ m})/2 = 1.3 \text{ m}^2$$

$$A_2 = (3.2 \text{ m} \cdot (0.8 \text{ m} + 0.8 \text{ m}))/2 = 2.6 \text{ m}^2$$

$$A_3 = (3.2 \text{ m} \cdot (0.8 \text{ m} + 7.2 \text{ m}))/2 = 12.8 \text{ m}^2$$

$$A_4 = (3.2 \text{ m} \cdot 7.2 \text{ m})/2 = 11.5 \text{ m}^2$$

Wind Forces

$$F_1 = q_{\text{wind}} \cdot A_1 = 1.3 \text{ kN}$$

$$F_2 = q_{\text{wind}} \cdot A_2 = 2.6 \text{ kN}$$

$$F_3 = q_{\text{wind}} \cdot A_3 = 12.8 \text{ kN}$$

$$F_4 = q_{\text{wind}} \cdot A_4 = 11.5 \text{ kN}$$

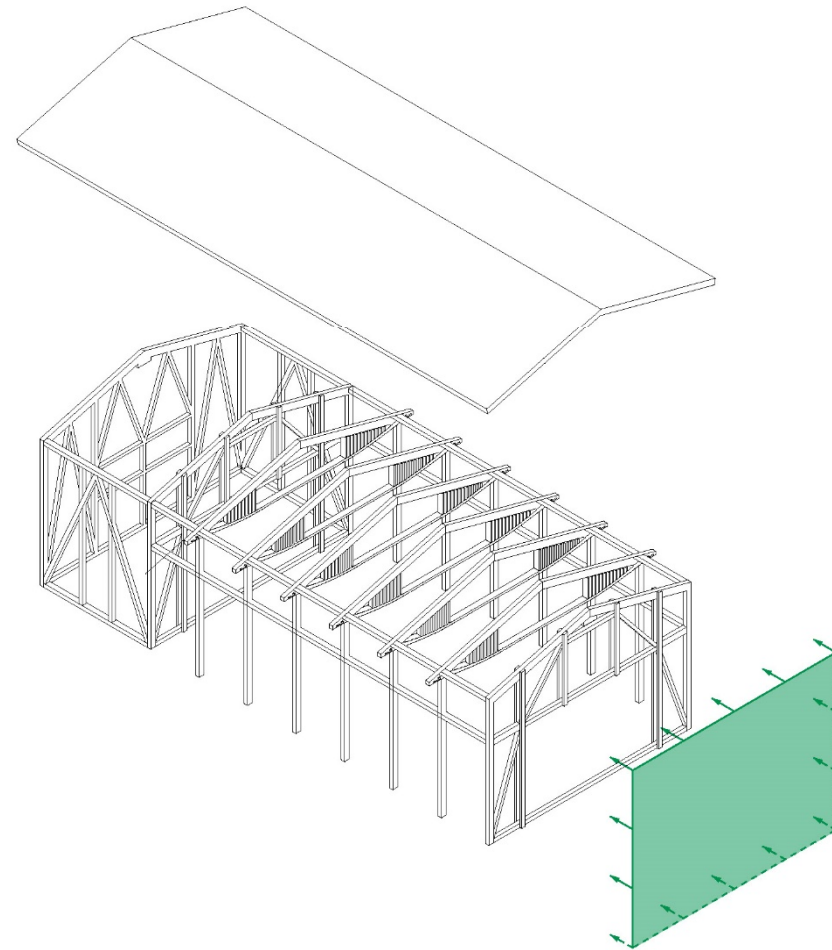
Horizontale Lasten

Horizontal loads

Horizontal Loads

Wind

$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$



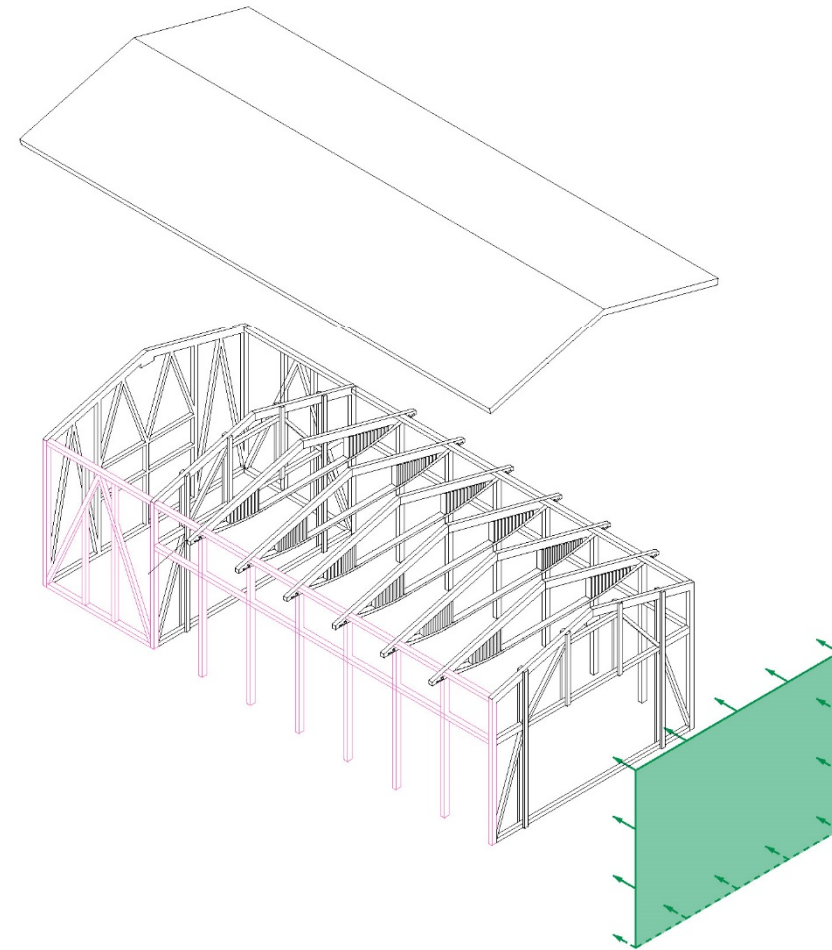
Horizontale Lasten

Horizontal loads

Horizontal Loads

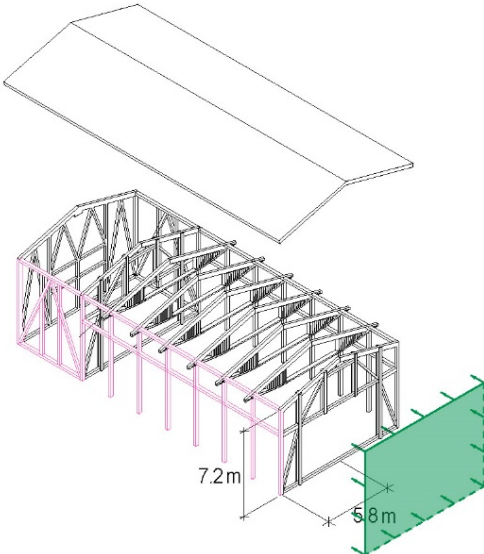
Wind

$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$



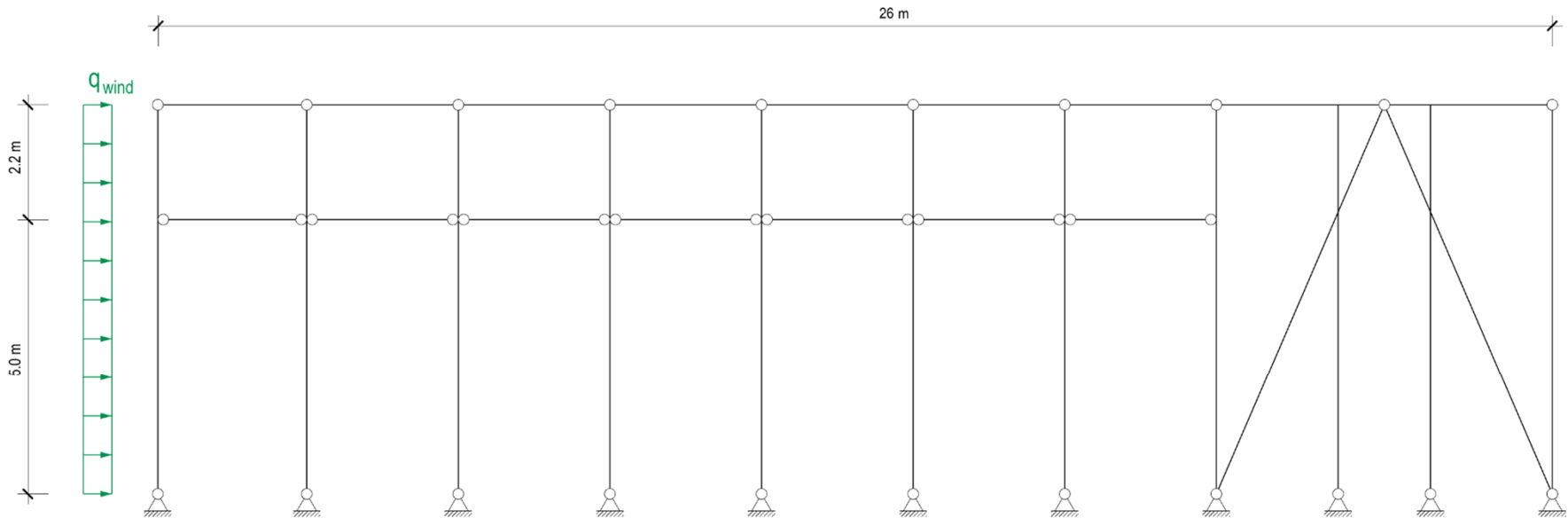
Horizontale Lasten

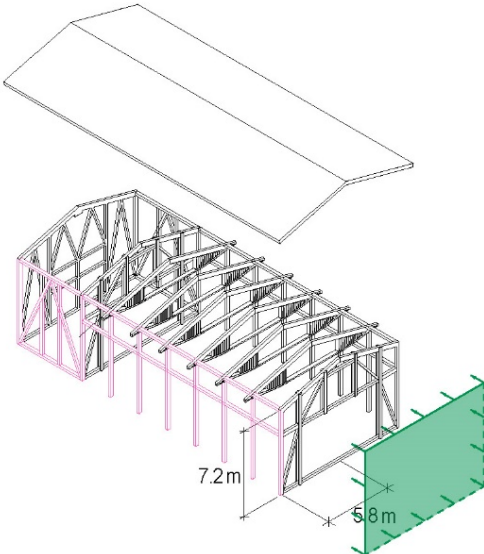
Horizontal loads



Horizontal Loads

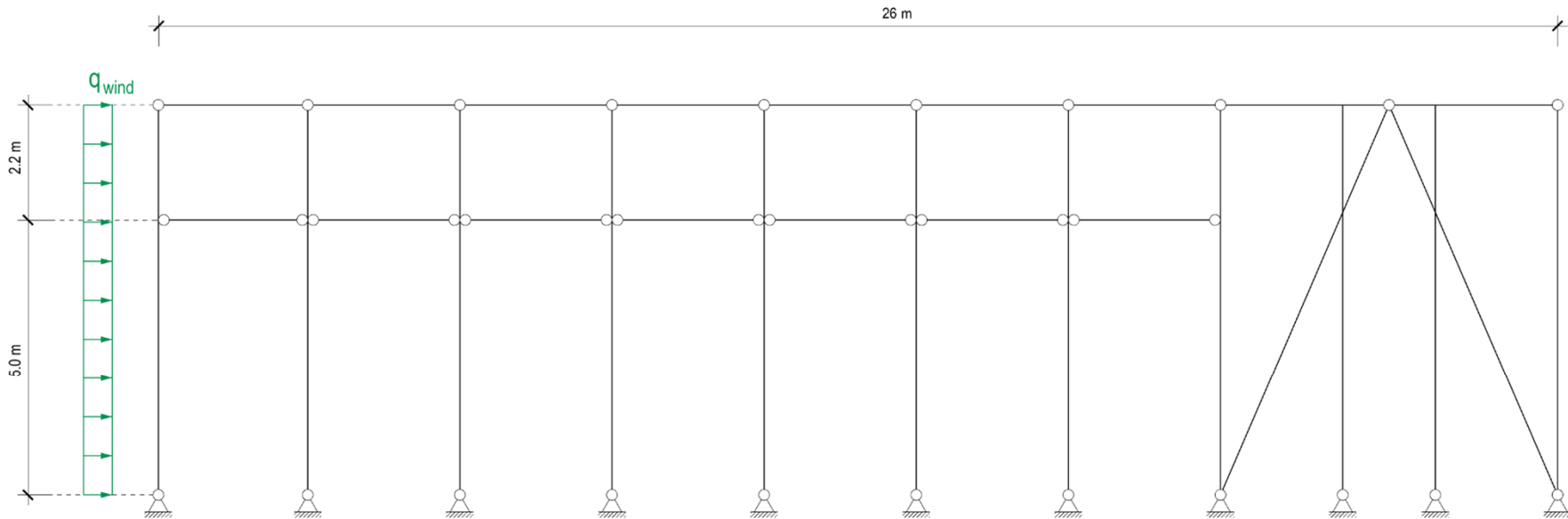
Wind
 $q_{wind} = 1.0 \text{ kN/m}^2$

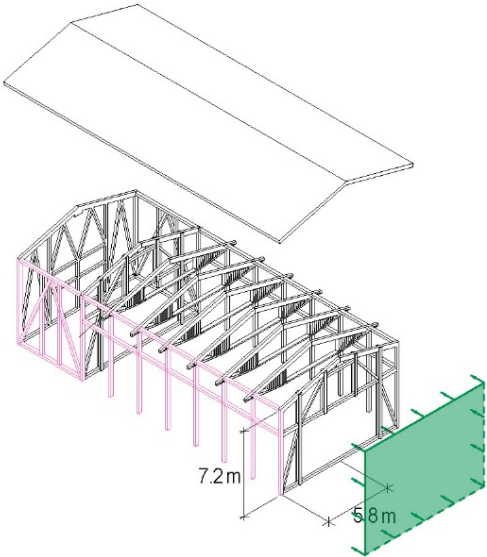




Horizontal Loads

Wind
 $q_{wind} = 1.0 \text{ kN/m}^2$





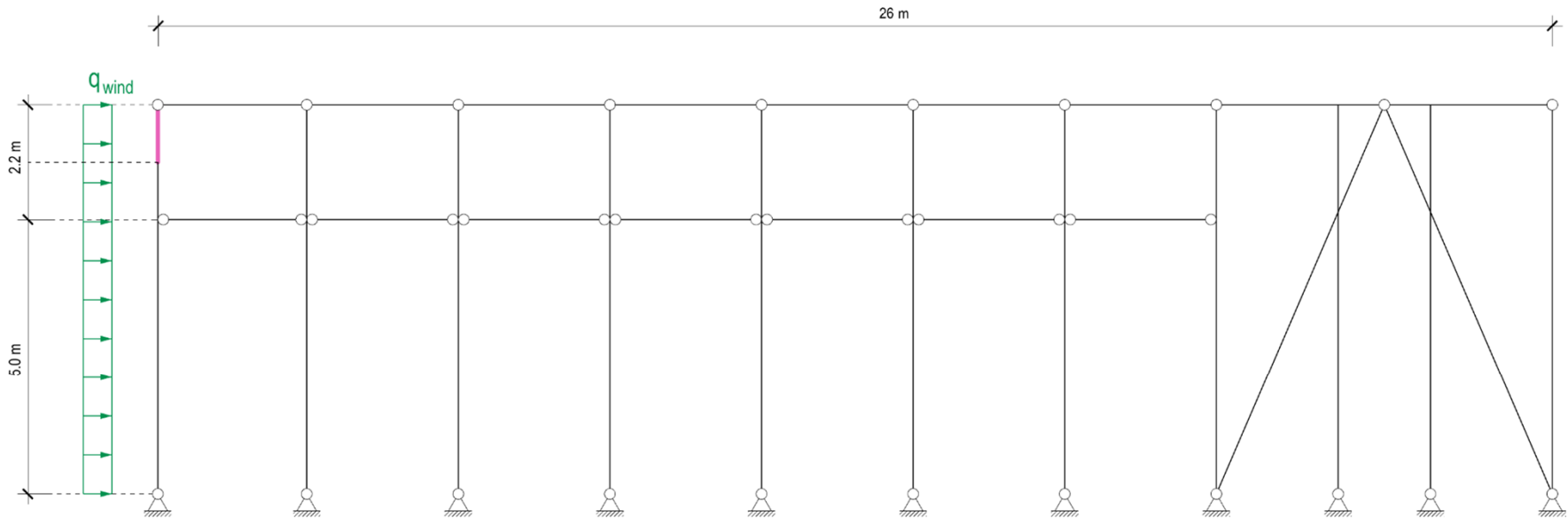
Horizontal Loads

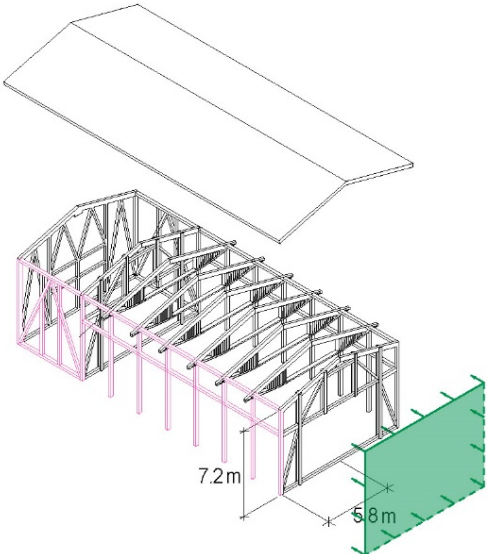
Wind

$q_{wind} = 1.0 \text{ kN/m}^2$

Tributary Areas

$A_1 = (5.8 \text{ m} \cdot 2.2 \text{ m})/2 = 6.4 \text{ m}^2$





Horizontal Loads

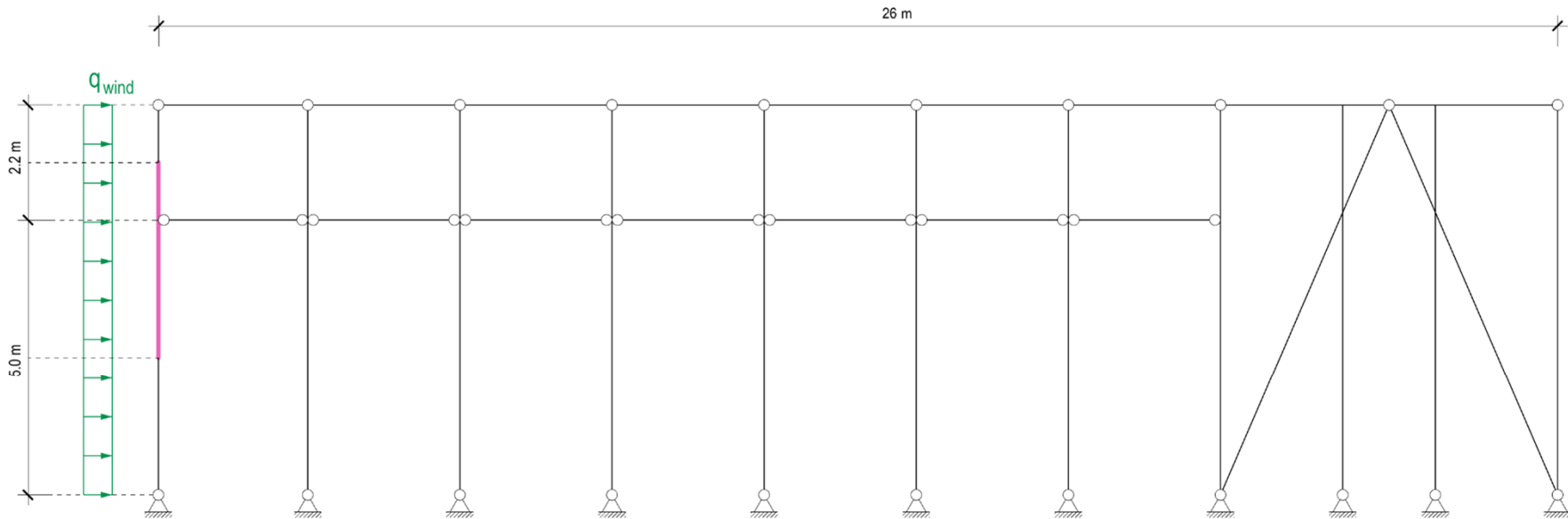
Wind

$q_{wind} = 1.0 \text{ kN/m}^2$

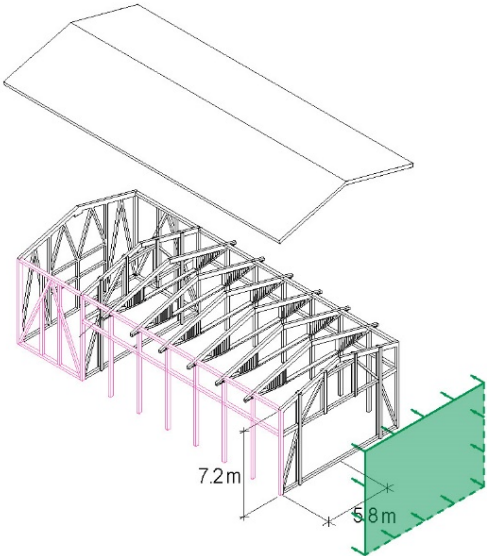
Tributary Areas

$A_1 = (5.8 \text{ m} \cdot 2.2 \text{ m})/2 = 6.4 \text{ m}^2$

$A_2 = (5.8 \text{ m} \cdot (2.2 \text{ m} + 5.0 \text{ m}))/2 = 20.9 \text{ m}^2$



Case Study: Gym Vrin



Horizontal Loads

Wind

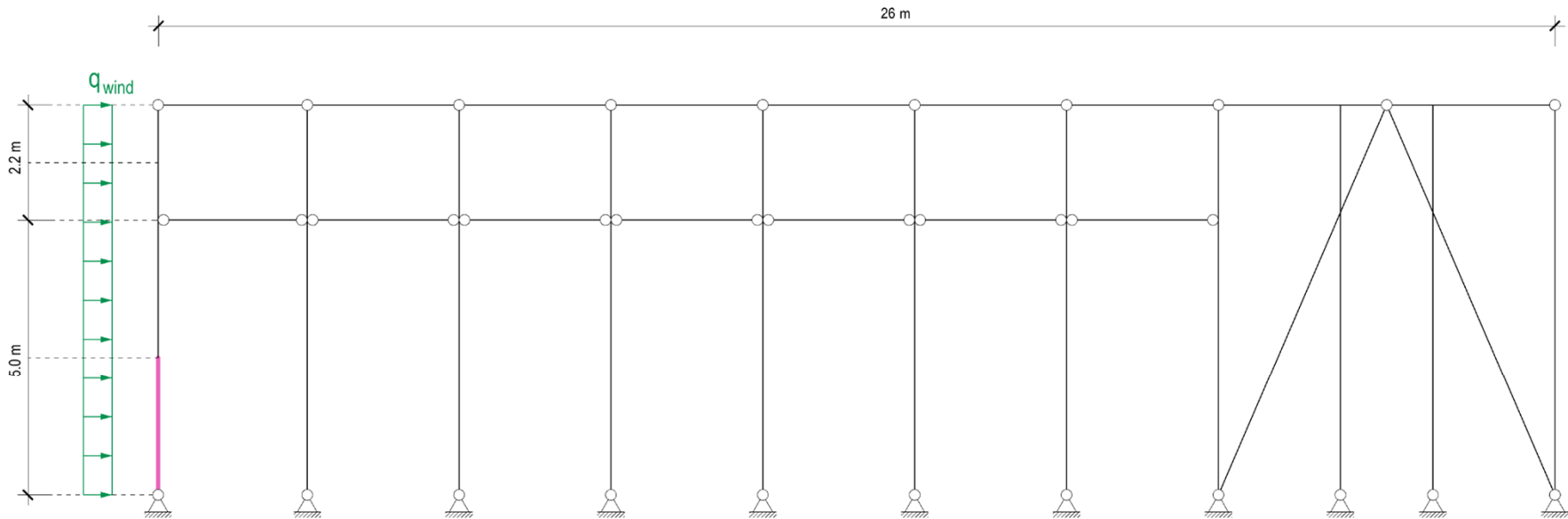
$q_{wind} = 1.0 \text{ kN/m}^2$

Tributary Areas

$A_1 = (5.8 \text{ m} \cdot 2.2 \text{ m})/2 = 6.4 \text{ m}^2$

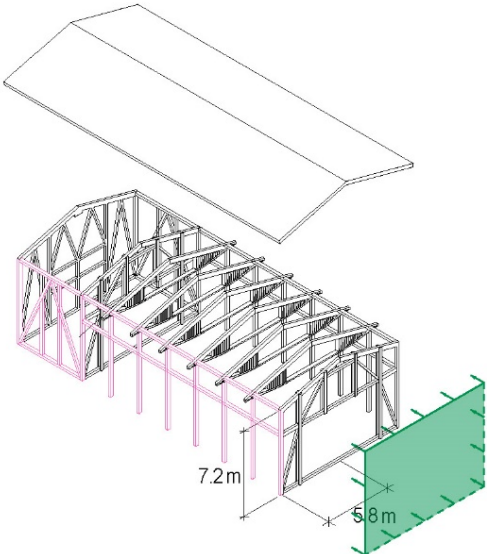
$A_2 = (5.8 \text{ m} \cdot (2.2 \text{ m} + 5.0 \text{ m}))/2 = 20.9 \text{ m}^2$

$A_3 = (5.8 \text{ m} \cdot 5.0 \text{ m})/2 = 14.5 \text{ m}^2$



Horizontale Lasten

Horizontal loads



Horizontal Loads

Wind

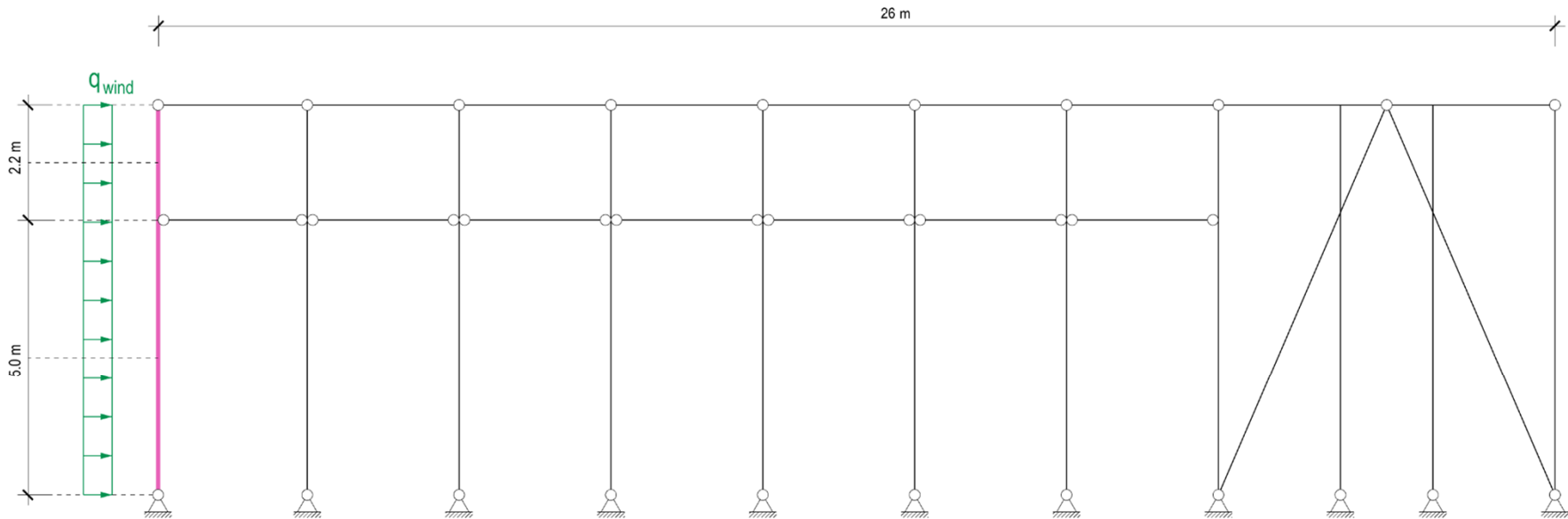
$q_{wind} = 1.0 \text{ kN/m}^2$

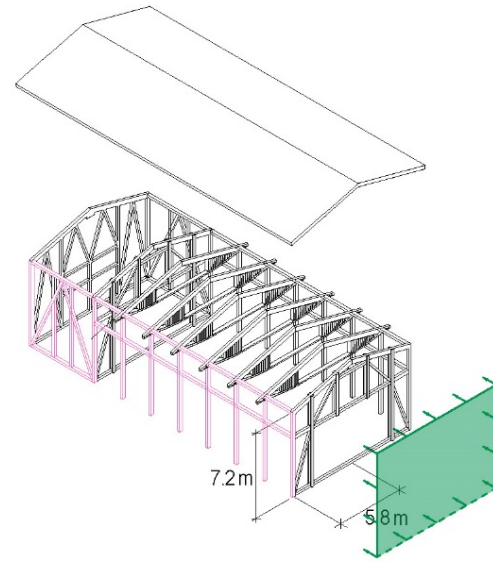
Tributary Areas

$A_1 = (5.8 \text{ m} \cdot 2.2 \text{ m})/2 = 6.4 \text{ m}^2$

$A_2 = (5.8 \text{ m} \cdot (2.2 \text{ m} + 5.0 \text{ m}))/2 = 20.9 \text{ m}^2$

$A_3 = (5.8 \text{ m} \cdot 5.0 \text{ m})/2 = 14.5 \text{ m}^2$





Horizontal Loads

Wind

$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$

Tributary Areas

$$A_1 = (5.8 \text{ m} \cdot 2.2 \text{ m})/2 = 6.4 \text{ m}^2$$

$$A_2 = (5.8 \text{ m} \cdot (2.2 \text{ m} + 5.0 \text{ m}))/2 = 20.9 \text{ m}^2$$

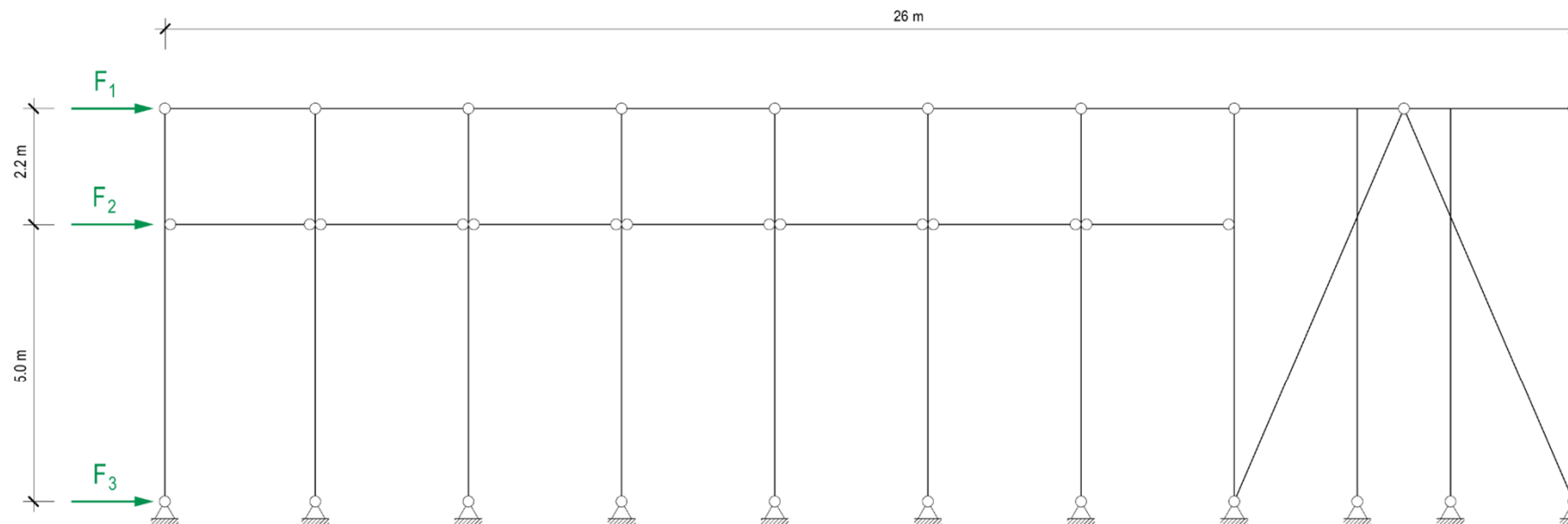
$$A_3 = (5.8 \text{ m} \cdot 5.0 \text{ m})/2 = 14.5 \text{ m}^2$$

Wind Forces

$$F_1 = q_{\text{wind}} \cdot A_1 = 6.4 \text{ kN}$$

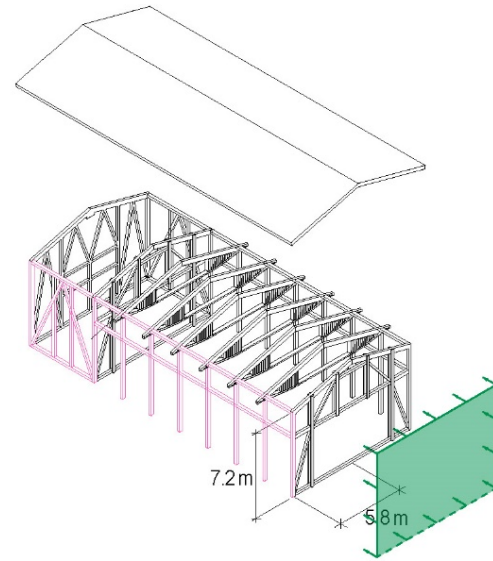
$$F_2 = q_{\text{wind}} \cdot A_2 = 20.9 \text{ kN}$$

$$F_3 = q_{\text{wind}} \cdot A_3 = 14.5 \text{ kN}$$



Horizontale Lasten

Horizontal loads



Horizontal Loads

Wind

$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$

Tributary Areas

$$A_1 = (5.8 \text{ m} \cdot 2.2 \text{ m})/2 = 6.4 \text{ m}^2$$

$$A_2 = (5.8 \text{ m} \cdot (2.2 \text{ m} + 5.0 \text{ m}))/2 = 20.9 \text{ m}^2$$

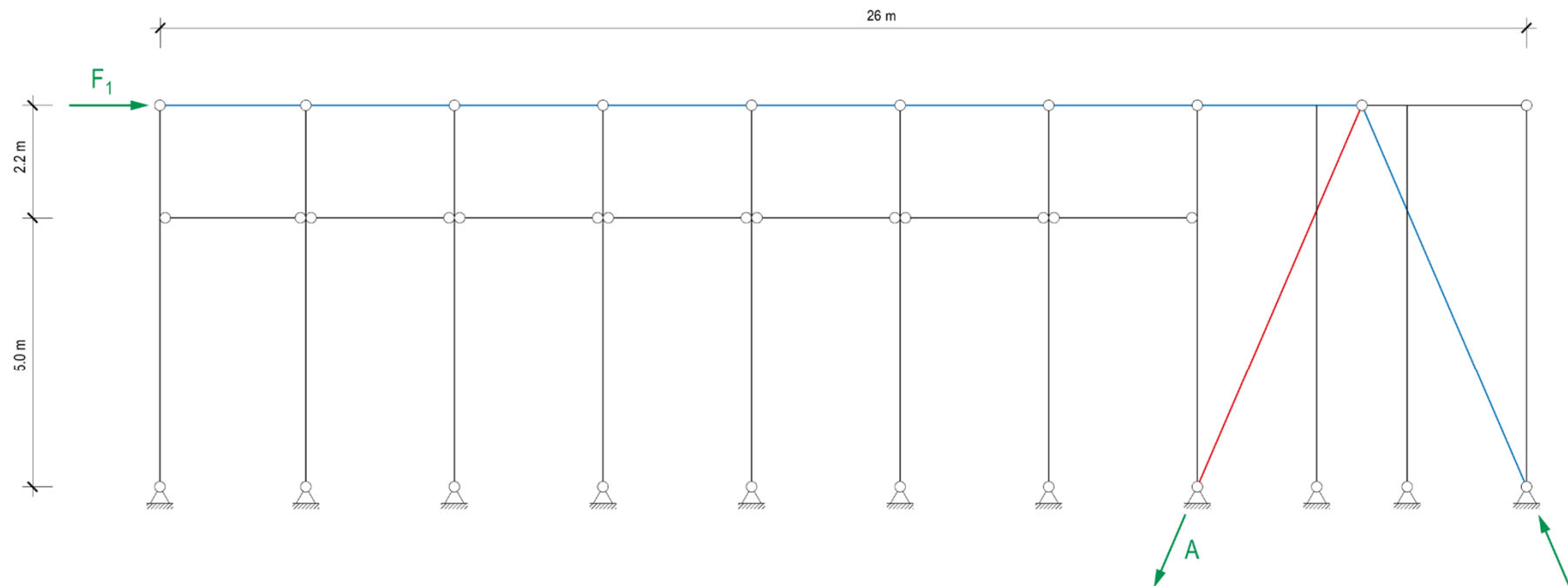
$$A_3 = (5.8 \text{ m} \cdot 5.0 \text{ m})/2 = 14.5 \text{ m}^2$$

Wind Forces

$$F_1 = q_{\text{wind}} \cdot A_1 = 6.4 \text{ kN}$$

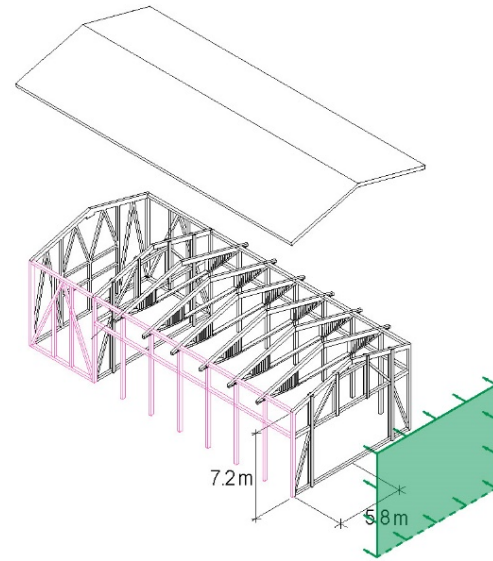
$$F_2 = q_{\text{wind}} \cdot A_2 = 20.9 \text{ kN}$$

$$F_3 = q_{\text{wind}} \cdot A_3 = 14.5 \text{ kN}$$



Horizontale Lasten

Horizontal loads



Horizontal Loads

Wind

$$q_{\text{wind}} = 1.0 \text{ kN/m}^2$$

Tributary Areas

$$A_1 = (5.8 \text{ m} \cdot 2.2 \text{ m})/2 = 6.4 \text{ m}^2$$

$$A_2 = (5.8 \text{ m} \cdot (2.2 \text{ m} + 5.0 \text{ m}))/2 = 20.9 \text{ m}^2$$

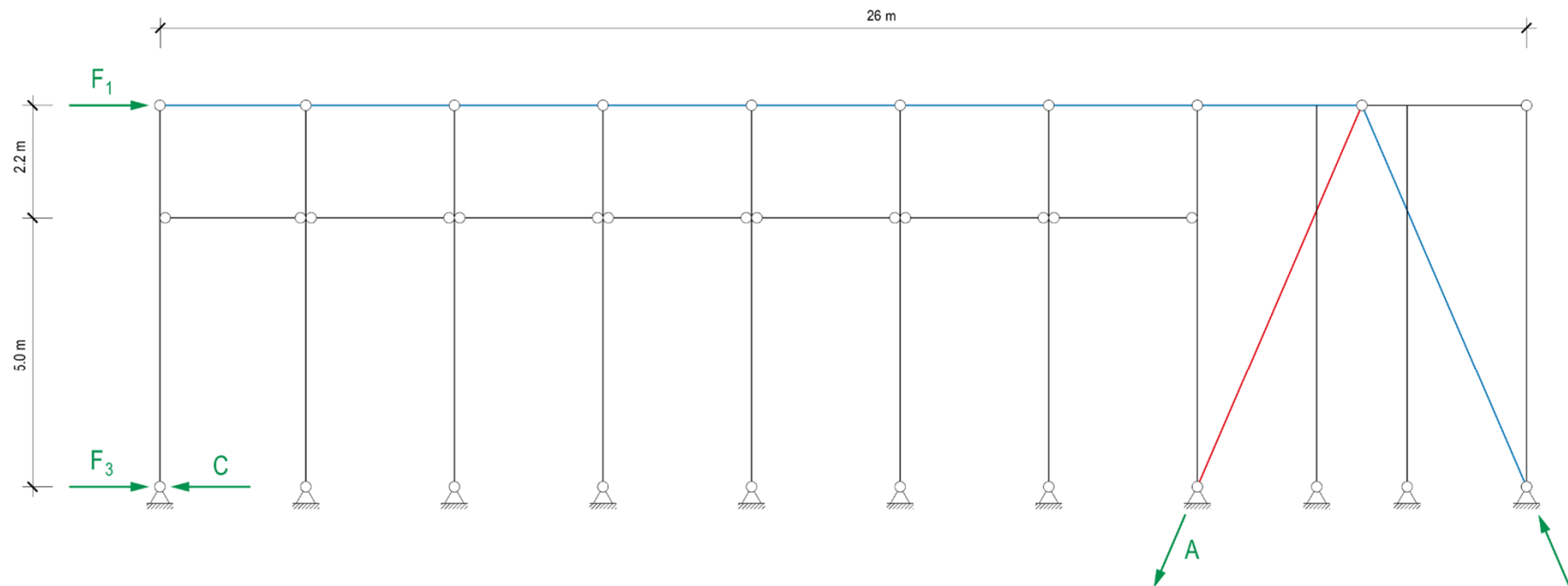
$$A_3 = (5.8 \text{ m} \cdot 5.0 \text{ m})/2 = 14.5 \text{ m}^2$$

Wind Forces

$$F_1 = q_{\text{wind}} \cdot A_1 = 6.4 \text{ kN}$$

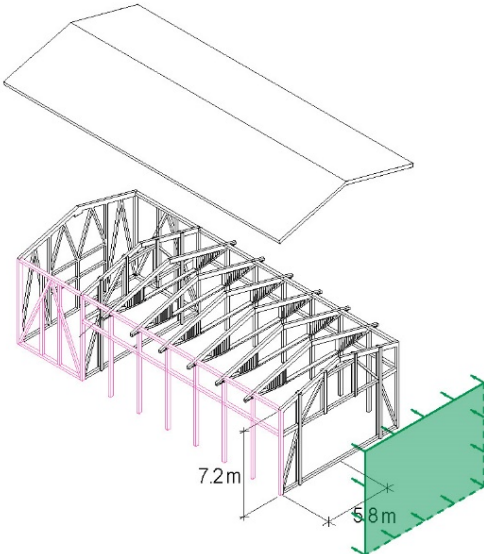
$$F_2 = q_{\text{wind}} \cdot A_2 = 20.9 \text{ kN}$$

$$F_3 = q_{\text{wind}} \cdot A_3 = 14.5 \text{ kN}$$



Horizontale Lasten

Horizontal loads



Horizontal Loads

Wind

$q_{wind} = 1.0 \text{ kN/m}^2$

Tributary Areas

$A_1 = (5.8 \text{ m} \cdot 2.2 \text{ m})/2 = 6.4 \text{ m}^2$

$A_2 = (5.8 \text{ m} \cdot (2.2 \text{ m} + 5.0 \text{ m}))/2 = 20.9 \text{ m}^2$

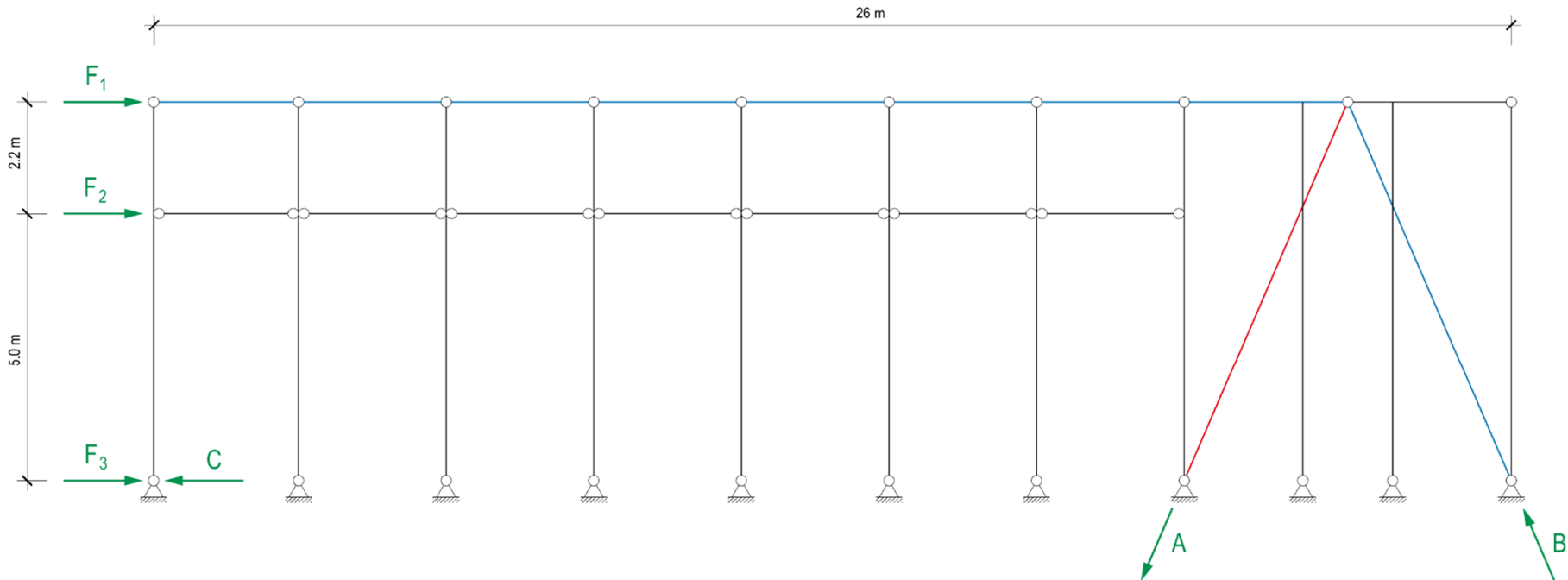
$A_3 = (5.8 \text{ m} \cdot 5.0 \text{ m})/2 = 14.5 \text{ m}^2$

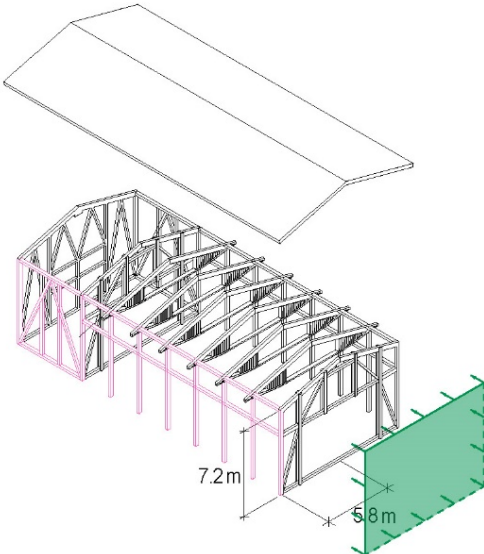
Wind Forces

$F_1 = q_{wind} \cdot A_1 = 6.4 \text{ kN}$

$F_2 = q_{wind} \cdot A_2 = 20.9 \text{ kN}$

$F_3 = q_{wind} \cdot A_3 = 14.5 \text{ kN}$





Horizontal Loads

Wind

$q_{wind} = 1.0 \text{ kN/m}^2$

Tributary Areas

$A_1 = (5.8 \text{ m} \cdot 2.2 \text{ m})/2 = 6.4 \text{ m}^2$

$A_2 = (5.8 \text{ m} \cdot (2.2 \text{ m} + 5.0 \text{ m}))/2 = 20.9 \text{ m}^2$

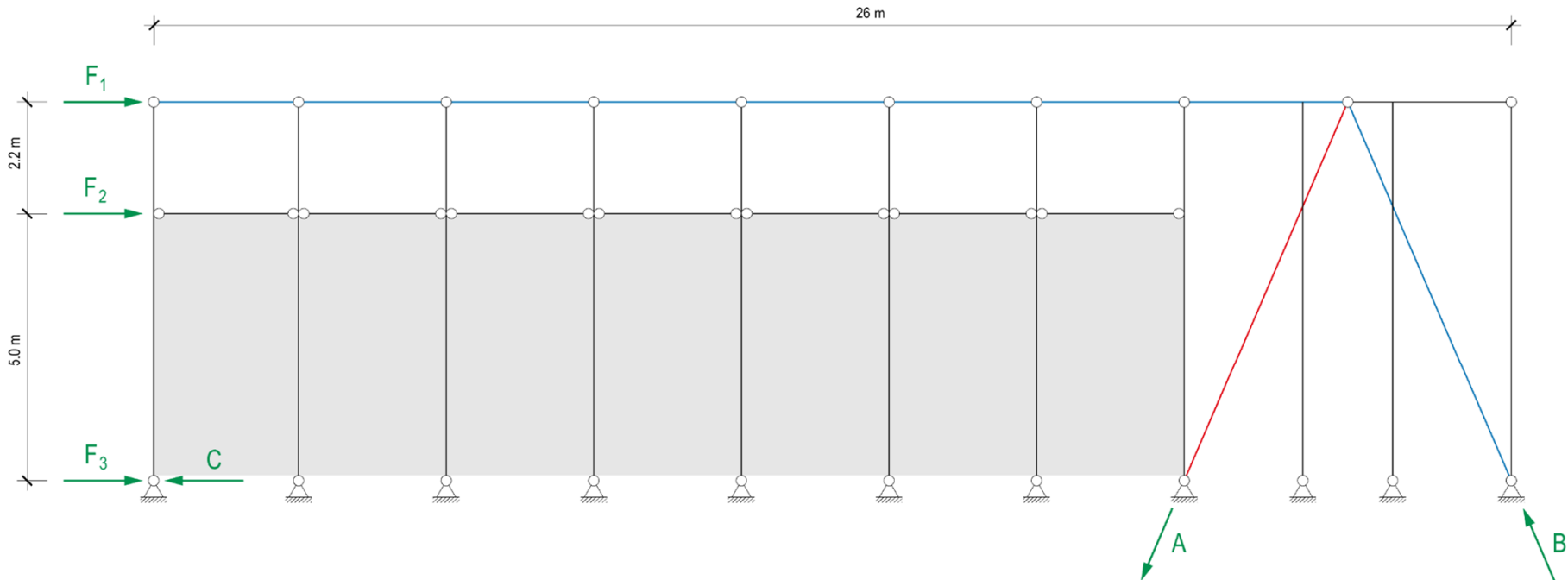
$A_3 = (5.8 \text{ m} \cdot 5.0 \text{ m})/2 = 14.5 \text{ m}^2$

Wind Forces

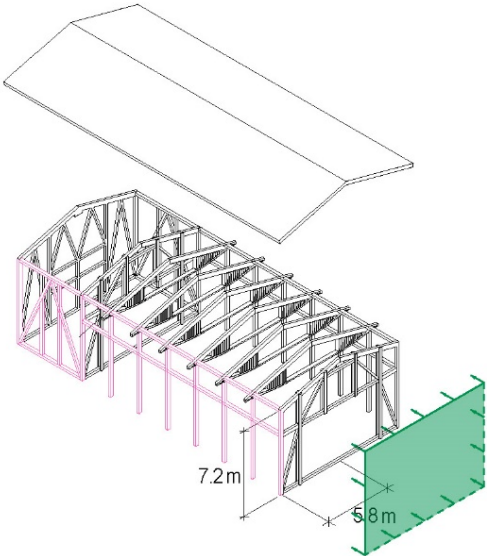
$F_1 = q_{wind} \cdot A_1 = 6.4 \text{ kN}$

$F_2 = q_{wind} \cdot A_2 = 20.9 \text{ kN}$

$F_3 = q_{wind} \cdot A_3 = 14.5 \text{ kN}$



Case Study: Gym Vrin



Horizontal Loads

Wind

$q_{wind} = 1.0 \text{ kN/m}^2$

Tributary Areas

$A_1 = (5.8 \text{ m} \cdot 2.2 \text{ m})/2 = 6.4 \text{ m}^2$

$A_2 = (5.8 \text{ m} \cdot (2.2 \text{ m} + 5.0 \text{ m}))/2 = 20.9 \text{ m}^2$

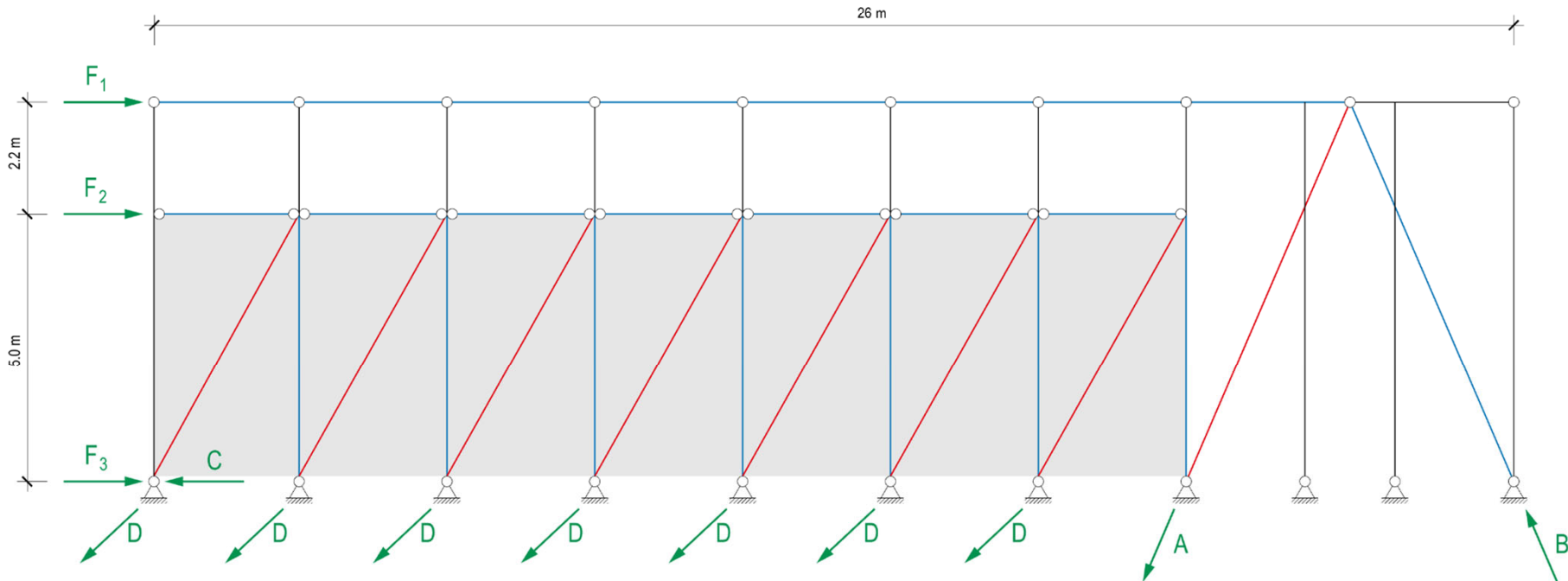
$A_3 = (5.8 \text{ m} \cdot 5.0 \text{ m})/2 = 14.5 \text{ m}^2$

Wind Forces

$F_1 = q_{wind} \cdot A_1 = 6.4 \text{ kN}$

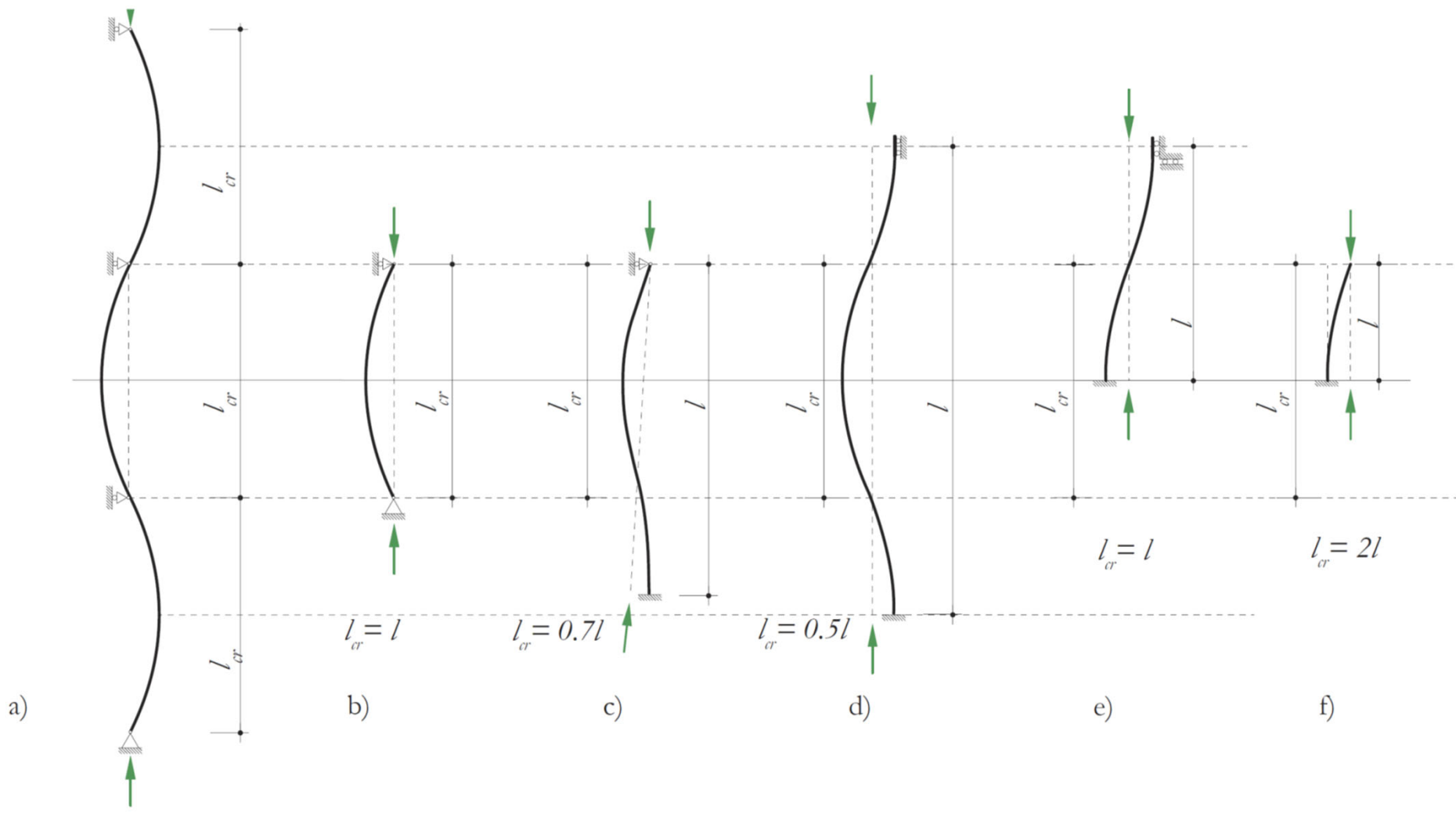
$F_2 = q_{wind} \cdot A_2 = 20.9 \text{ kN}$

$F_3 = q_{wind} \cdot A_3 = 14.5 \text{ kN}$



Horizontale Lasten

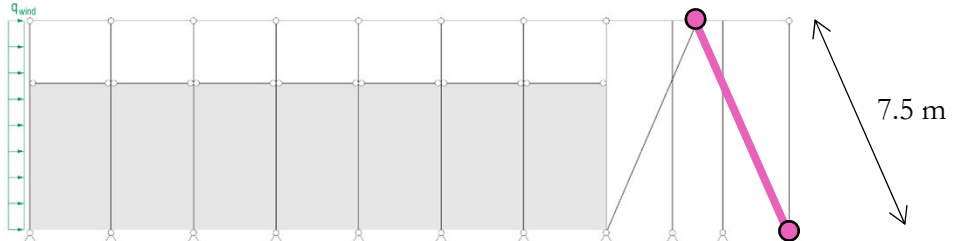
Horizontal loads



Kritische Längen von Elementen unter axialem Druck

Critical lengths of elements under axial compression

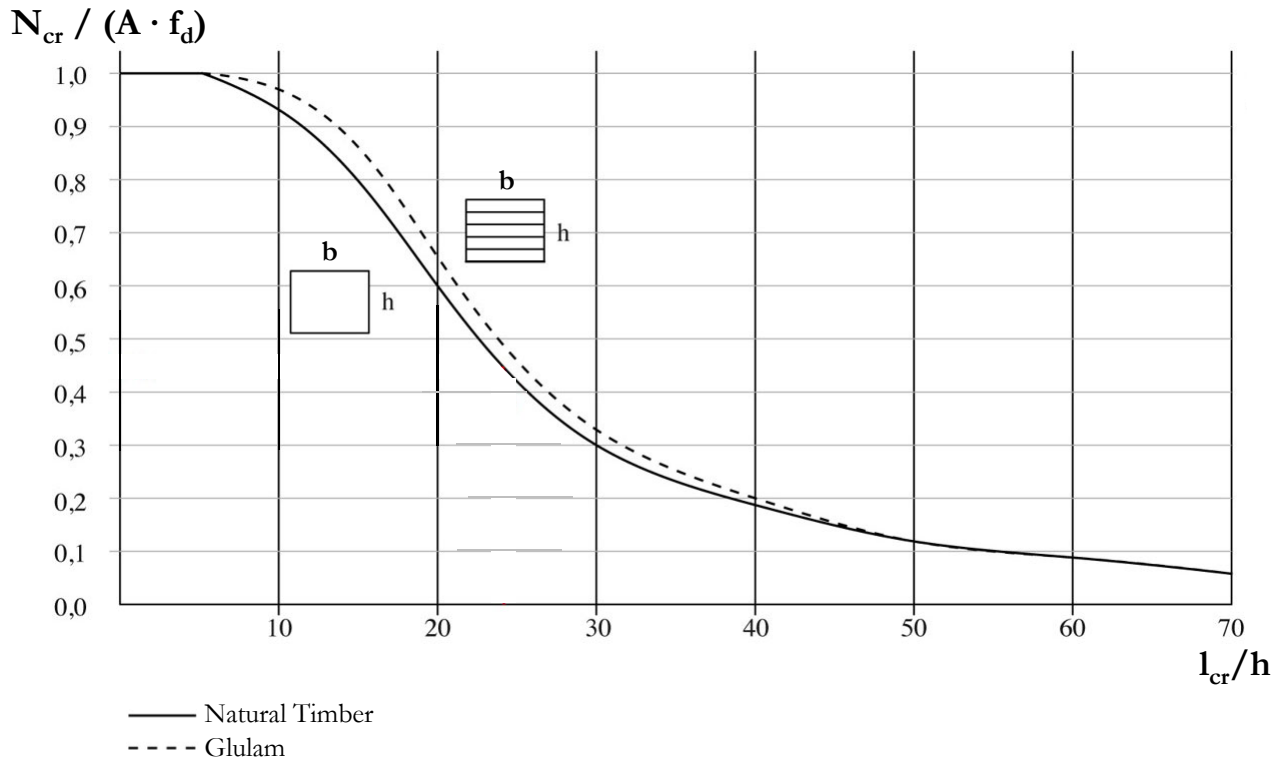
Case Study: Gym Vrin



Square Profile
 $b = 250 \text{ mm}$
 $h = 200 \text{ mm}$
 $\text{Area } (A) = b \cdot h = 50'000 \text{ mm}^2$

Fir timber (full section)
 $f_d = f_s / \gamma_m = 20 / 1.3 =$
 $= 15.4 \text{ N/mm}^2$

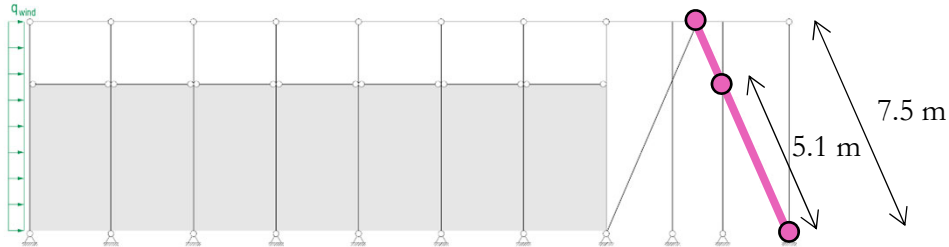
$l_{cr,1} = 7500 \text{ mm}$



Knickkurven von Holzprofilen

Buckling curves of timber sections

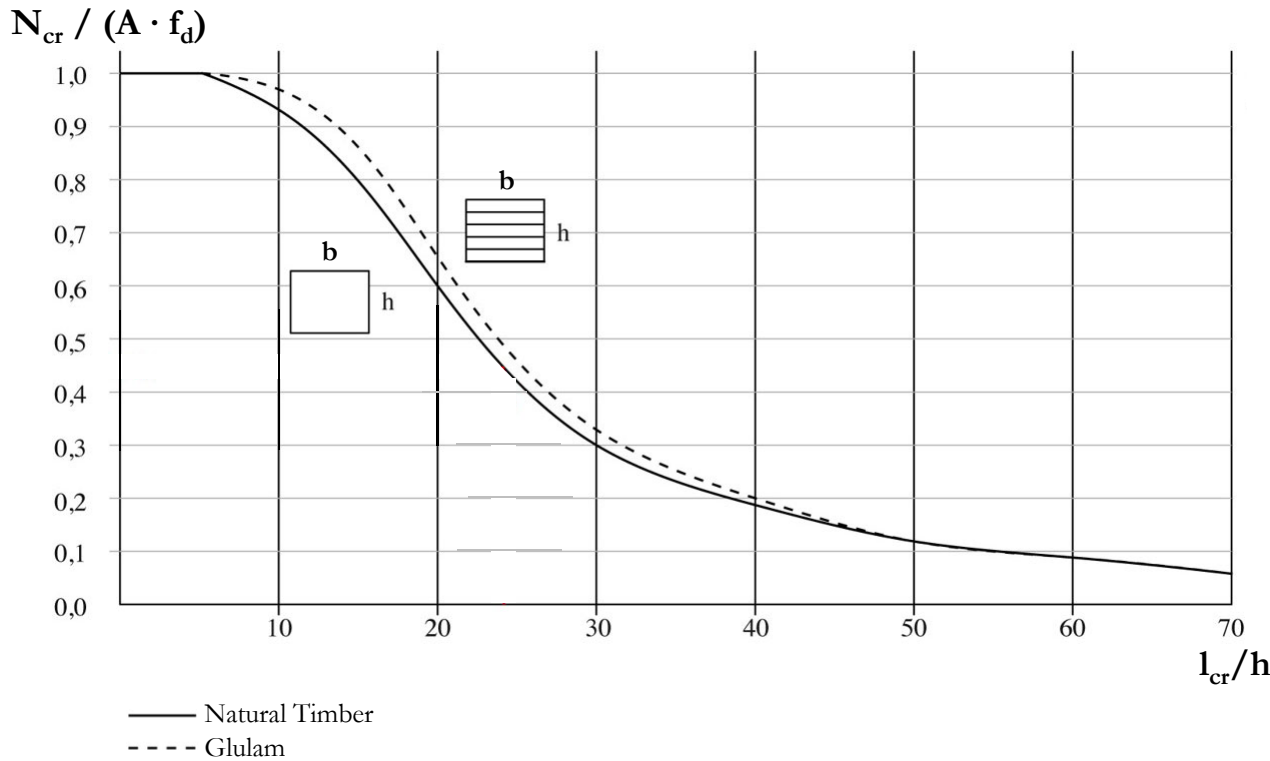
Case Study: Gym Vrin



Square Profile
 $b = 250 \text{ mm}$
 $h = 200 \text{ mm}$
 $\text{Area (A)} = b \cdot h = 50'000 \text{ mm}^2$

Fir timber (full section)
 $f_d = f_s / \gamma_m = 20 / 1.3 = 15.4 \text{ N/mm}^2$

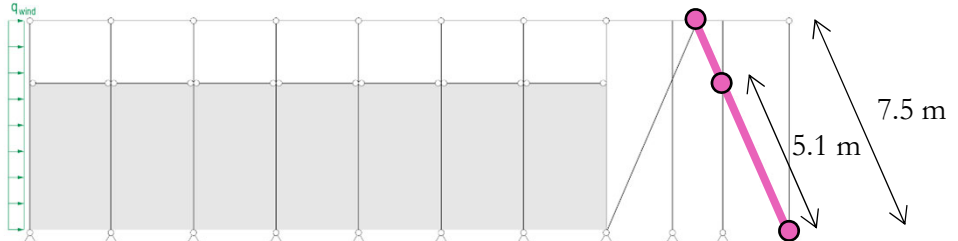
$l_{cr,1} = 7500 \text{ mm}$
 $l_{cr,2} = 5100 \text{ mm}$



Knickkurven von Holzprofilen

Buckling curves of timber sections

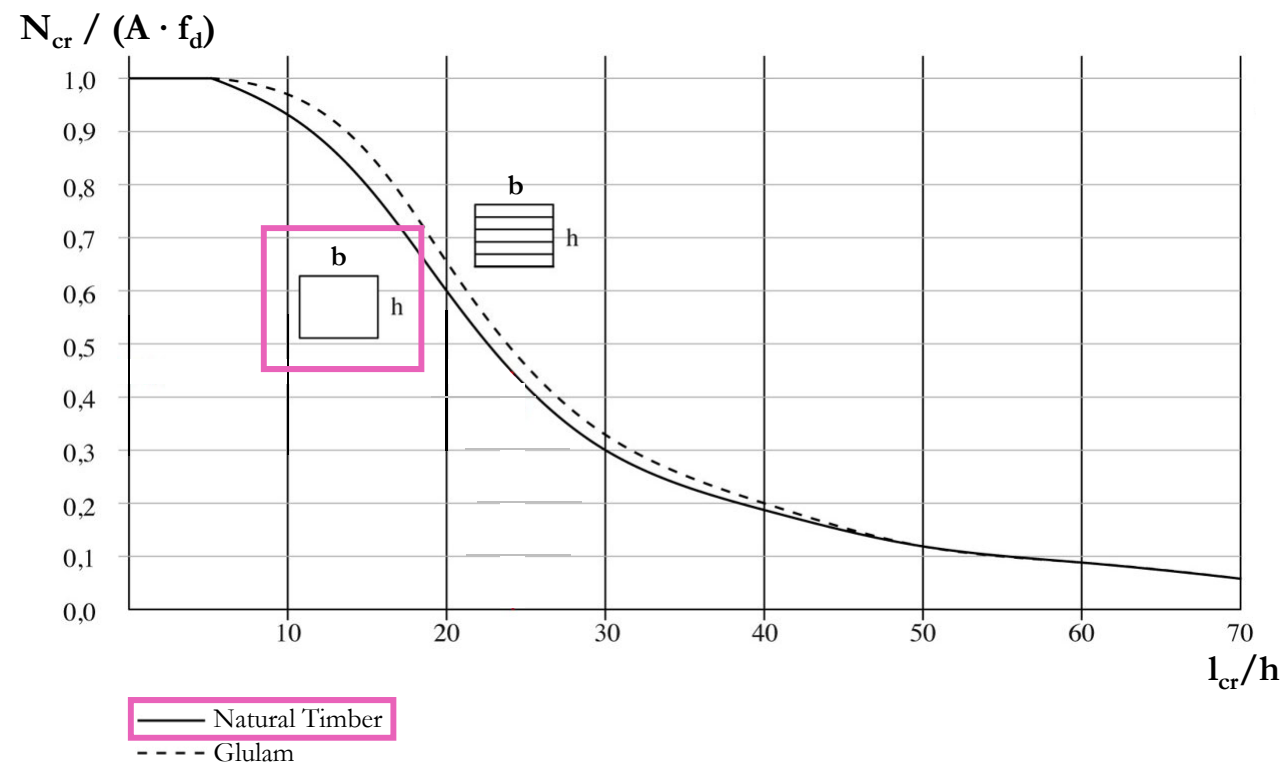
Case Study: Gym Vrin



Square Profile
 $b = 250 \text{ mm}$
 $h = 200 \text{ mm}$
 Area (A) = $b \cdot h = 50'000 \text{ mm}^2$

Fir timber (full section)
 $f_d = f_s / \gamma_m = 20 / 1.3 = 15.4 \text{ N/mm}^2$

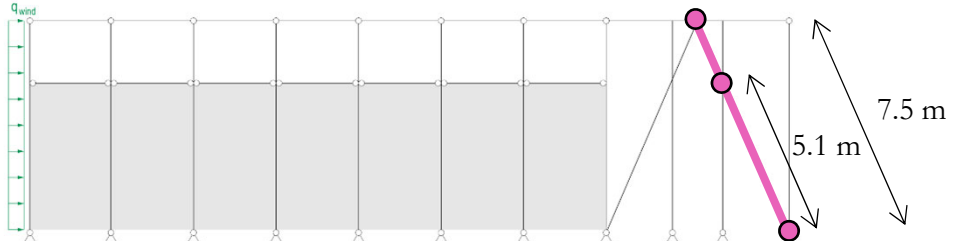
$l_{cr,1} = 7500 \text{ mm}$
 $l_{cr,2} = 5100 \text{ mm}$



Knickkurven von Holzprofilen

Buckling curves of timber sections

Case Study: Gym Vrin

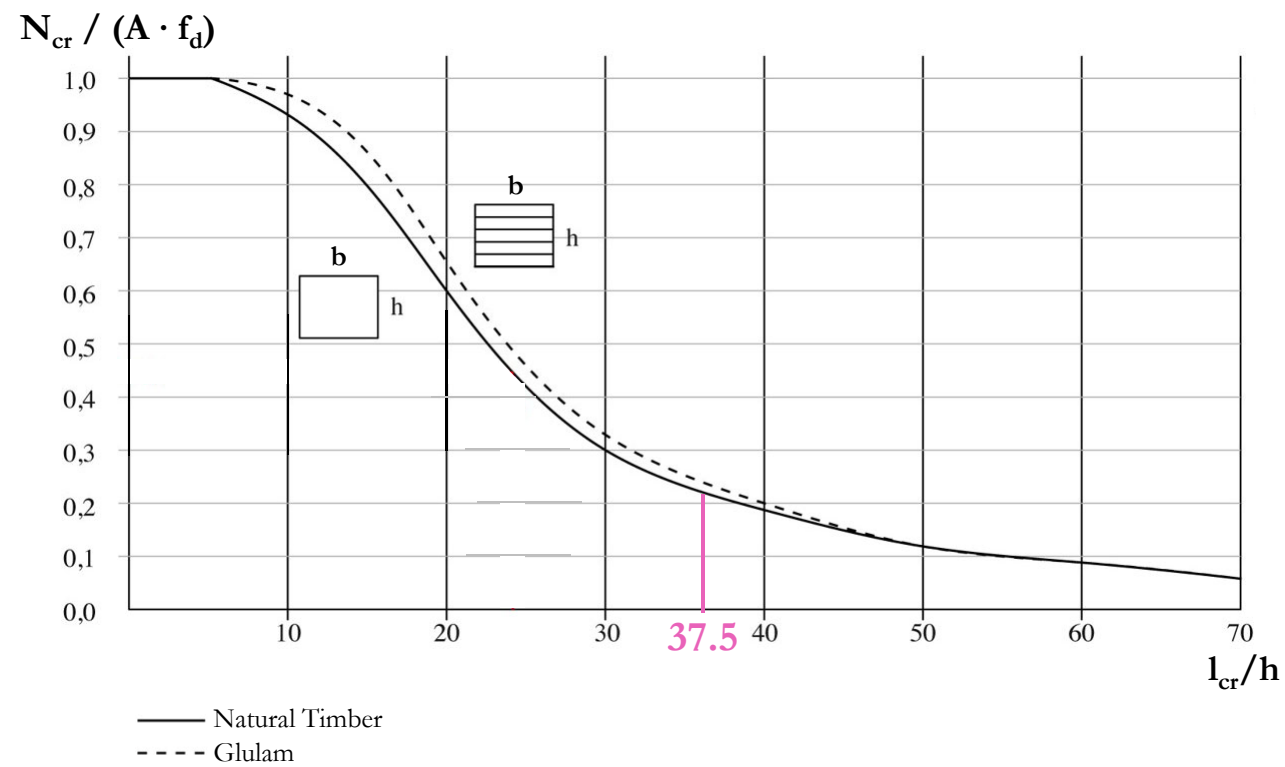


Square Profile
 $b = 250 \text{ mm}$
 $h = 200 \text{ mm}$
 Area (A) = $b \cdot h = 50'000 \text{ mm}^2$

Fir timber (full section)
 $f_d = f_s / \gamma_m = 20 / 1.3 = 15.4 \text{ N/mm}^2$

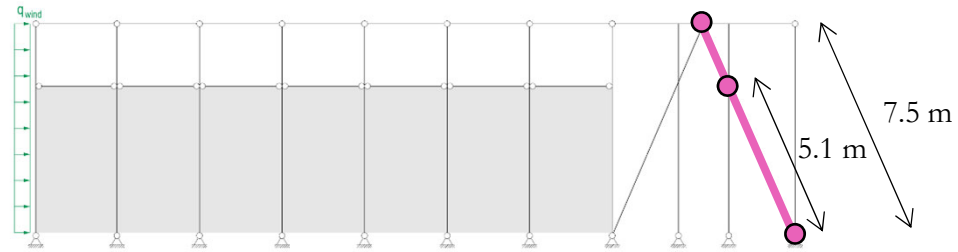
$l_{cr,1} = 7500 \text{ mm}$
 $l_{cr,2} = 5100 \text{ mm}$

 $l_{cr,1}/h = 37.5$



Knickkurven von Holzprofilen

Buckling curves of timber sections



Square Profile

$b = 250 \text{ mm}$

$h = 200 \text{ mm}$

Area (A) = $b \cdot h = 50'000 \text{ mm}^2$

Fir timber (full section)

$f_d = f_s / \gamma_m = 20 / 1.3 =$

$= 15.4 \text{ N/mm}^2$

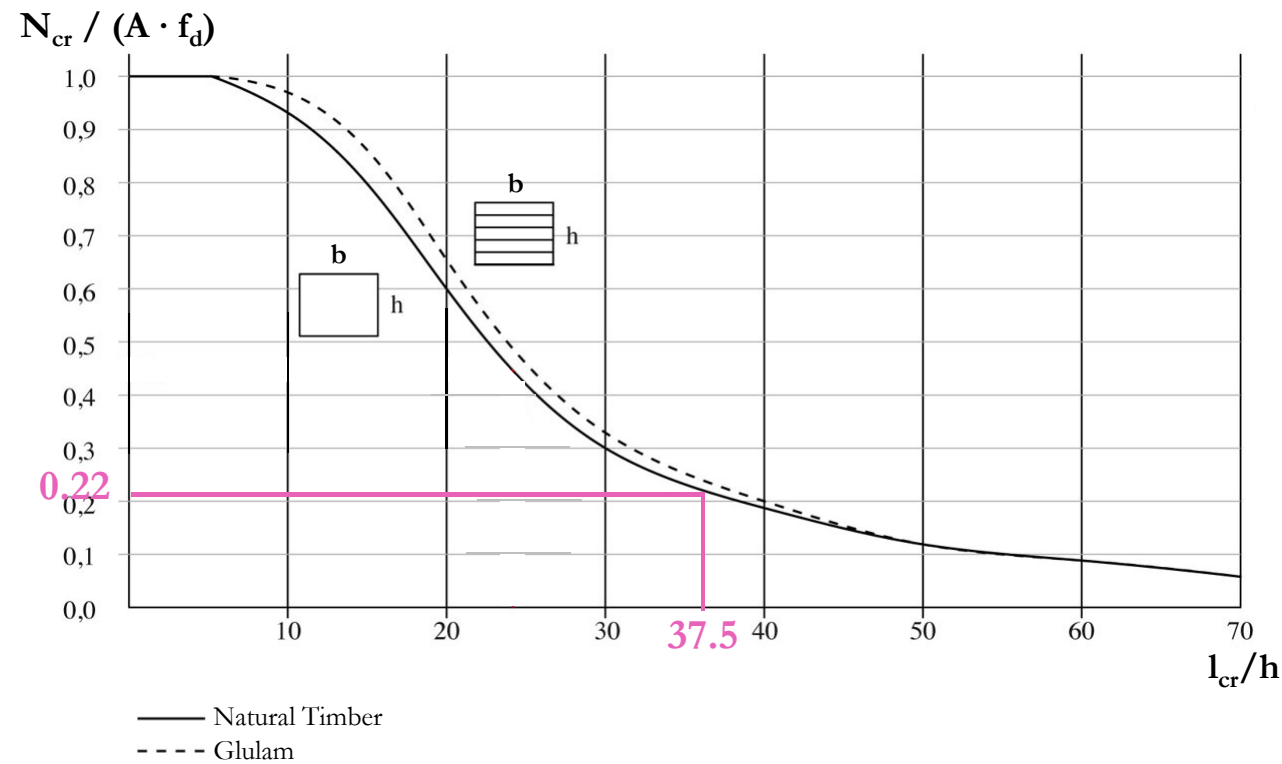
$l_{cr,1} = 7500 \text{ mm}$

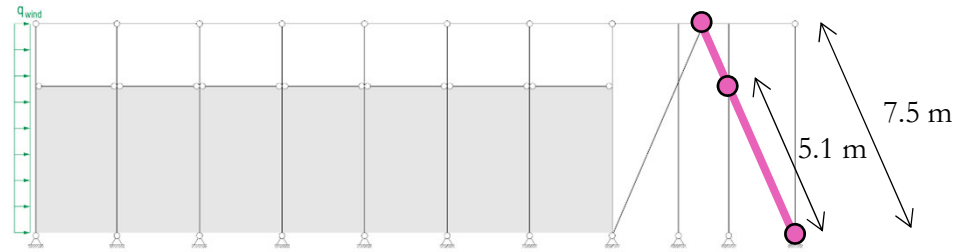
$l_{cr,2} = 5100 \text{ mm}$

$l_{cr,1} / h = 37.5$

$N_{cr,1} / (A \cdot f_d) = 0.22$

$N_{cr,1} = 0.22 \cdot (A \cdot f_d) = 169.4 \text{ kN}$





Square Profile

$$b = 250 \text{ mm}$$

$$h = 200 \text{ mm}$$

$$\text{Area (A)} = b \cdot h = 50'000 \text{ mm}^2$$

Fir timber (full section)

$$f_d = f_s / \gamma_m = 20 / 1.3 =$$

$$= 15.4 \text{ N/mm}^2$$

$$l_{cr,1} = 7500 \text{ mm}$$

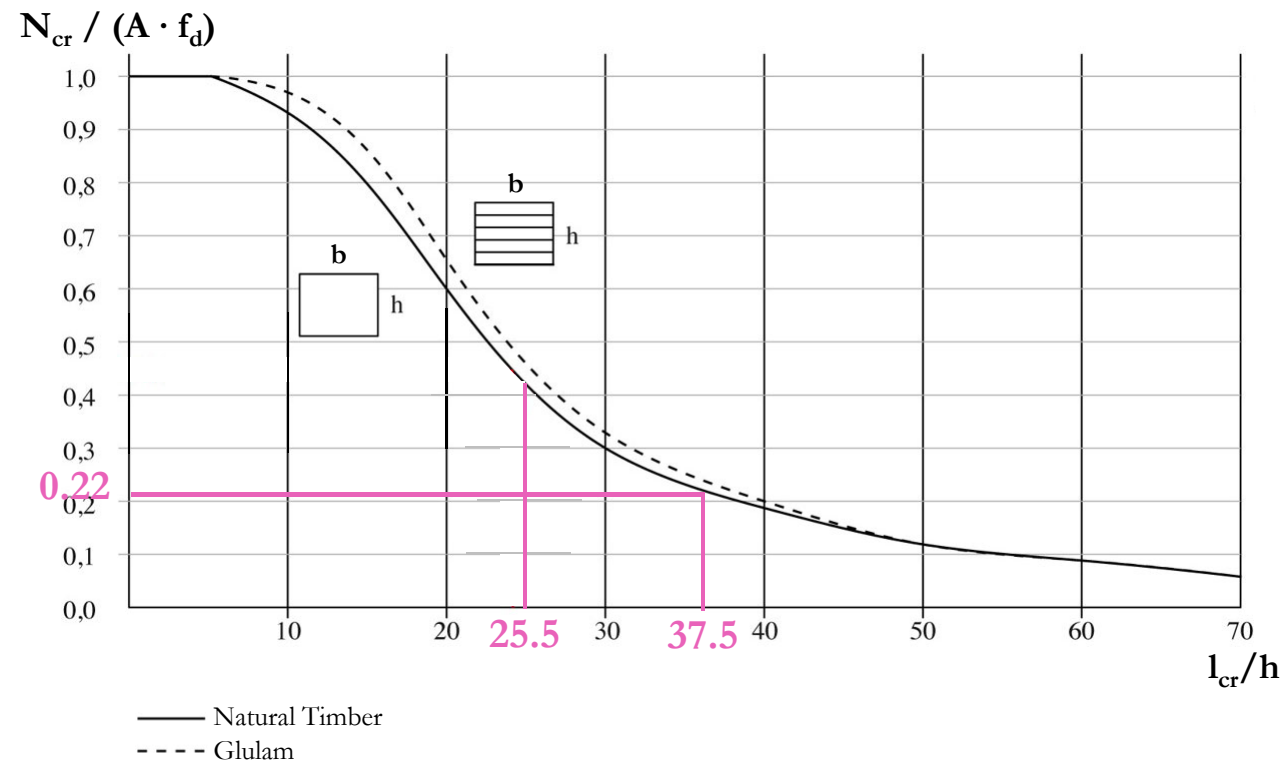
$$l_{cr,2} = 5100 \text{ mm}$$

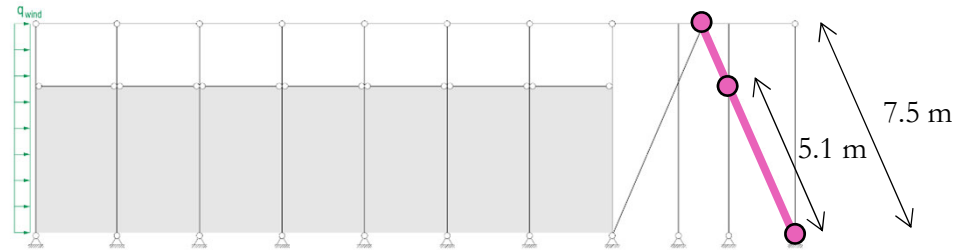
$$l_{cr,1}/h = 37.5$$

$$N_{cr,1} / (A \cdot f_d) = 0.22$$

$$N_{cr,1} = 0.22 \cdot (A \cdot f_d) = 169.4 \text{ kN}$$

$$l_{cr,2}/h = 25.5$$





Square Profile
 $b = 250 \text{ mm}$
 $h = 200 \text{ mm}$
 $\text{Area (A)} = b \cdot h = 50'000 \text{ mm}^2$

Fir timber (full section)
 $f_d = f_s / \gamma_m = 20 / 1.3 = 15.4 \text{ N/mm}^2$

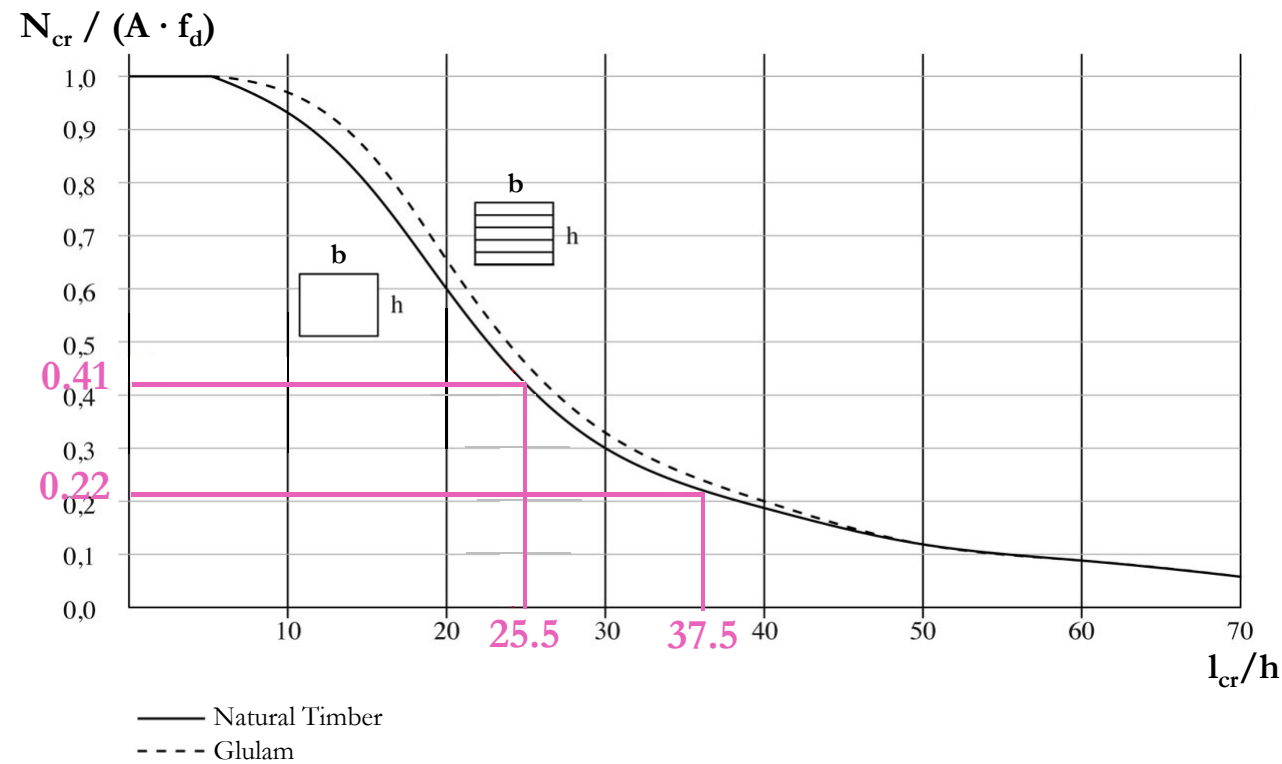
$l_{cr,1} = 7500 \text{ mm}$
 $l_{cr,2} = 5100 \text{ mm}$

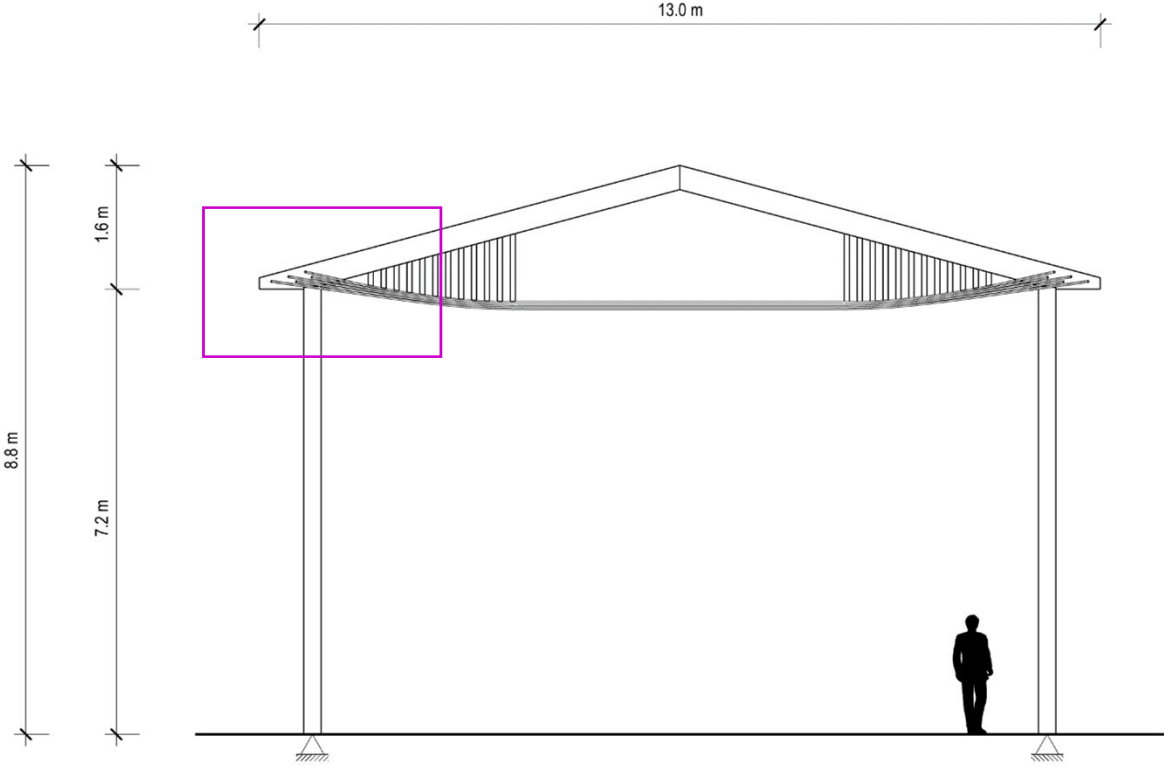
$l_{cr,1}/h = 37.5$

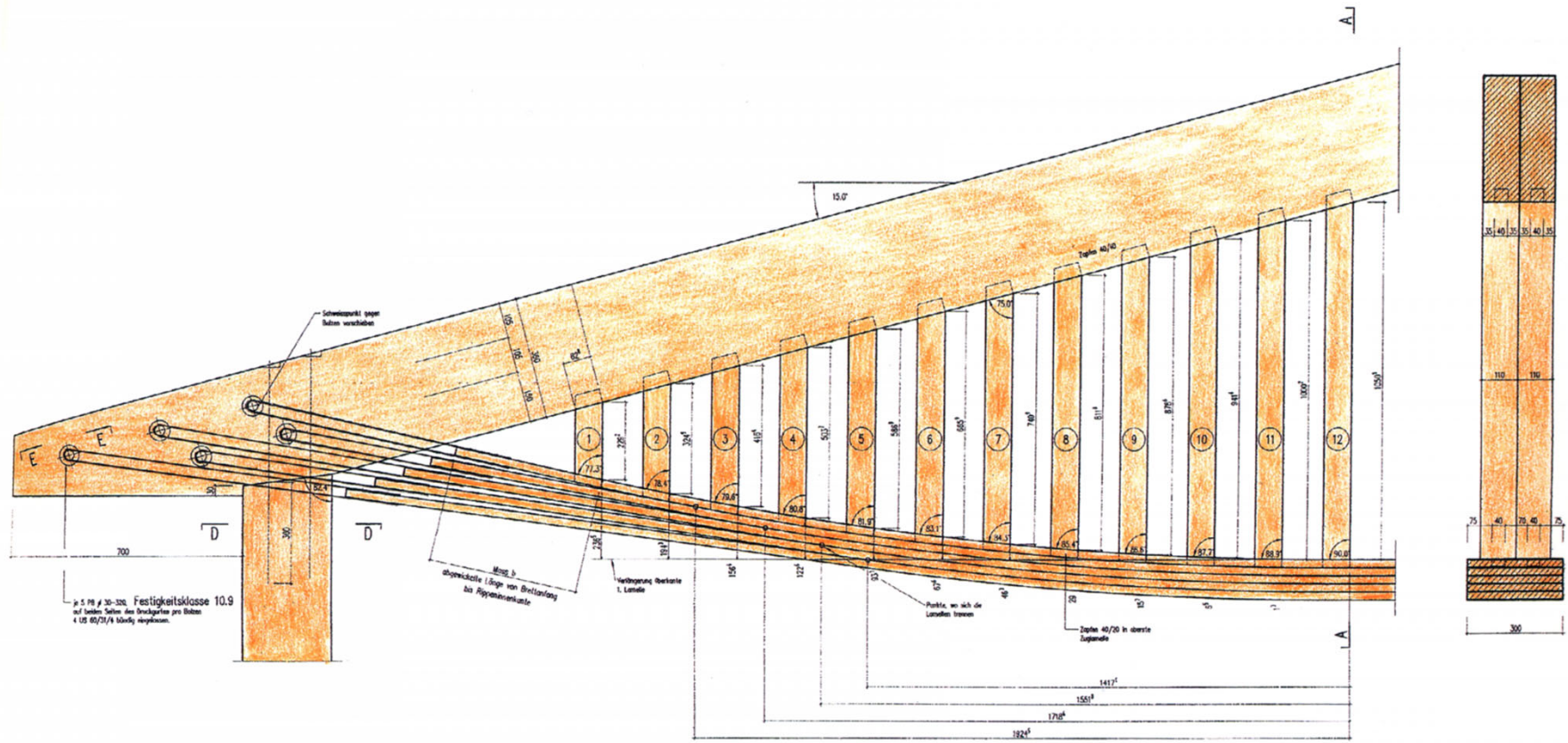
$N_{cr,1} / (A \cdot f_d) = 0.22$
 $N_{cr,1} = 0.22 \cdot (A \cdot f_d) = 169.4 \text{ kN}$

$l_{cr,2}/h = 25.5$

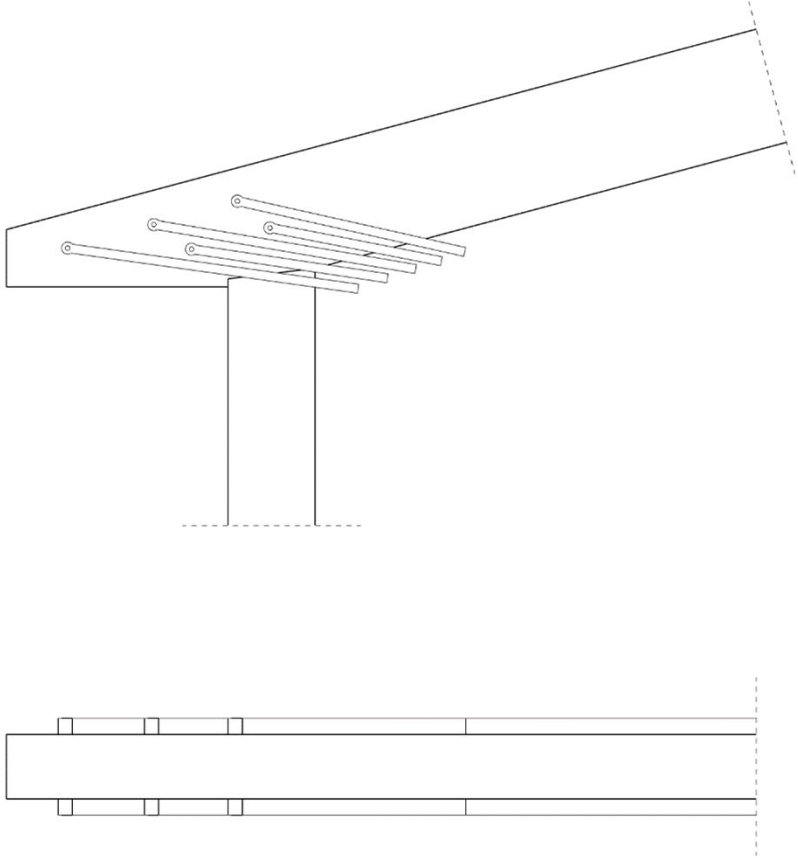
$N_{cr,2} / (A \cdot f_d) = 0.41$
 $N_{cr,2} = 0.41 \cdot (A \cdot f_d) = 315.7 \text{ kN}$

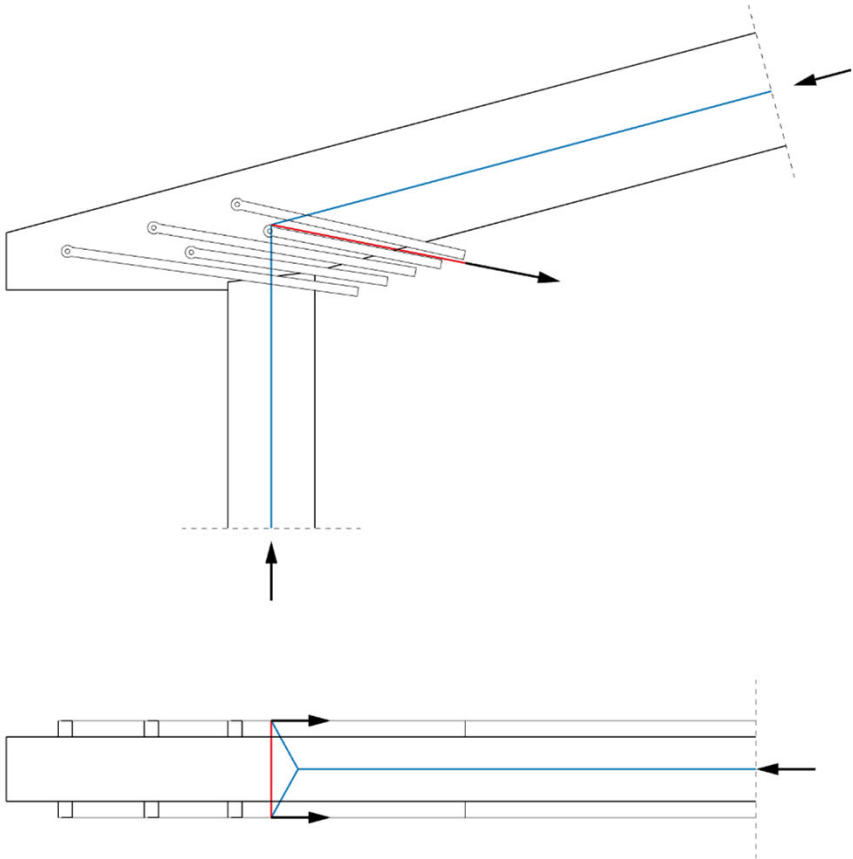




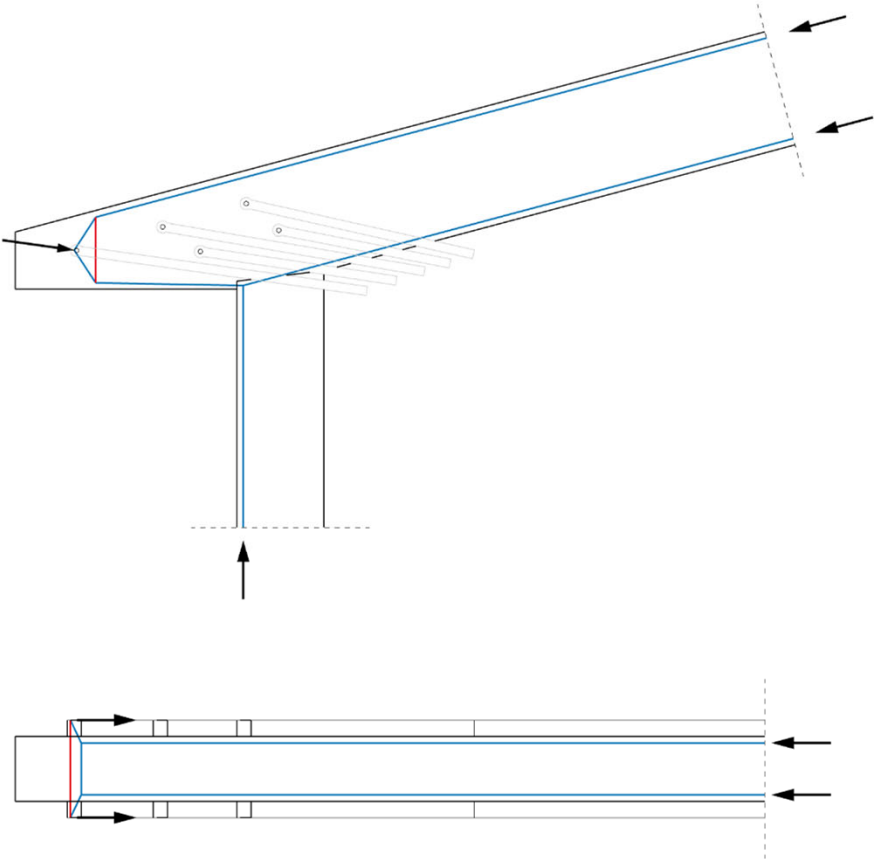


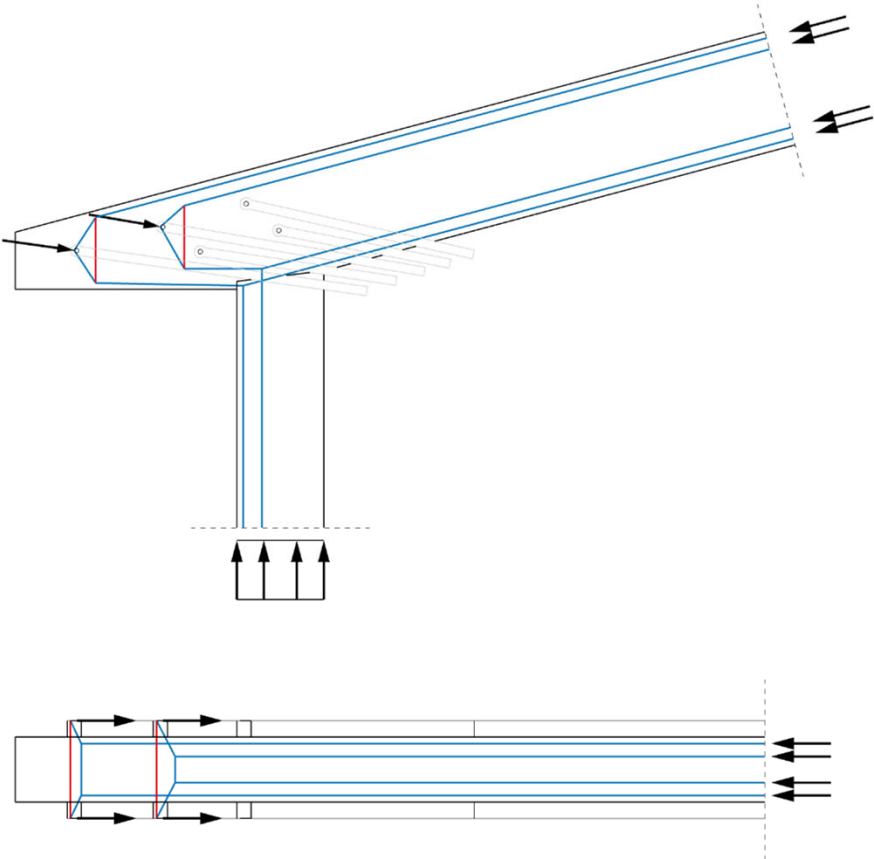


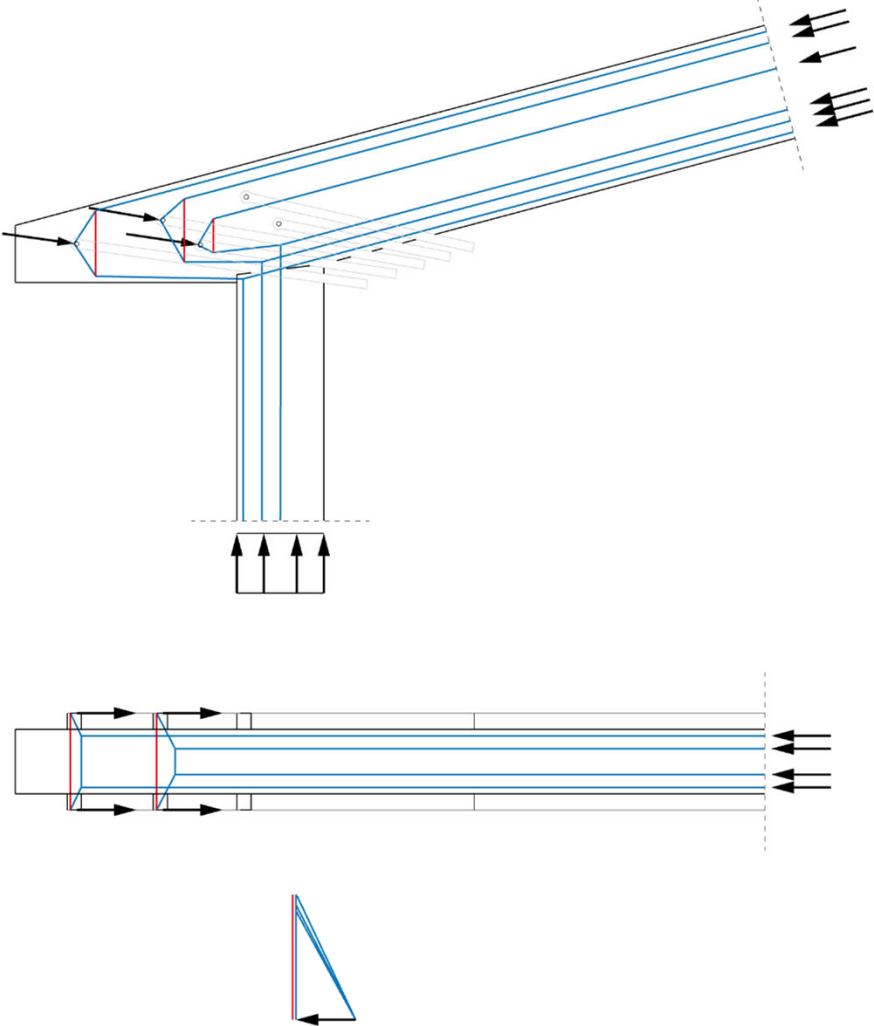


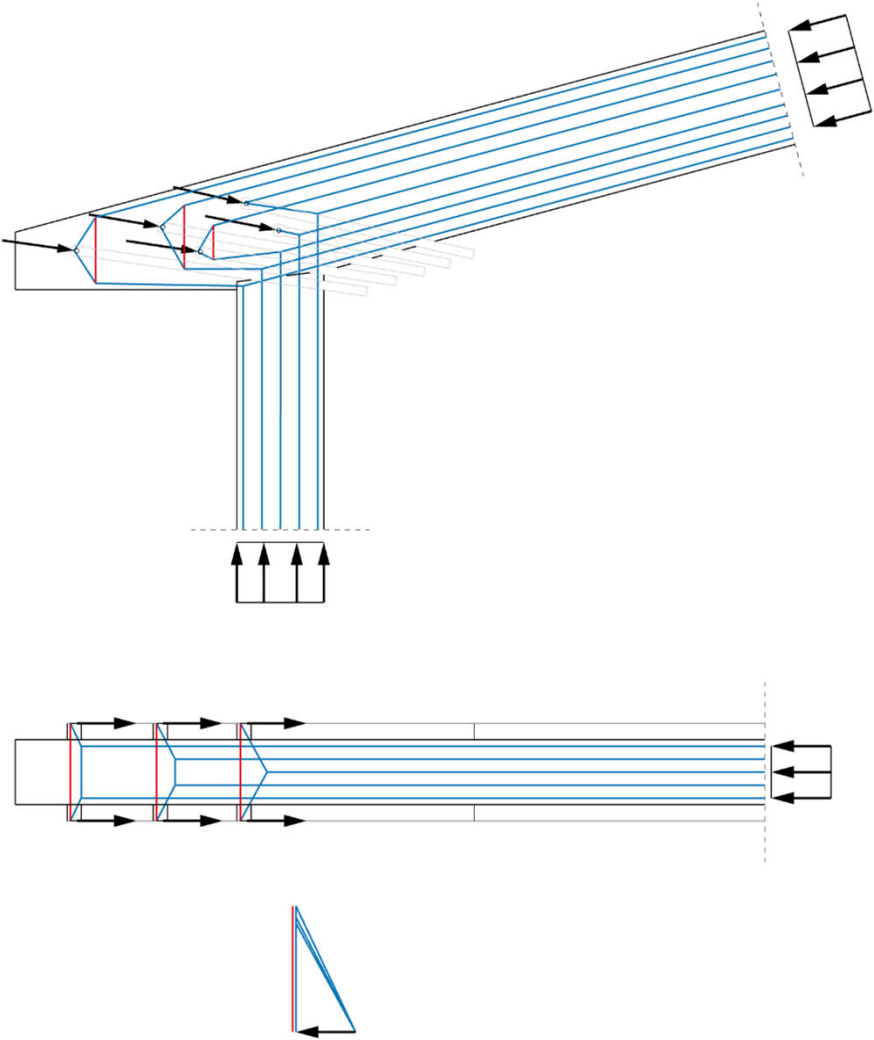


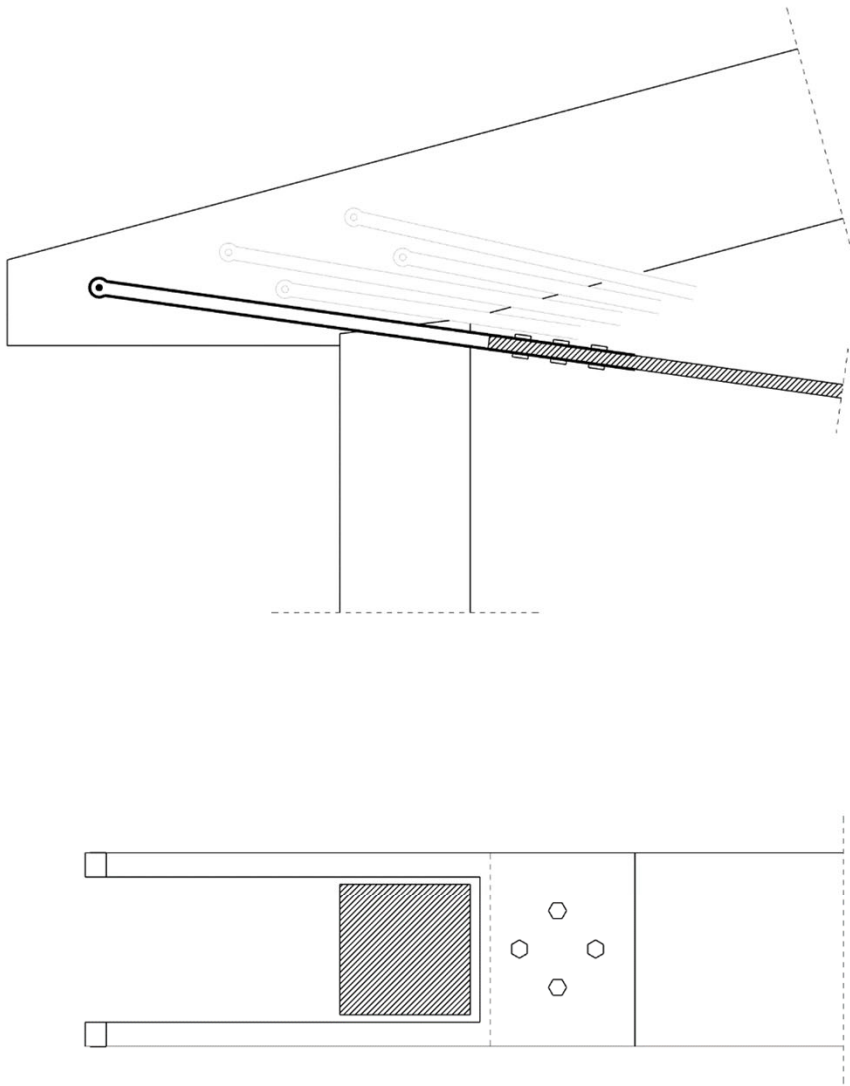
Case Study: Gym Vrin

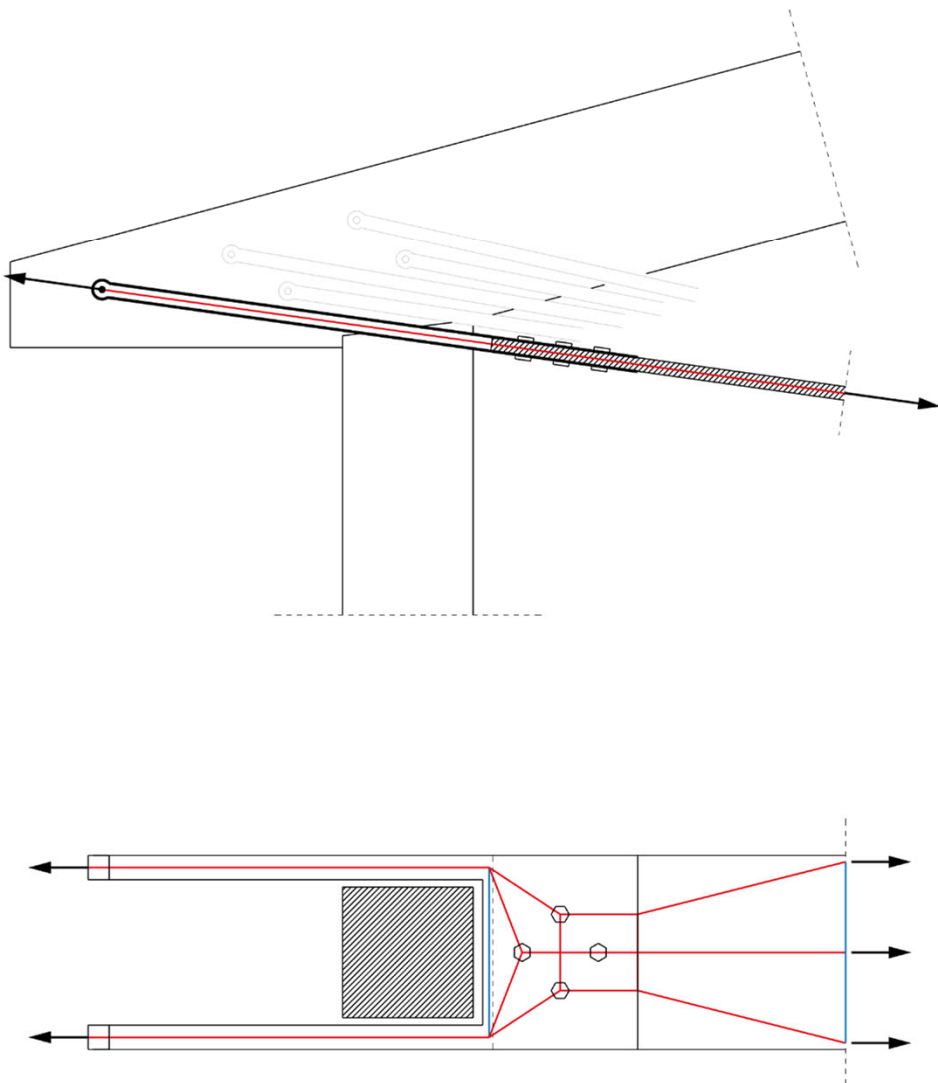












Holz

Timber

Einführung

Introduction

Mechanische Eigenschaften

Mechanical Properties

Bautechnologie

Building Technologies

Fallstudie: Mehrzweckhalle Vrin

Case Study: Gym Vrin



Ausgewählte Projekte

Selected Projects



Saint Benedict Chapel
Peter Zumthor



Wood House
Smiljan Radic



Nine Bridges Country Club
Shigeru Ban

Saint Benedict Chapel

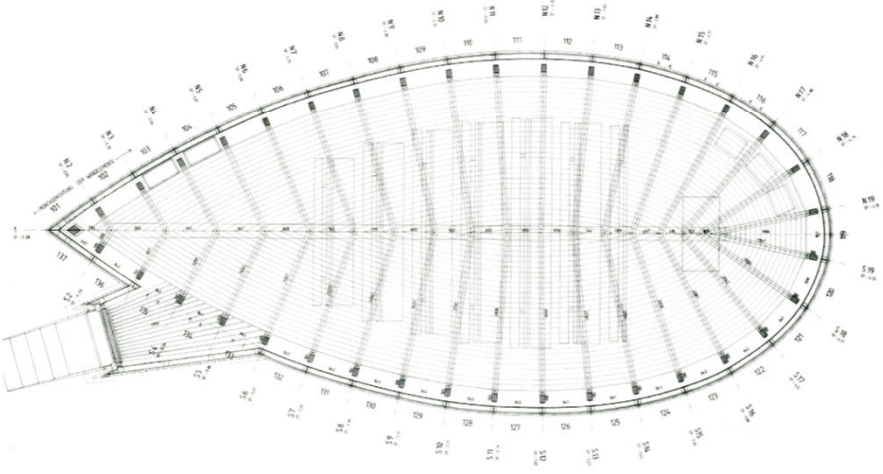
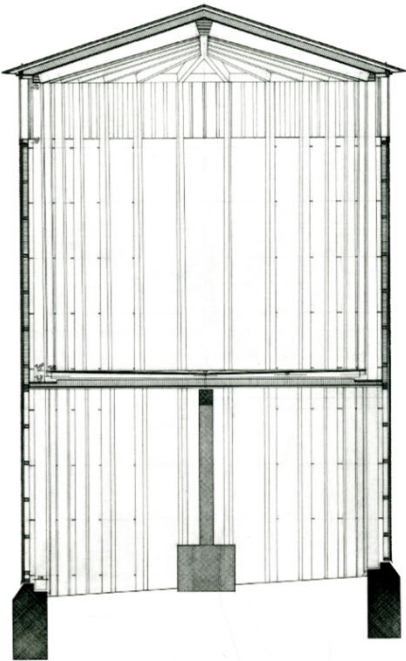
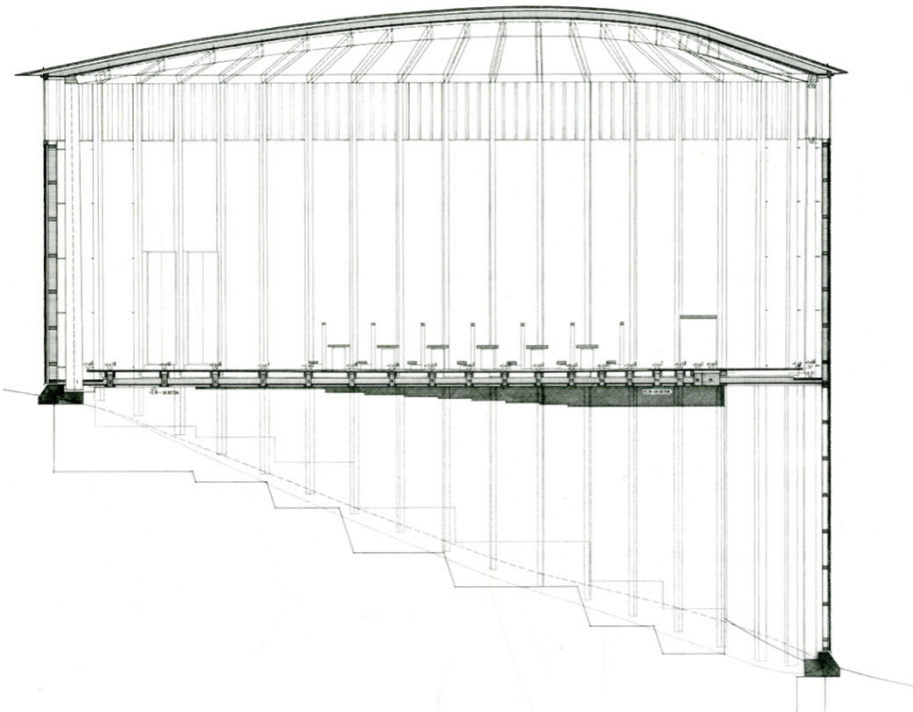
Sumvitg (Graubünden), 1988

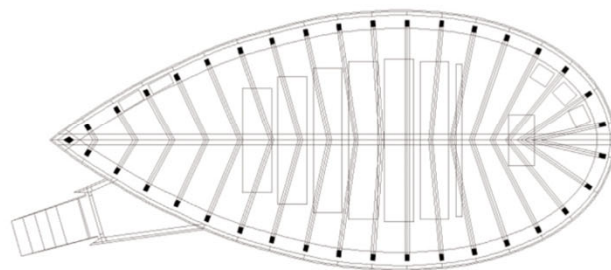
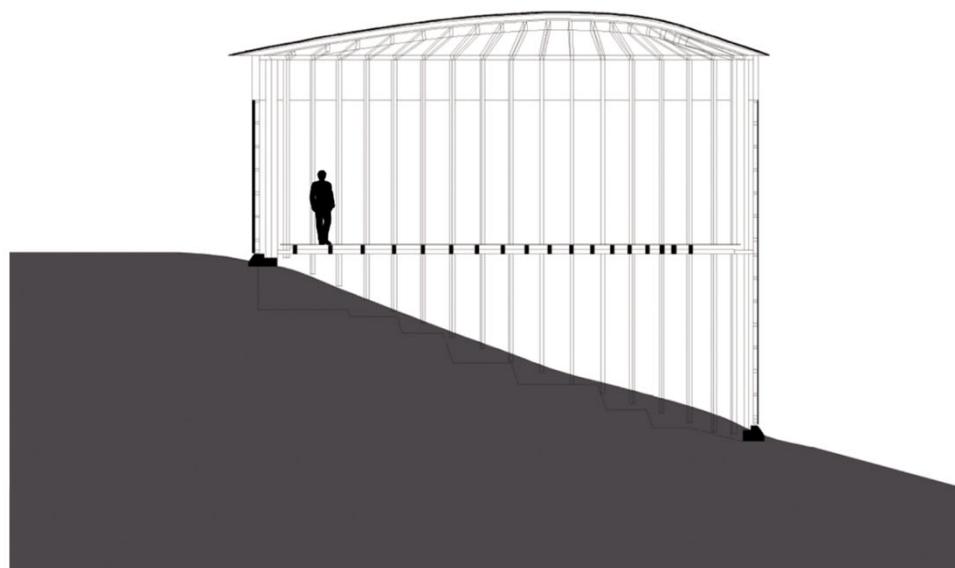
Architect: Peter Zumthor

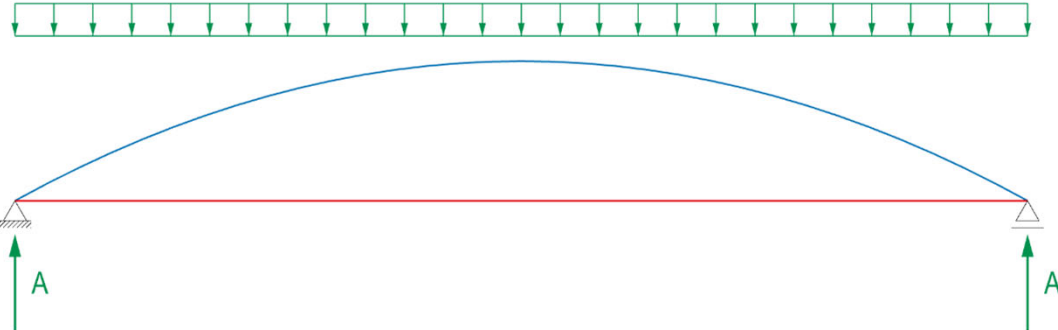
Engineer: Jürg Buchli & Jürg Conzett

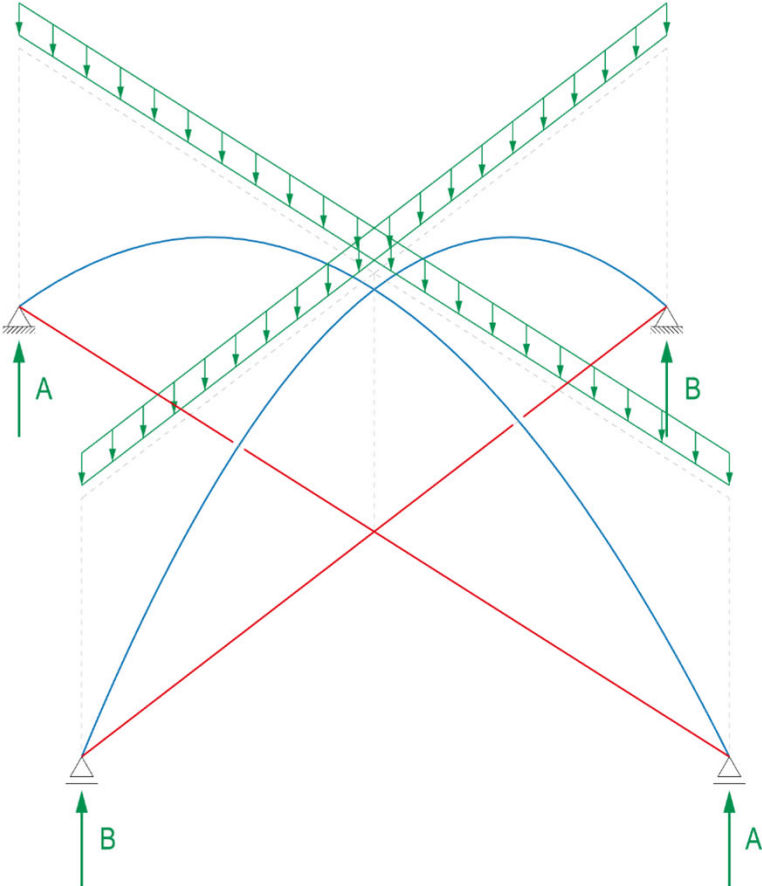


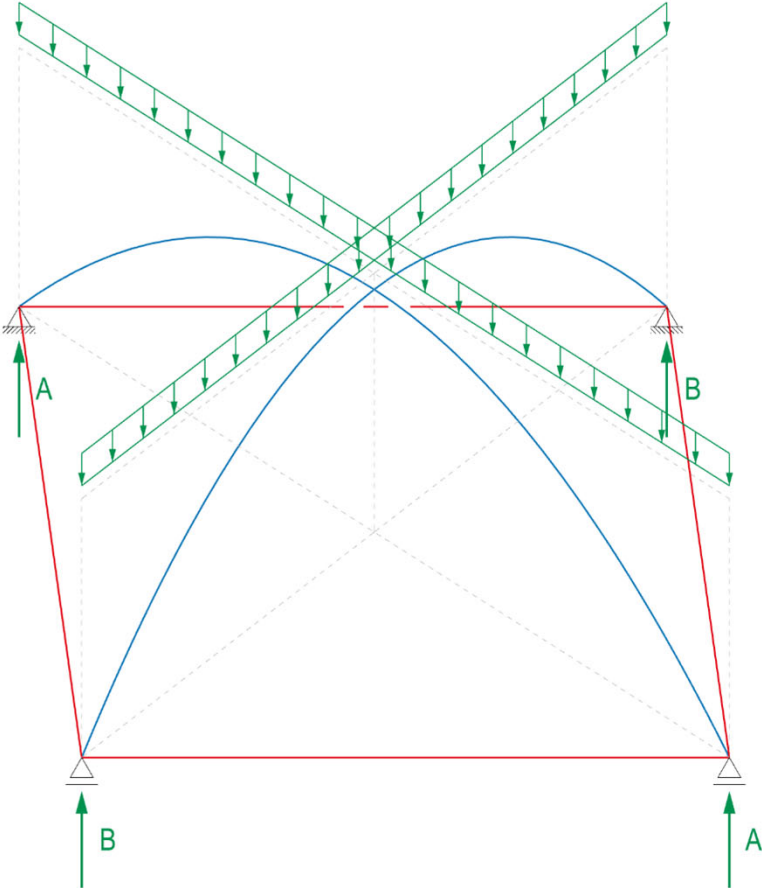


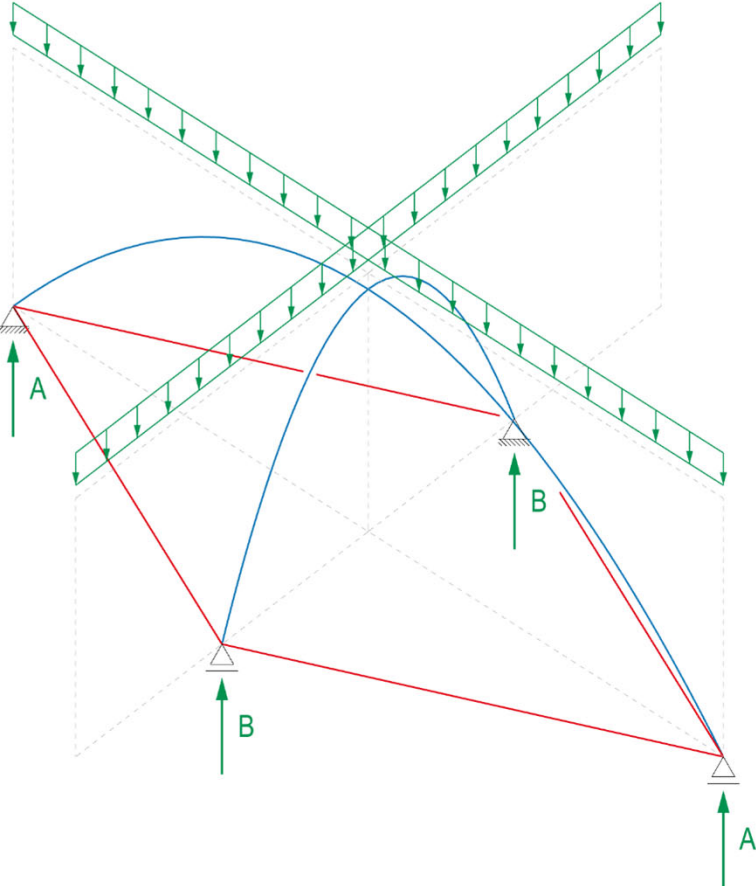


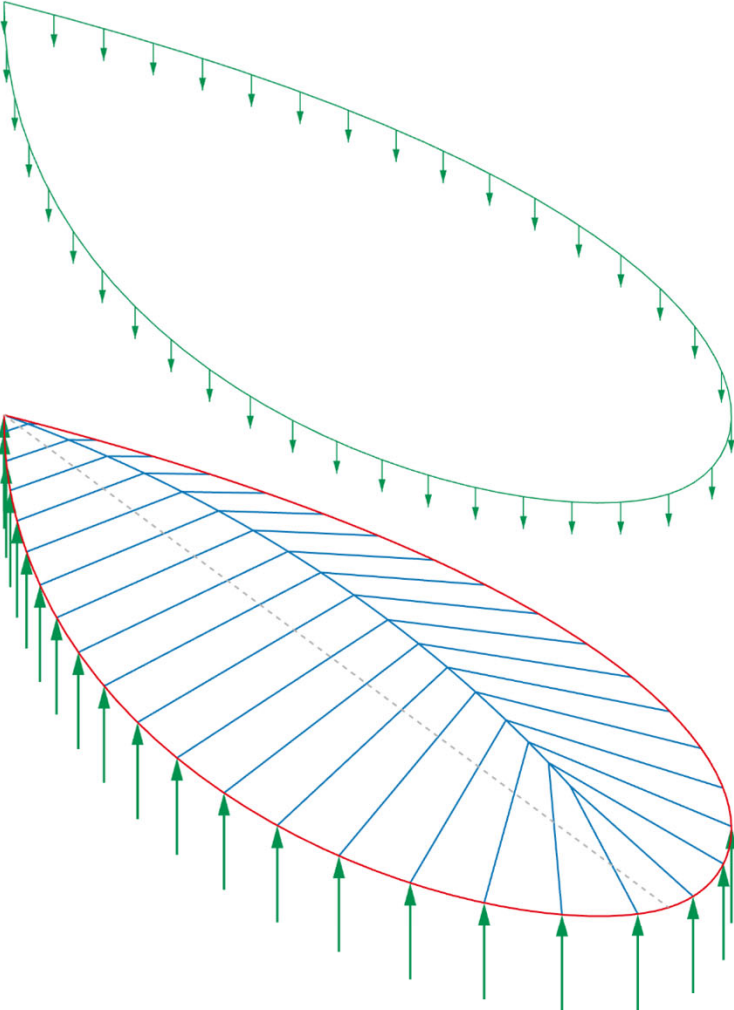


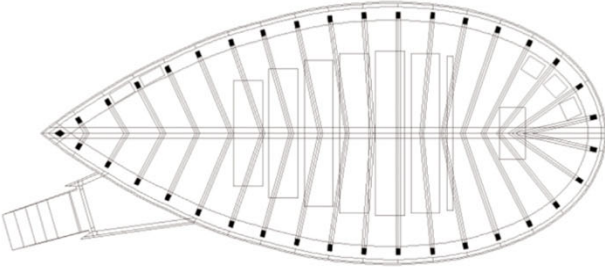


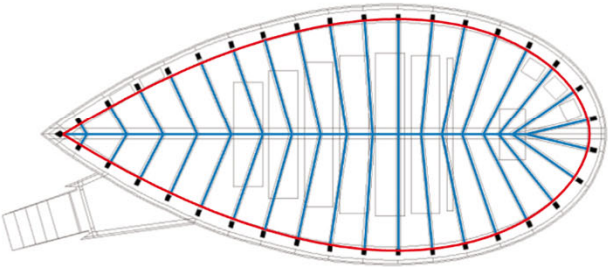
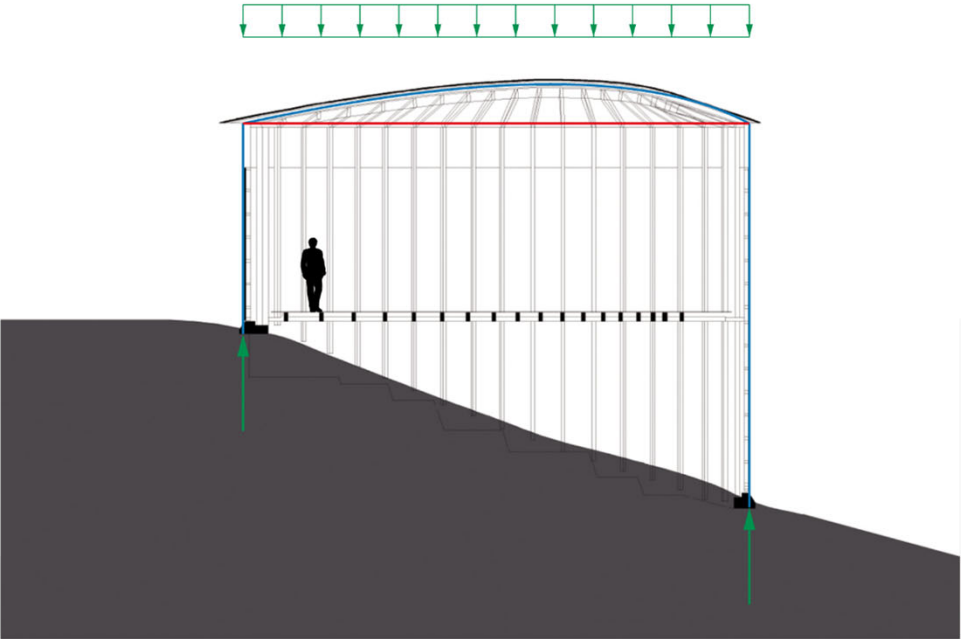


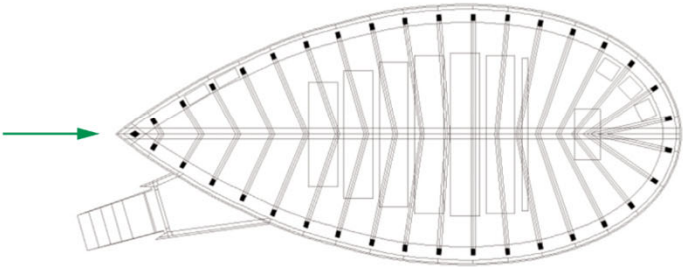
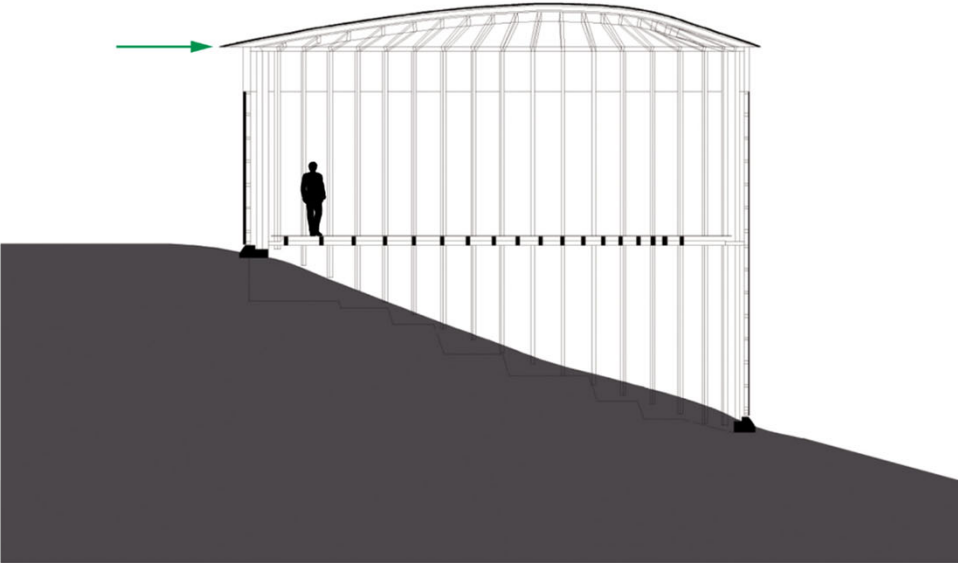


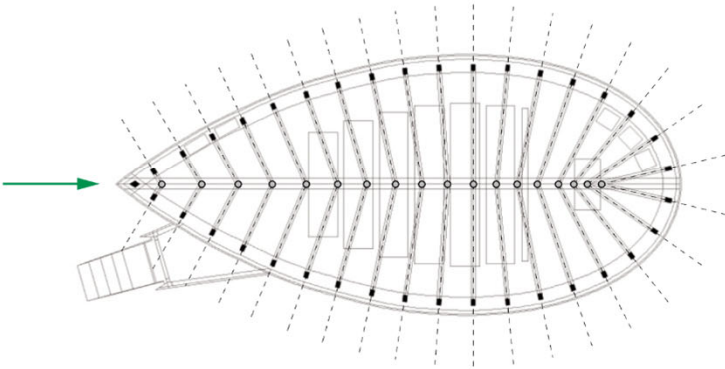
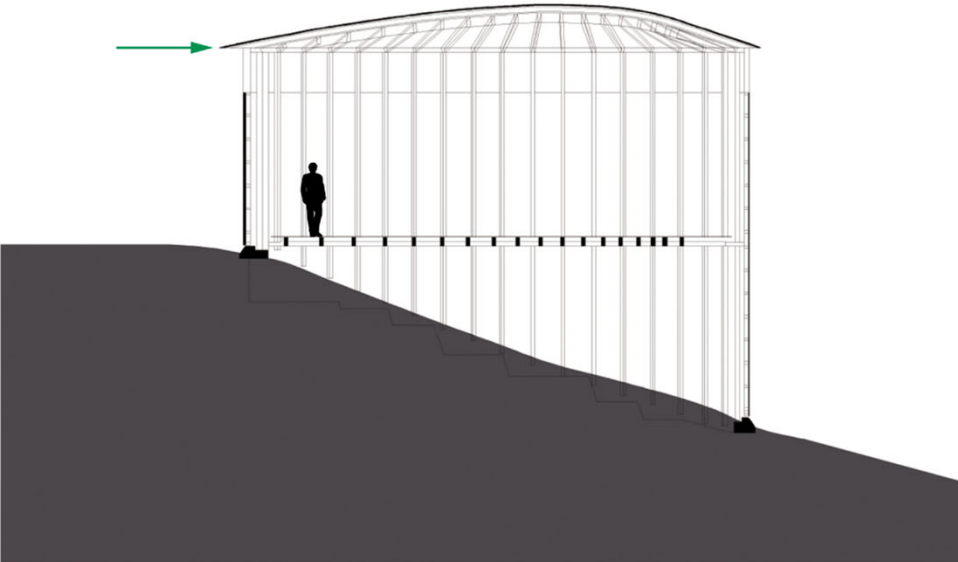


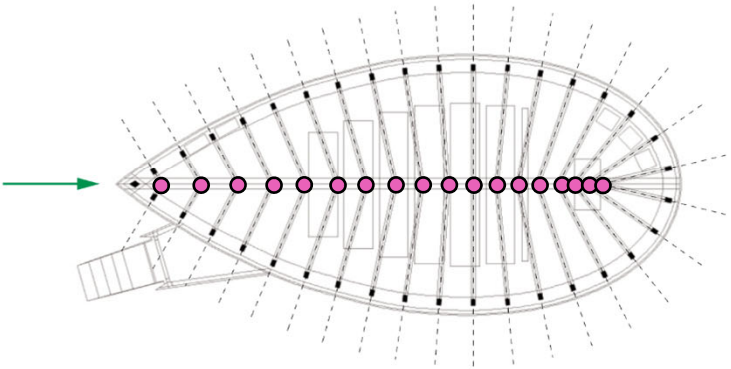
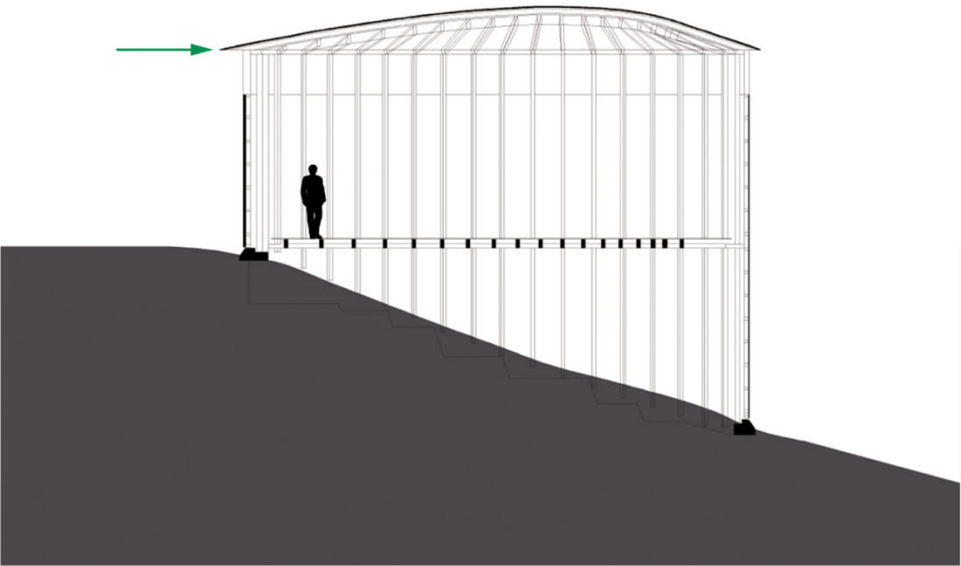














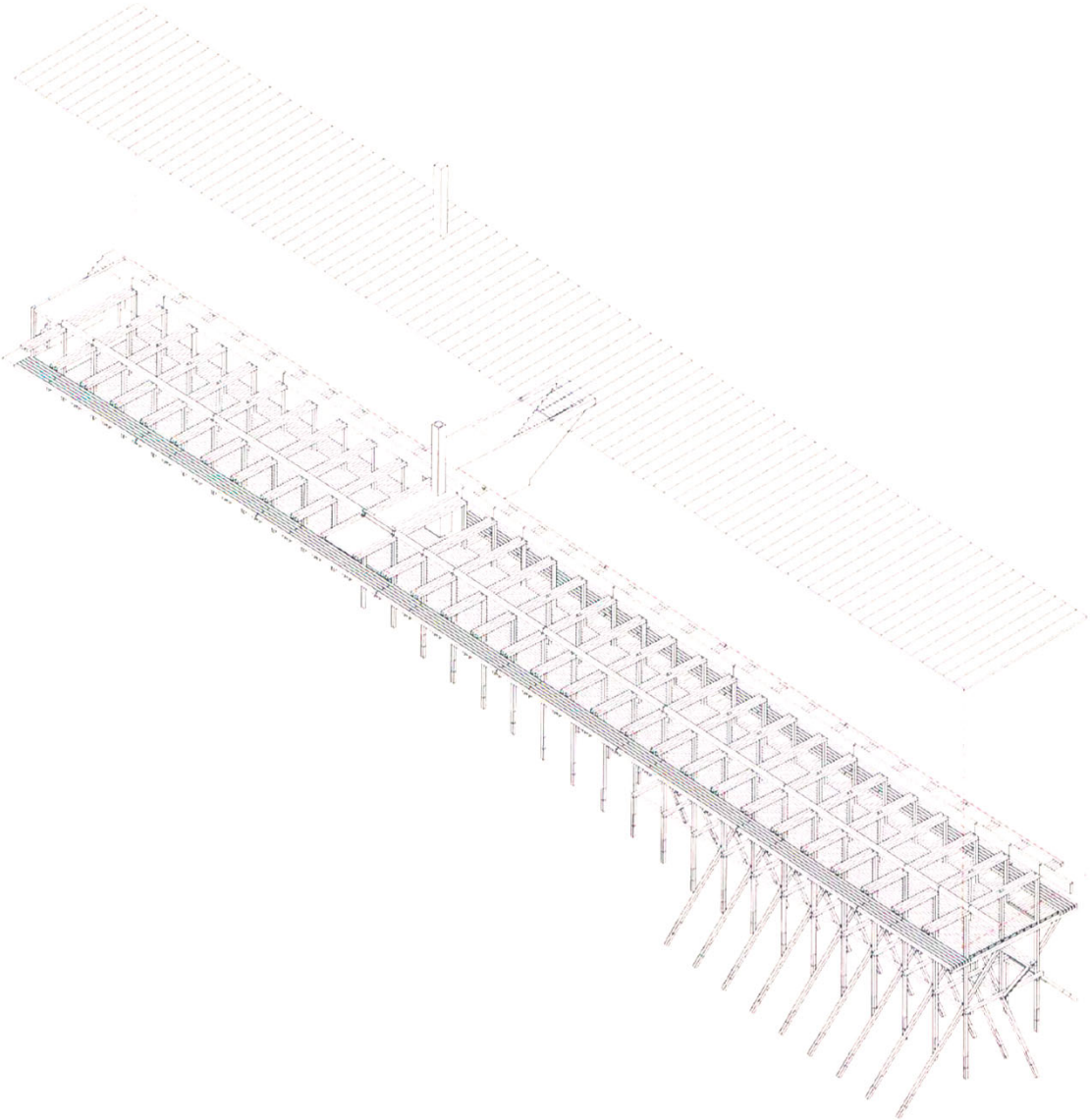
Wood House

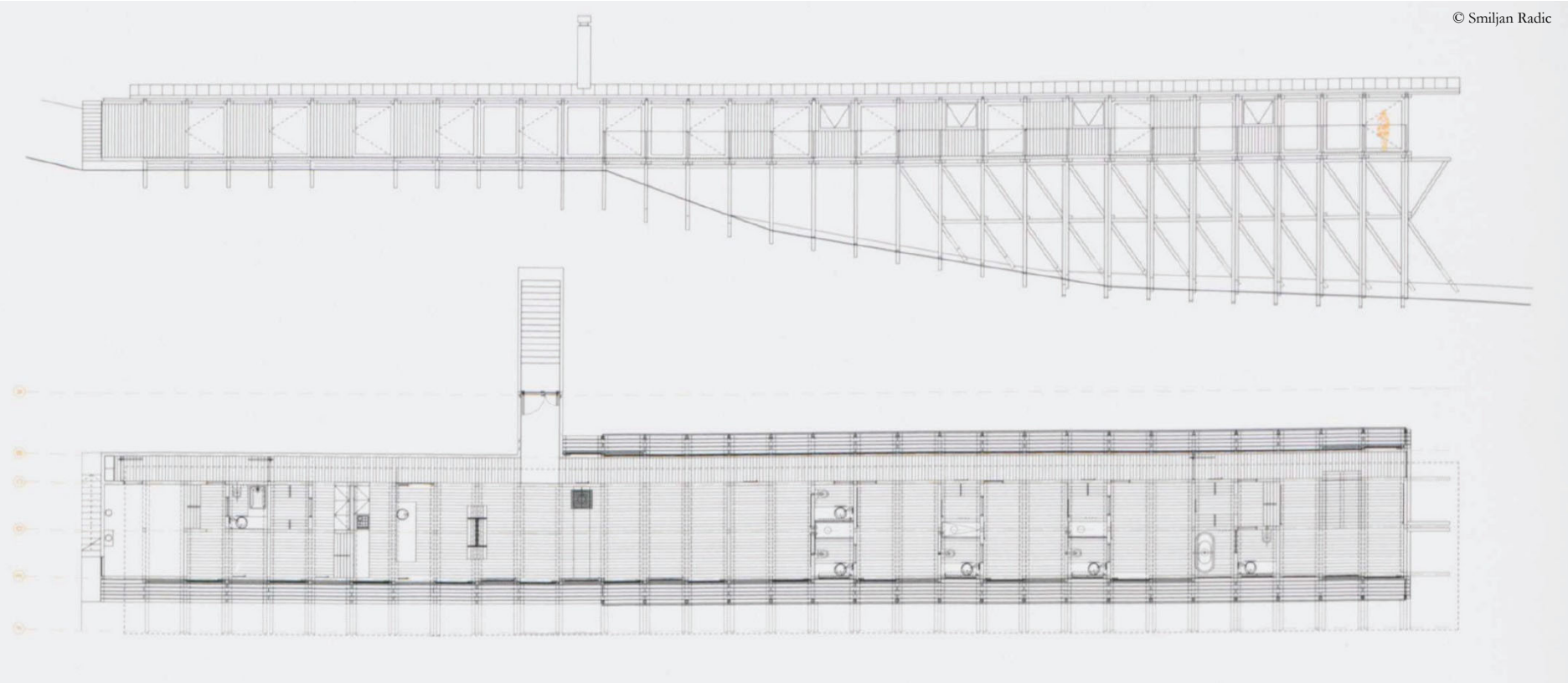
Colico Lagoon, 2014-2015

Architect: Smiljan Radic



© Smiljan Radic

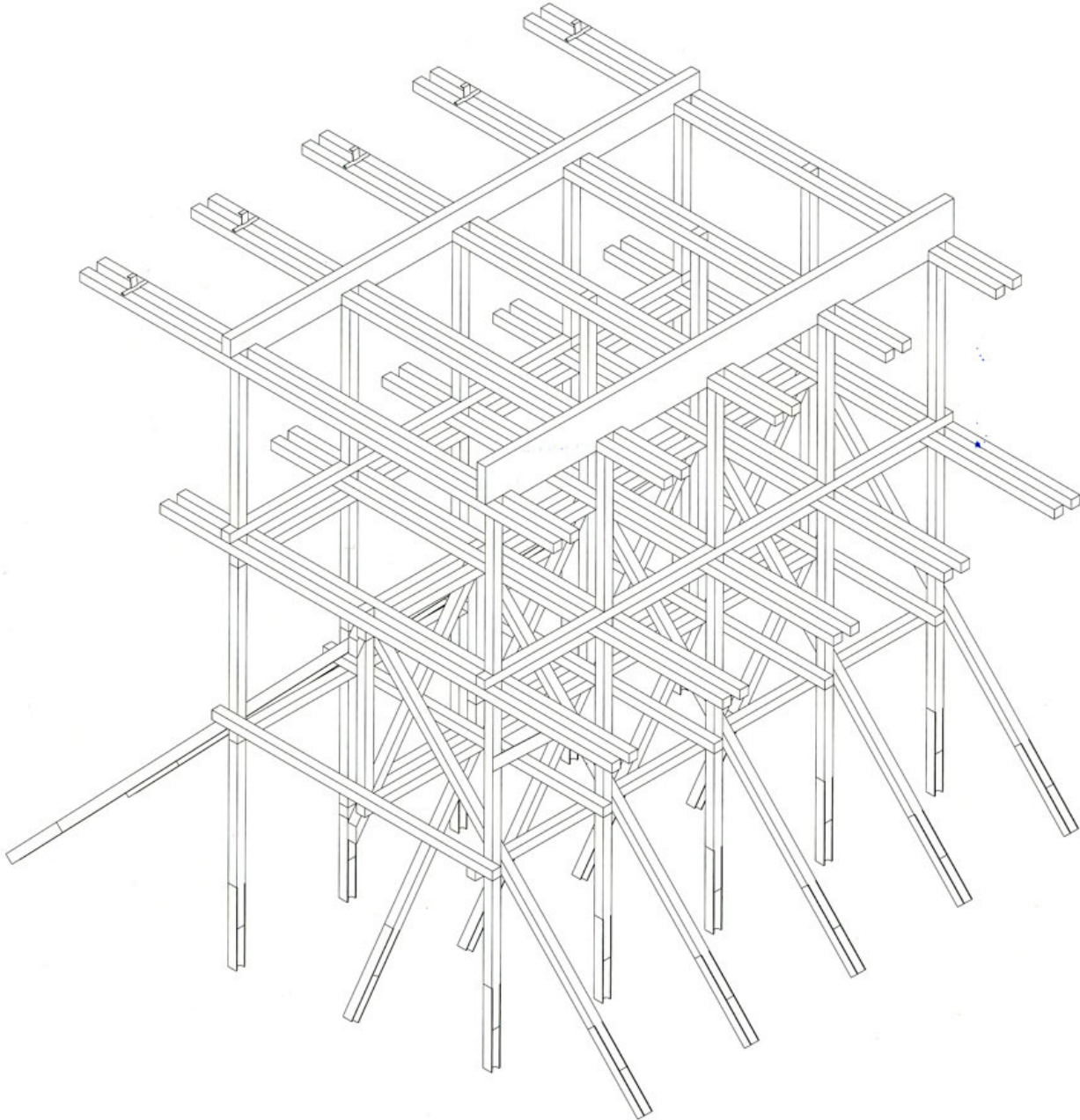




Seitenansicht und Grundriss

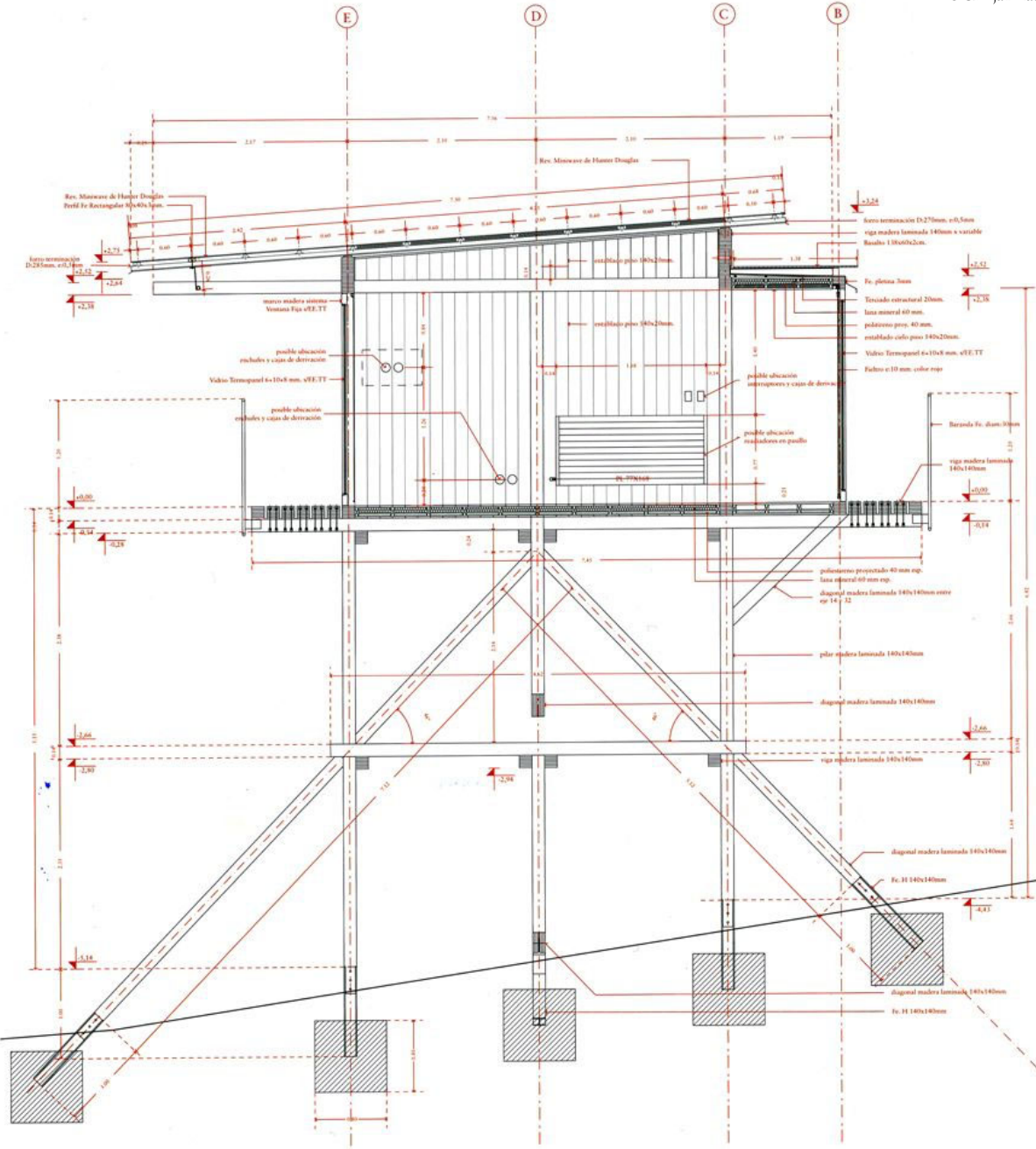
Side view and plan

© Smiljan Radic



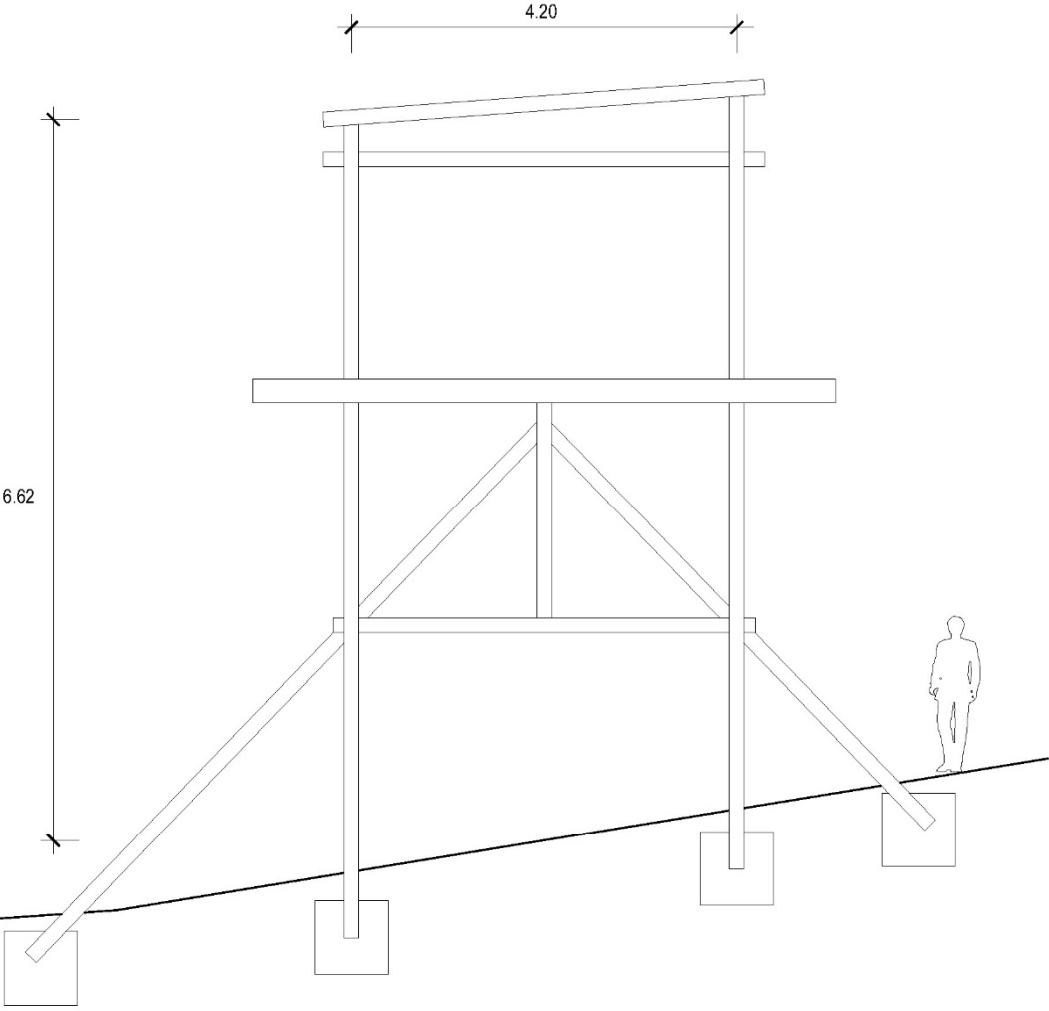


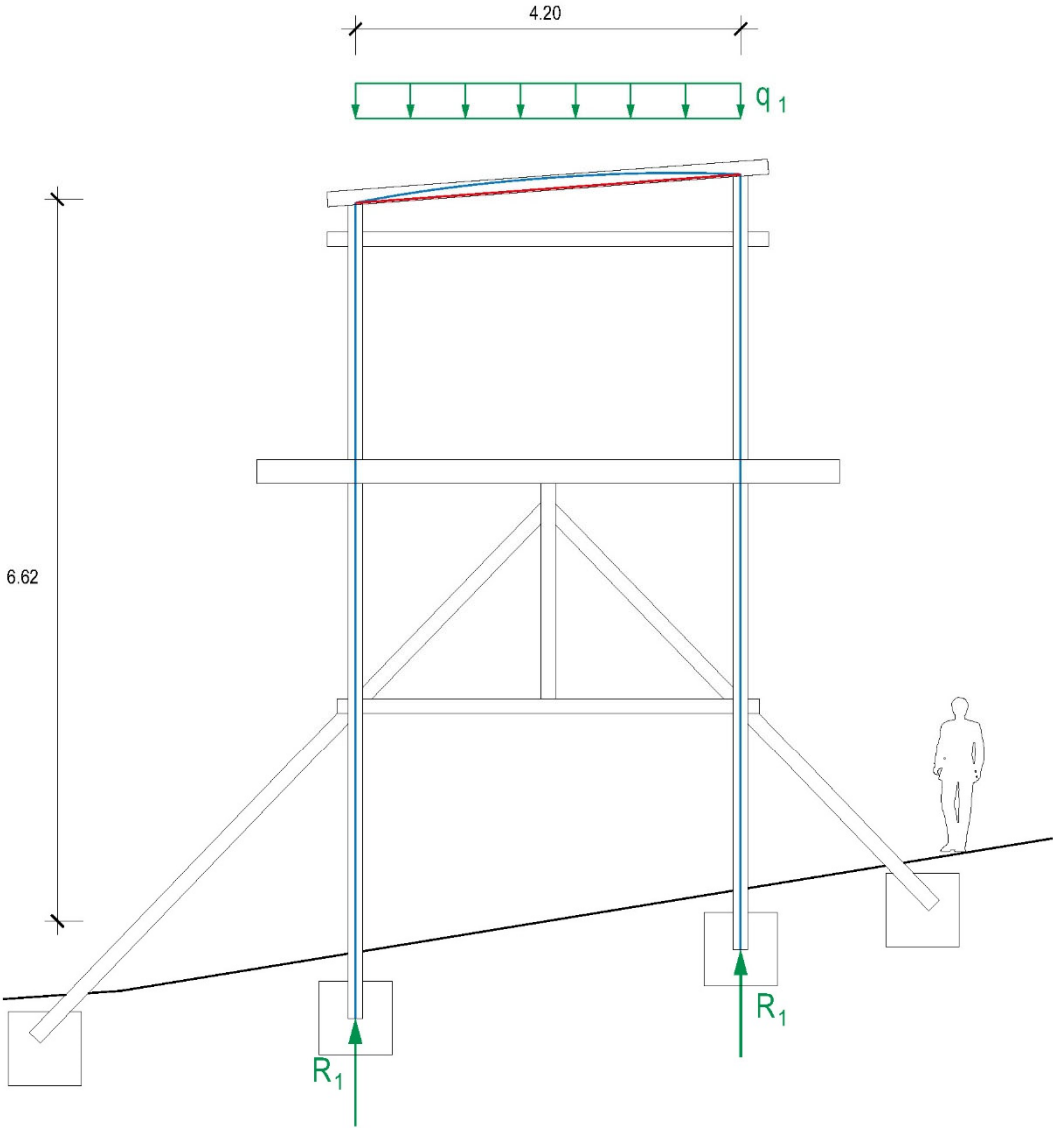
© Smiljan Radic



Querschnitt

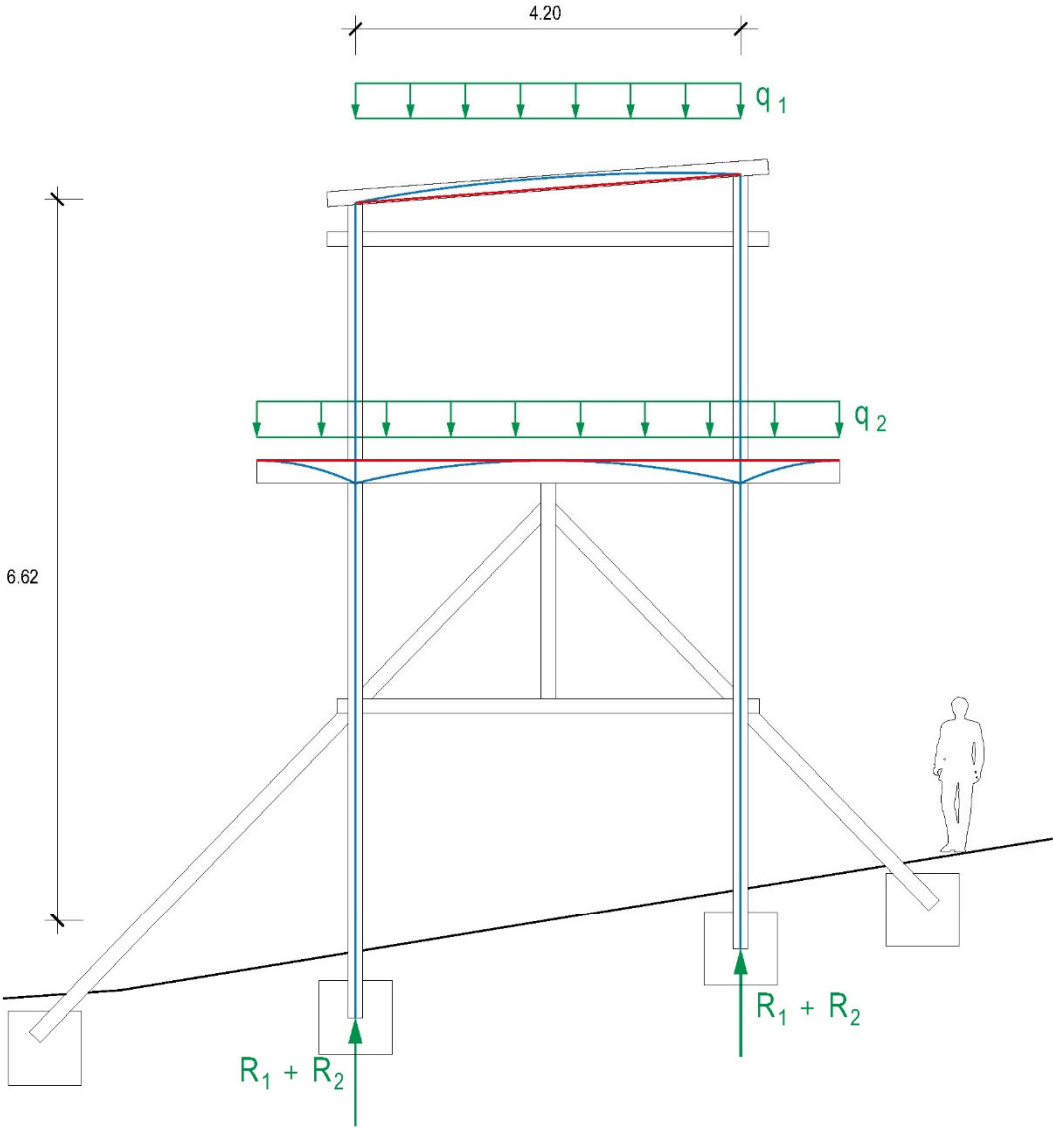
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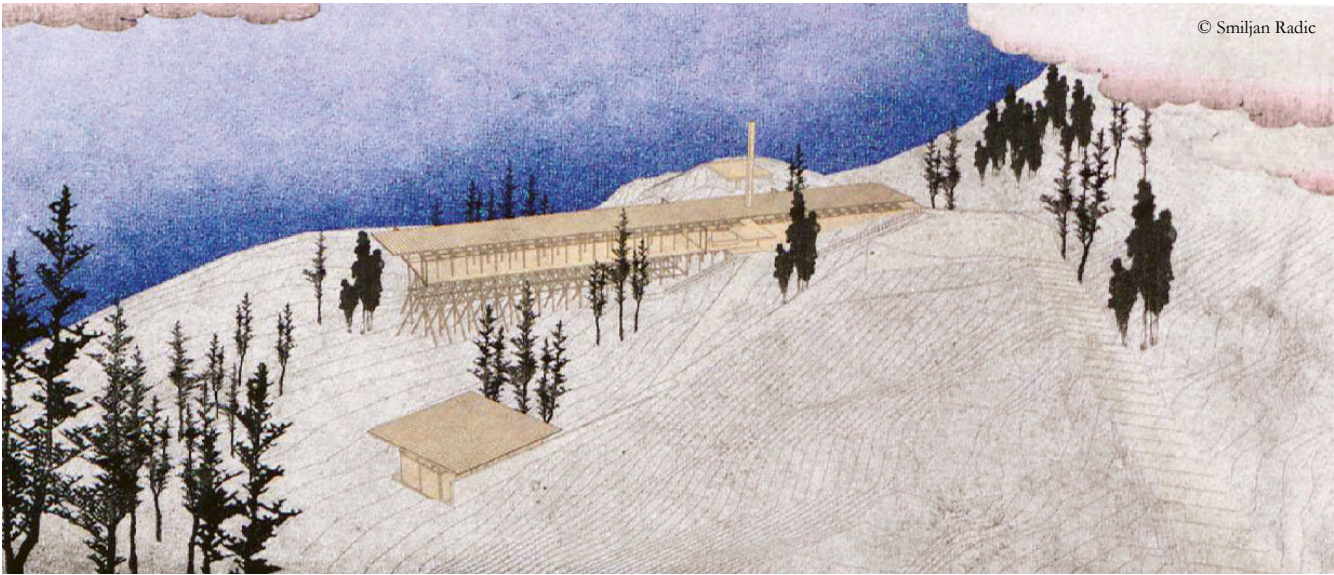


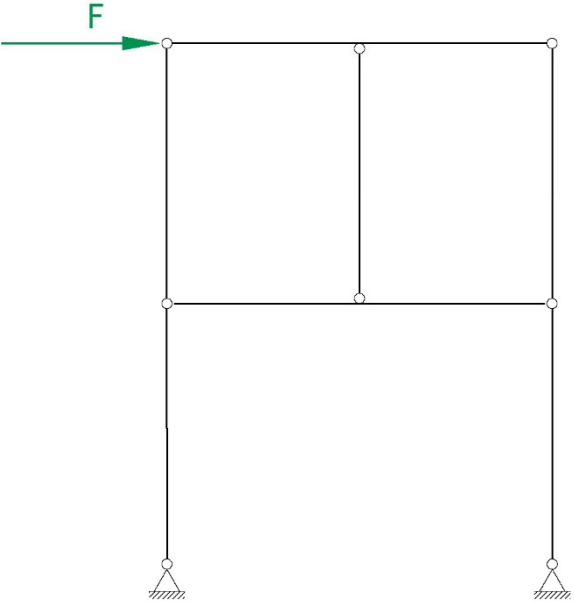
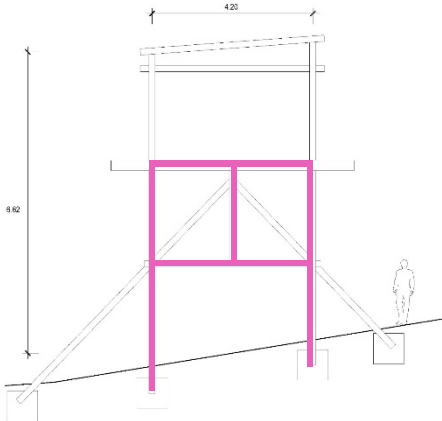


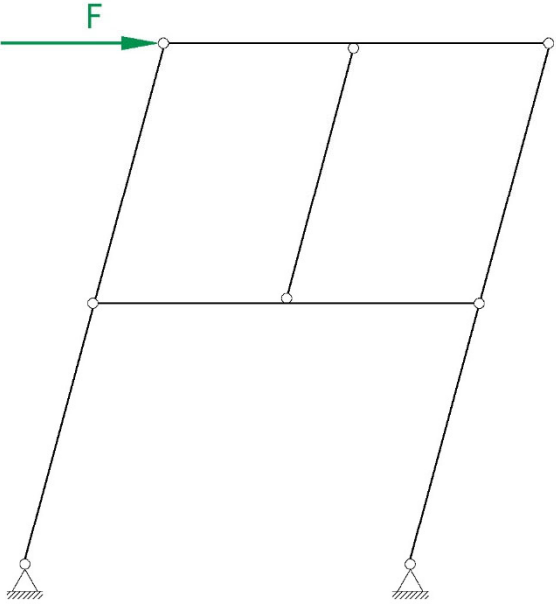
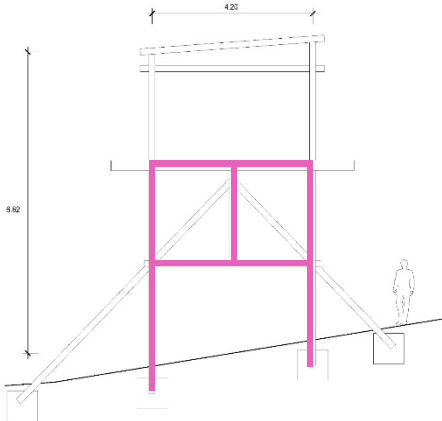
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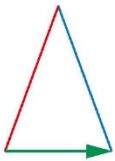
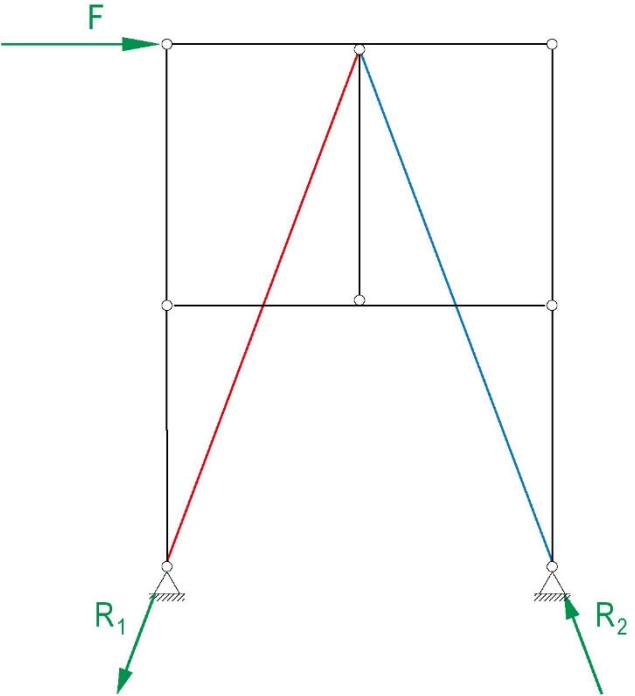
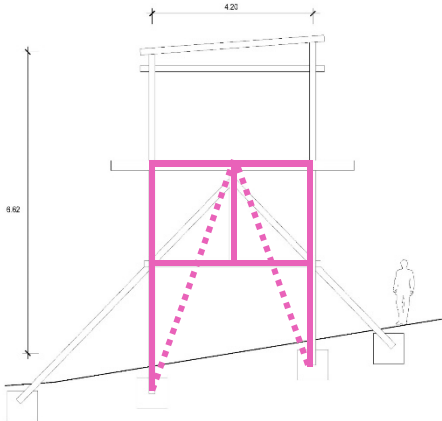
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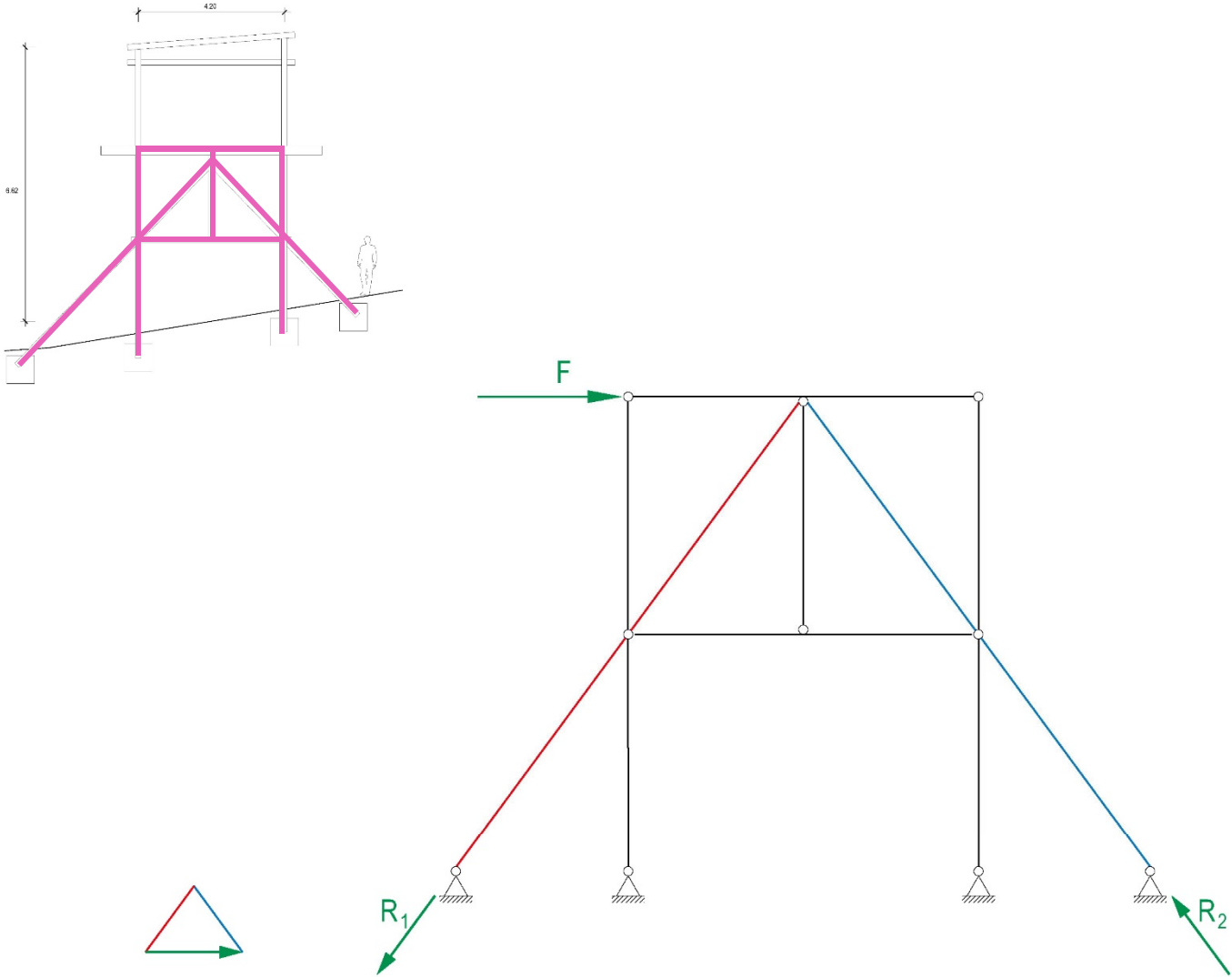


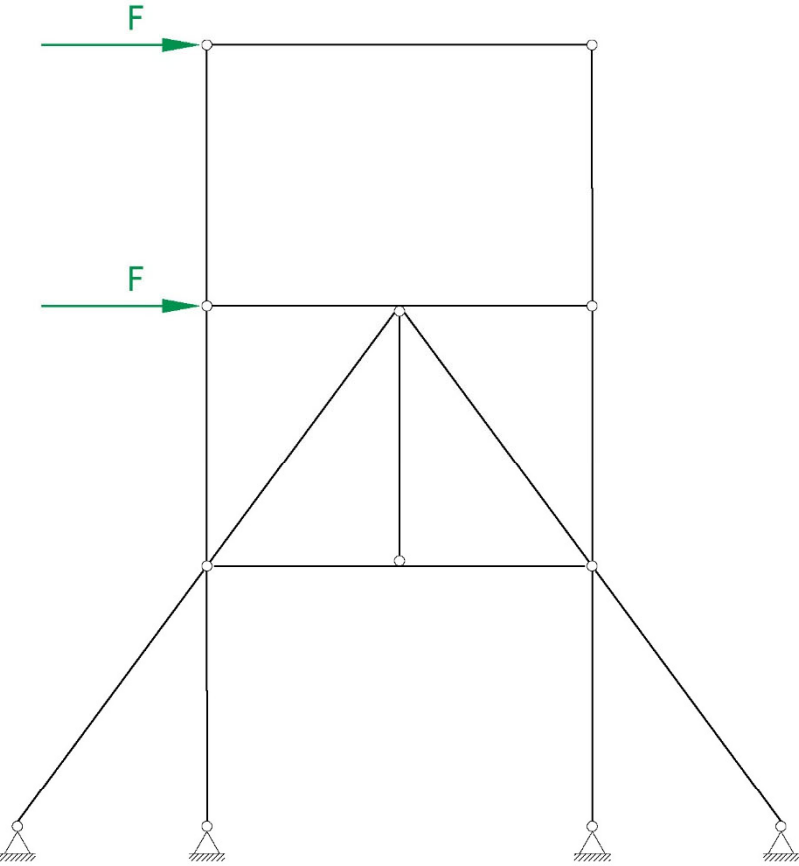
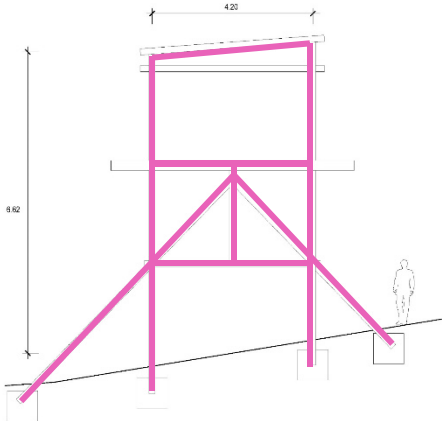


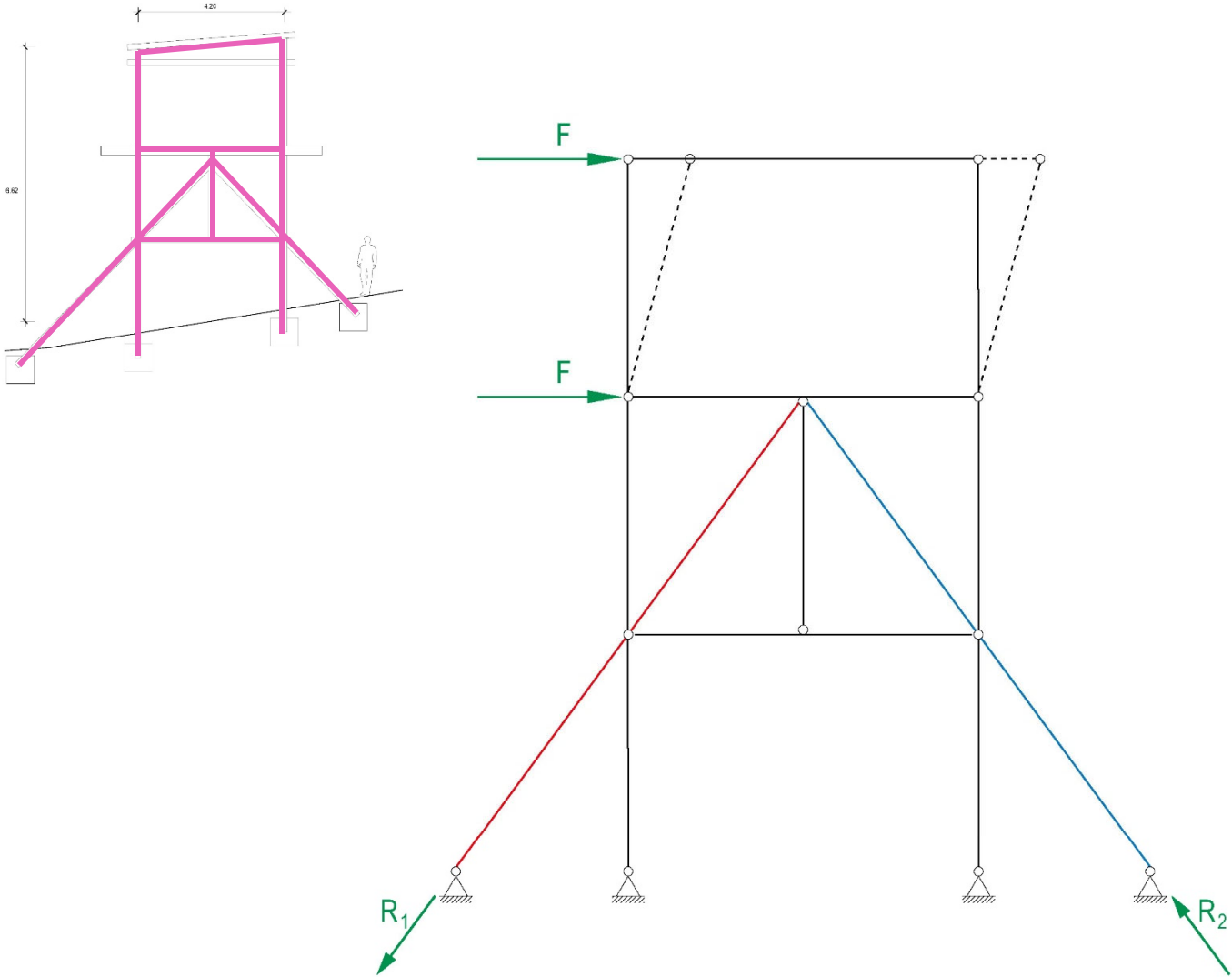


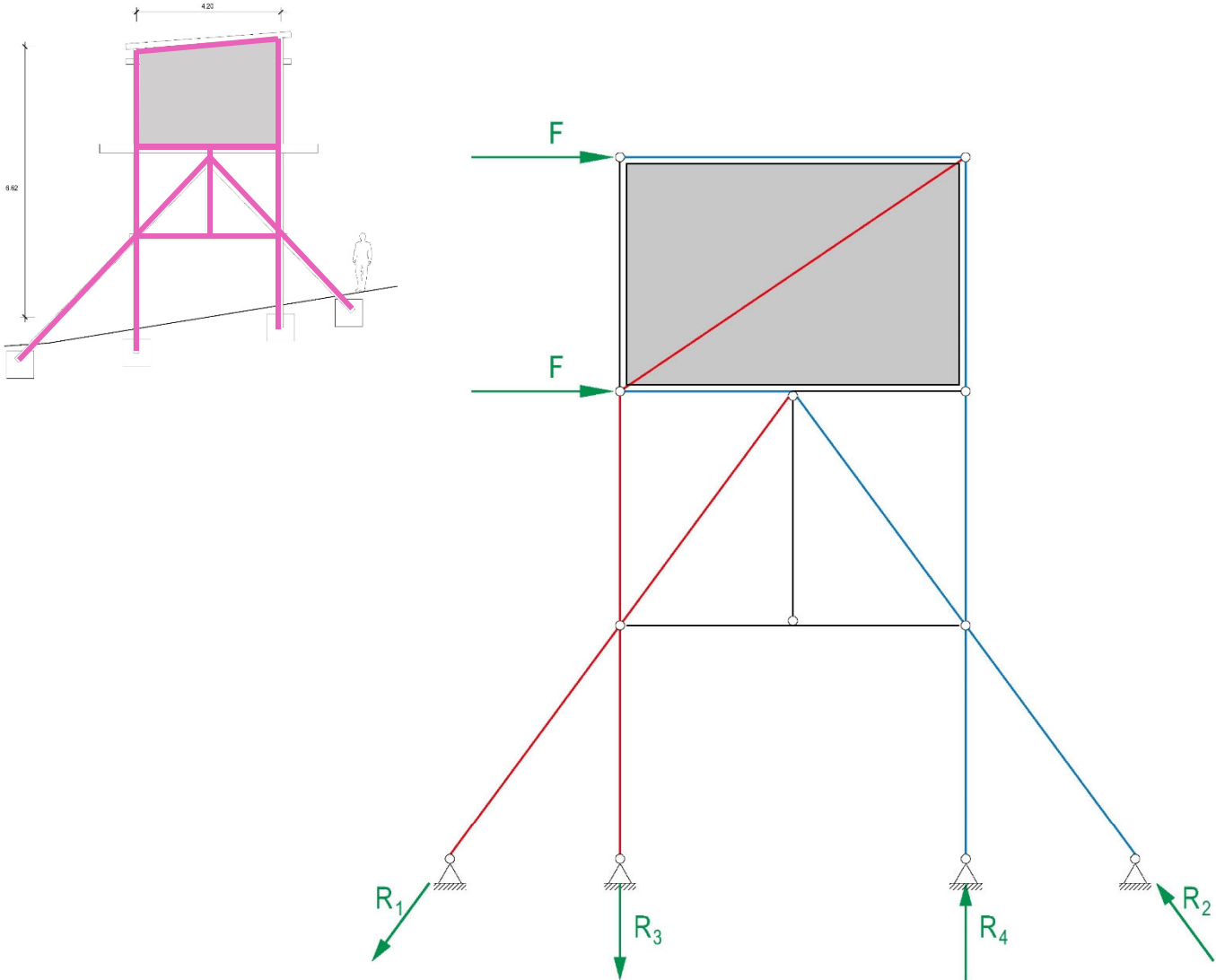


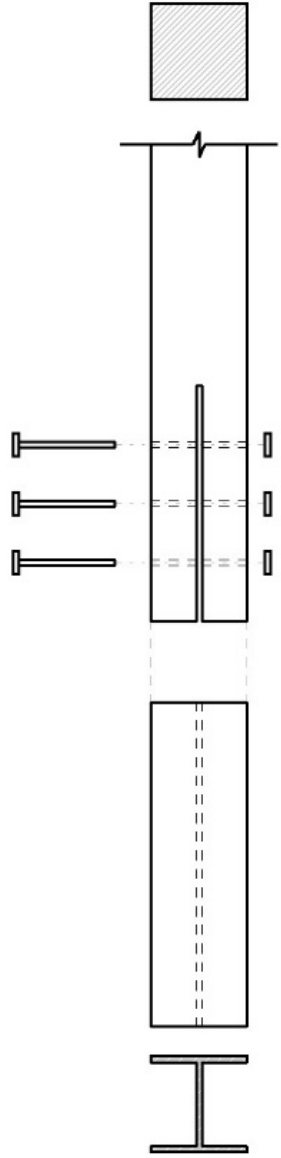
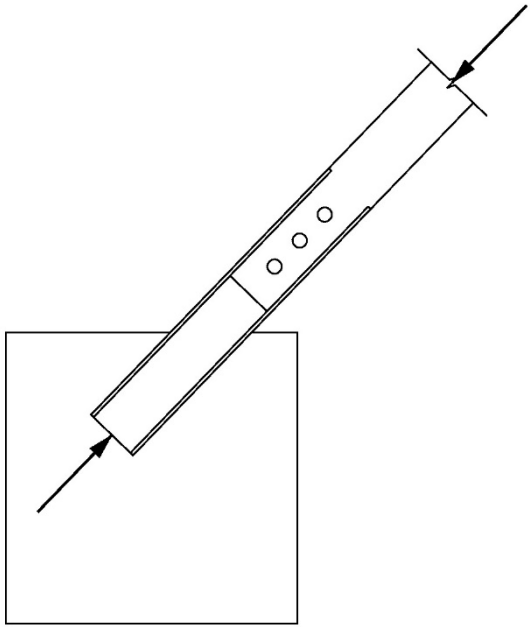


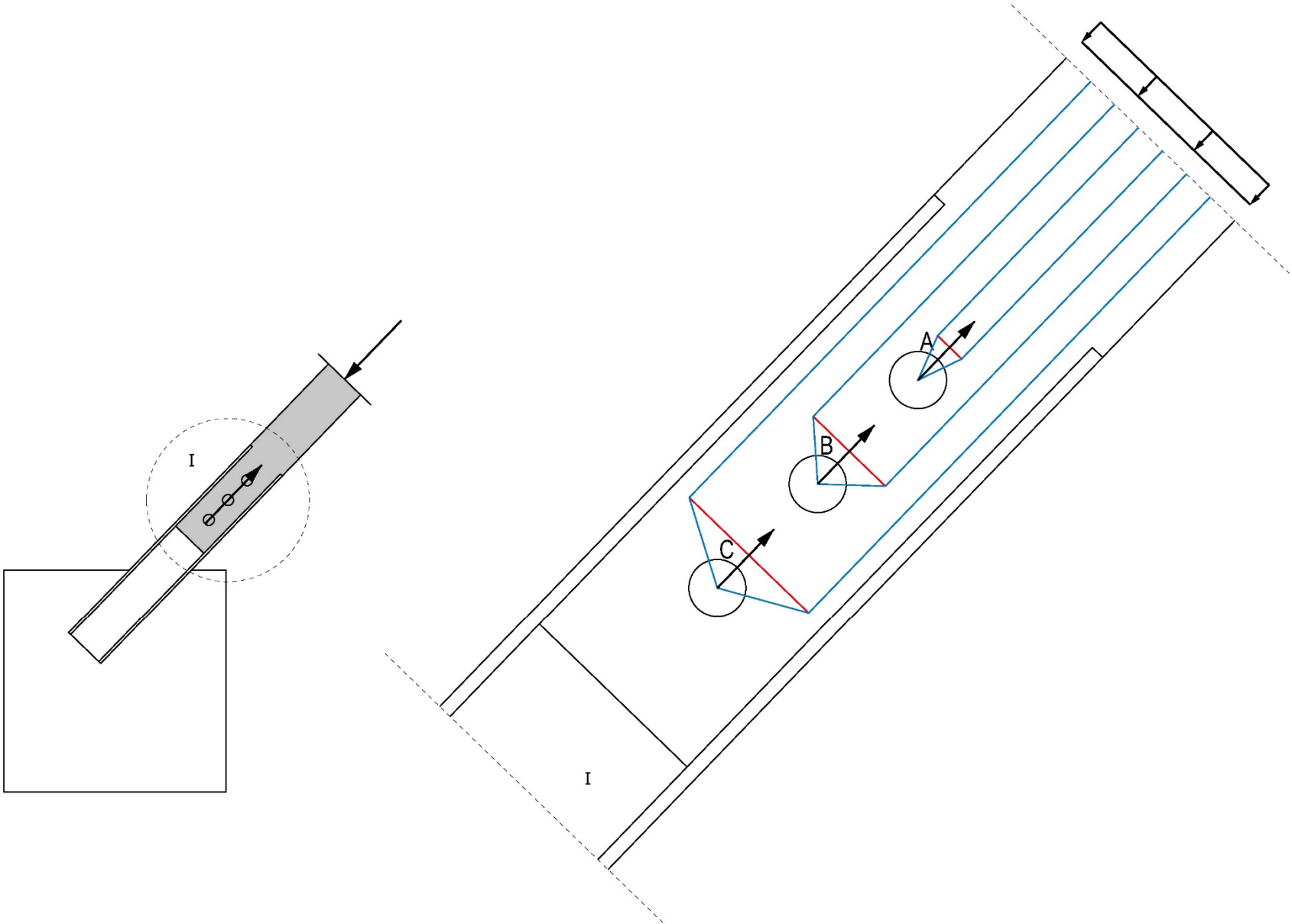


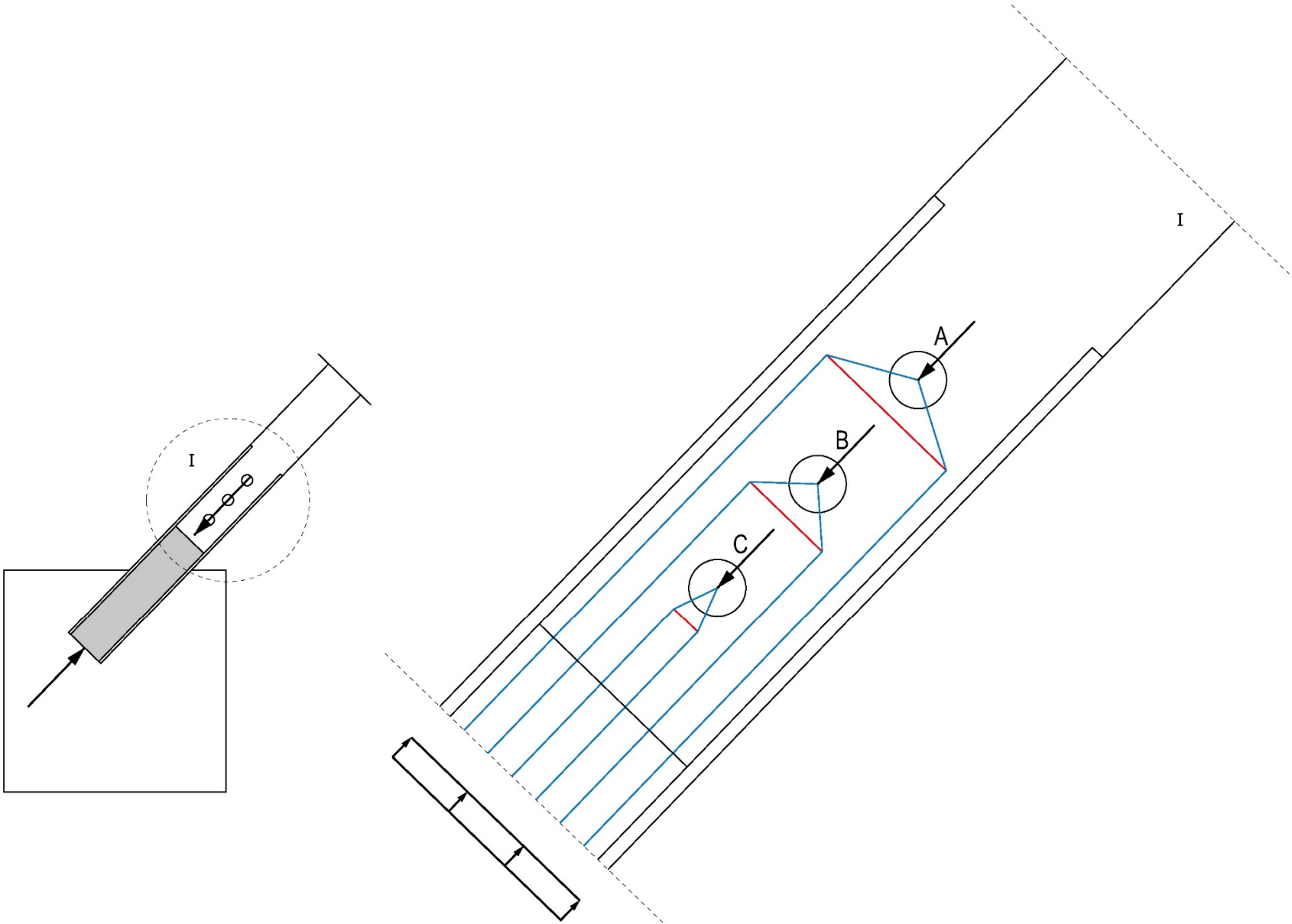












Nine Bridges Country Club

Jeju Island (South Korea), 2009

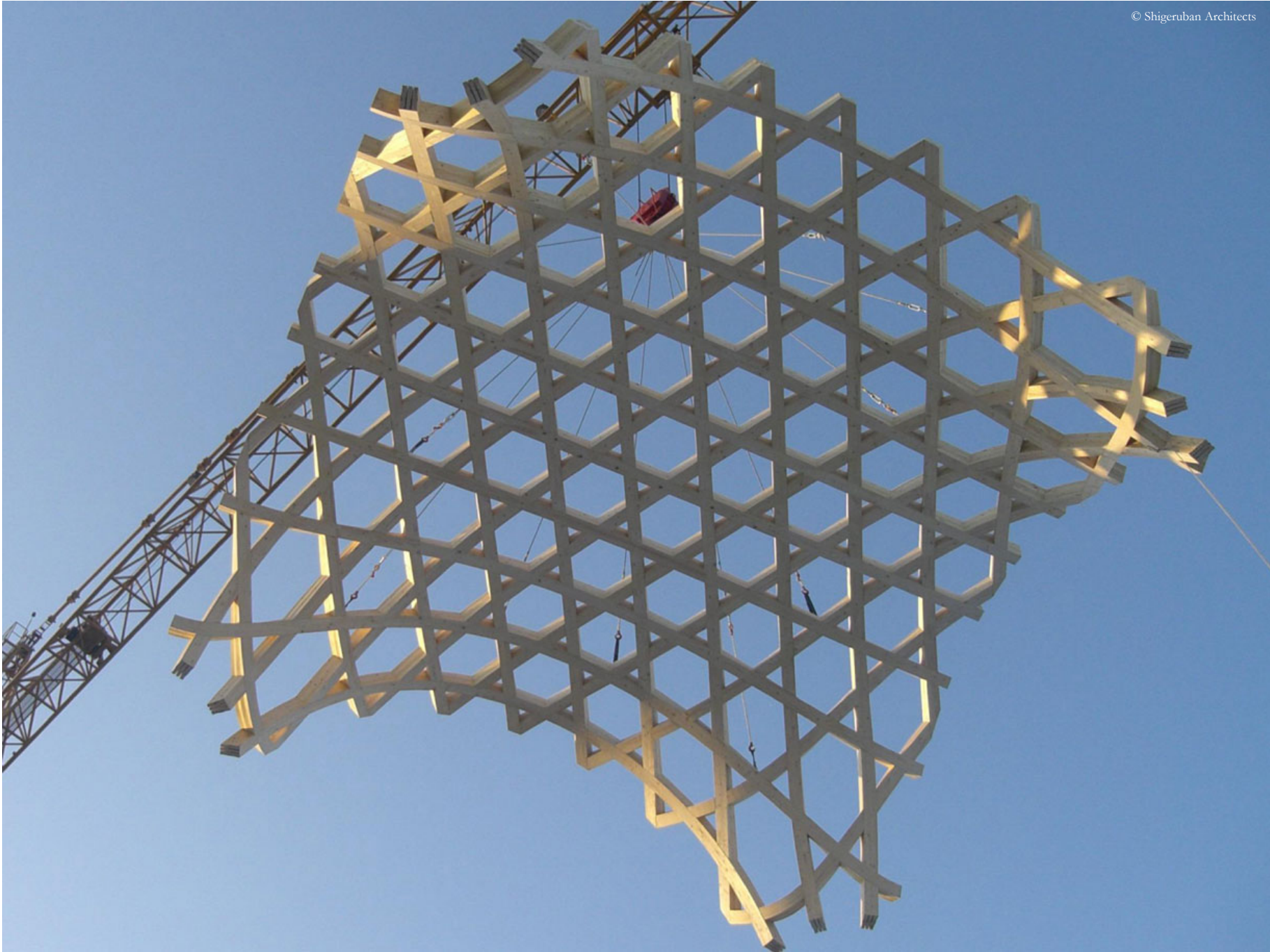
Architect: Shigeru Ban

Engineer: Blumer Lehmann

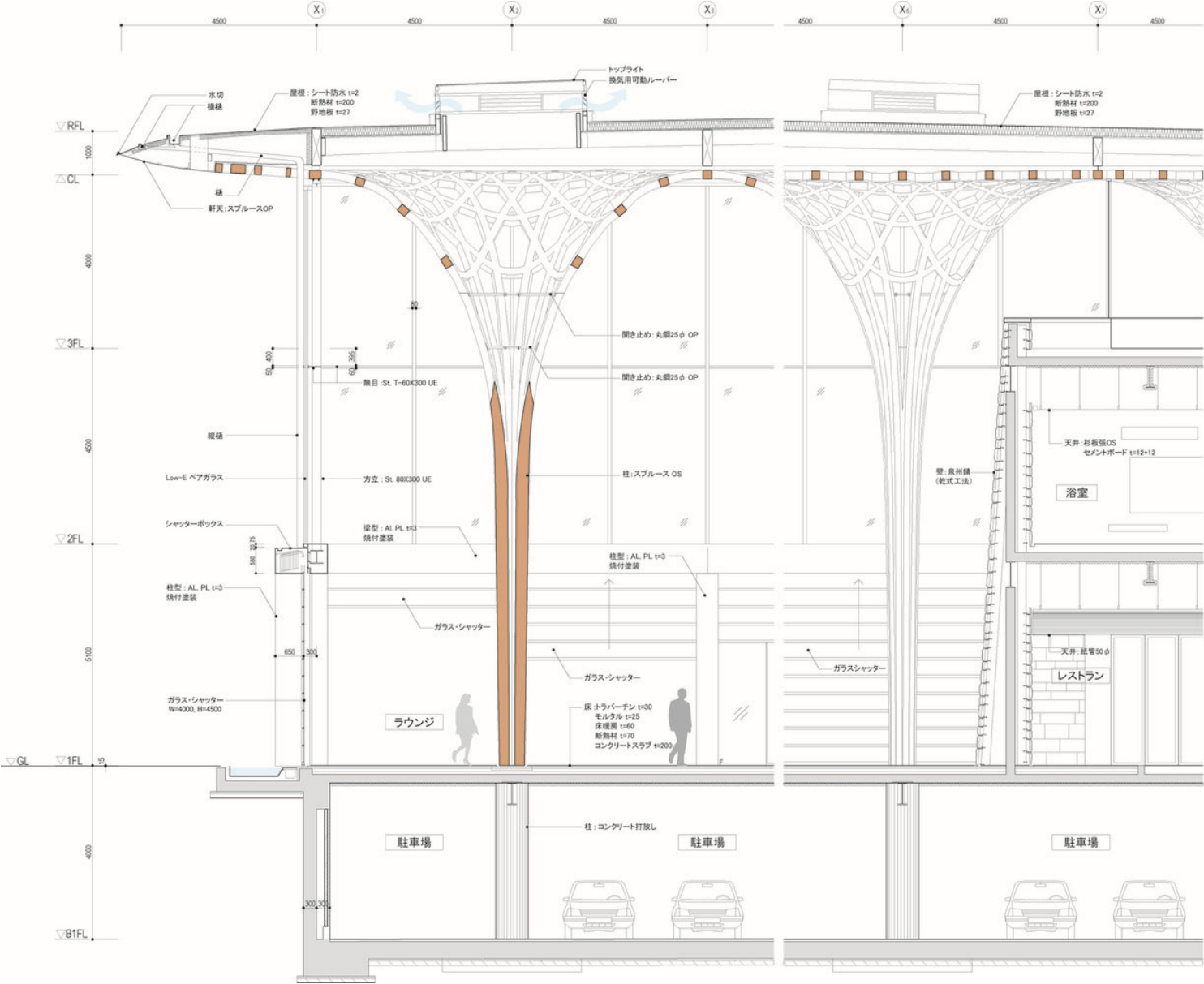


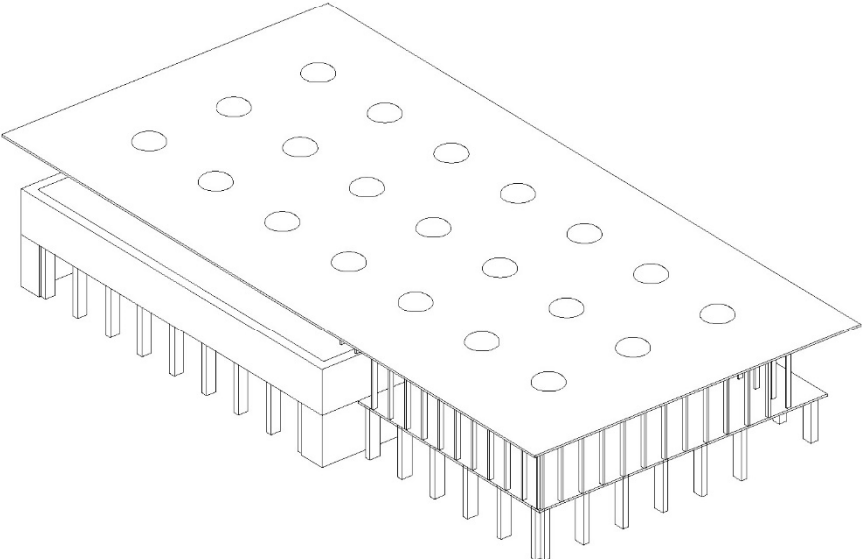






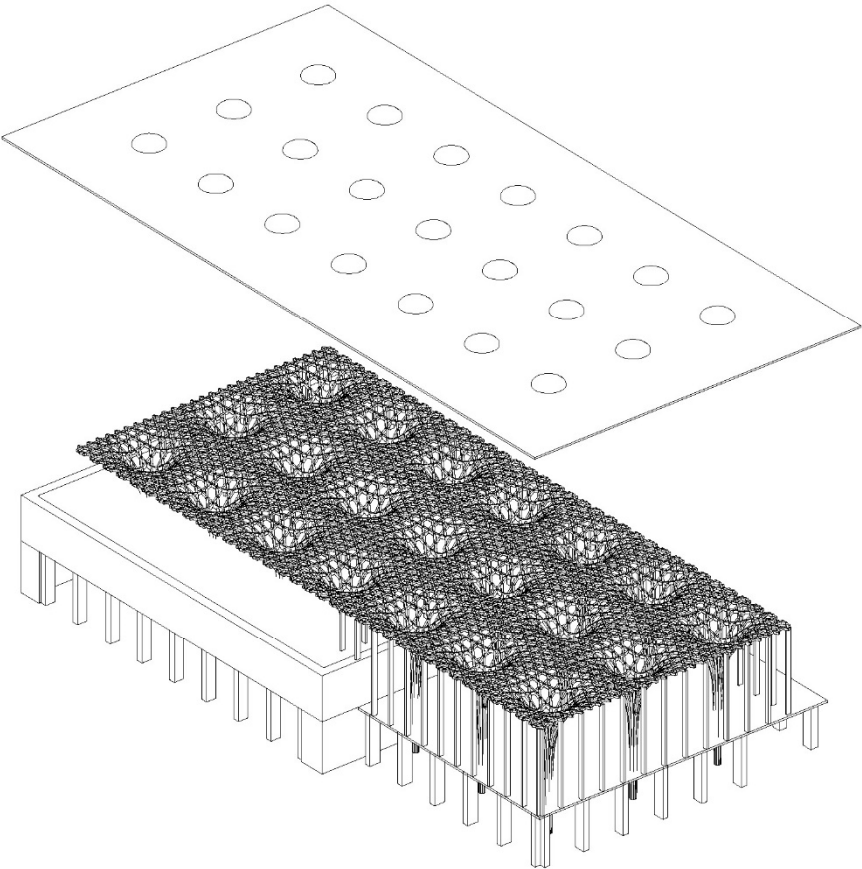






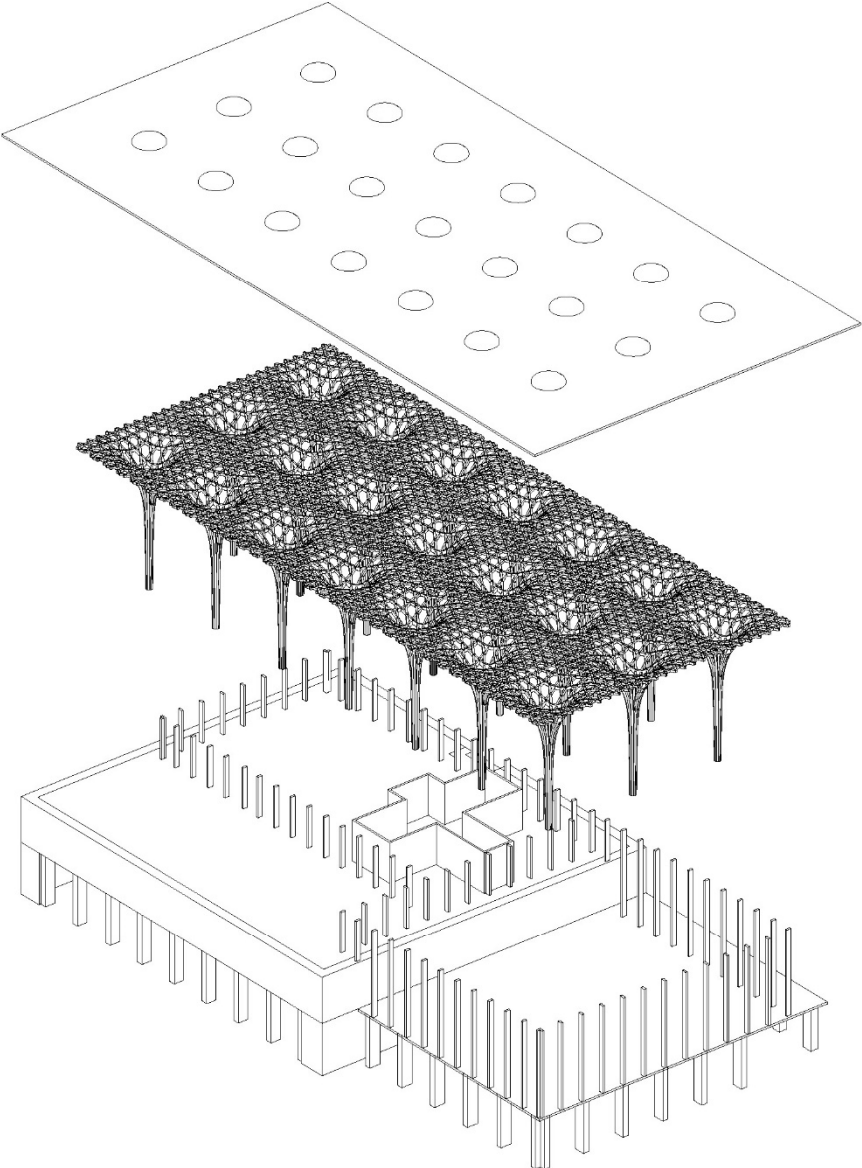
Axonometrische Ansicht

Axonometric view



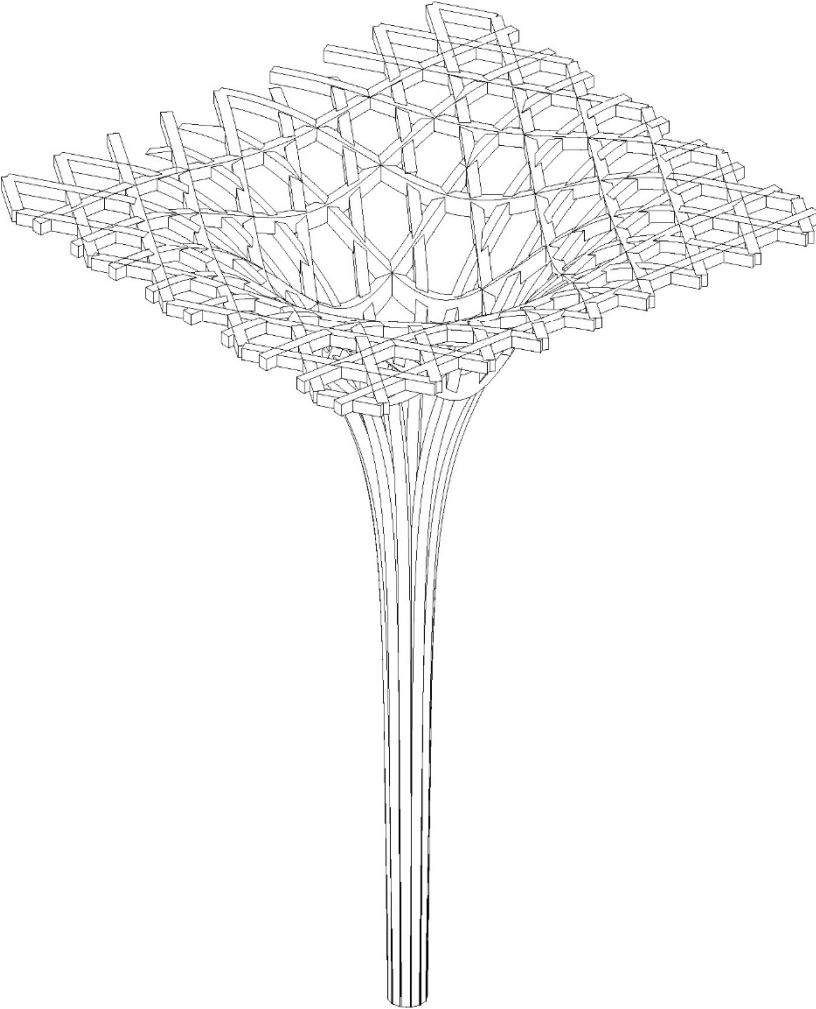
Axonometrische Ansicht

Axonometric view

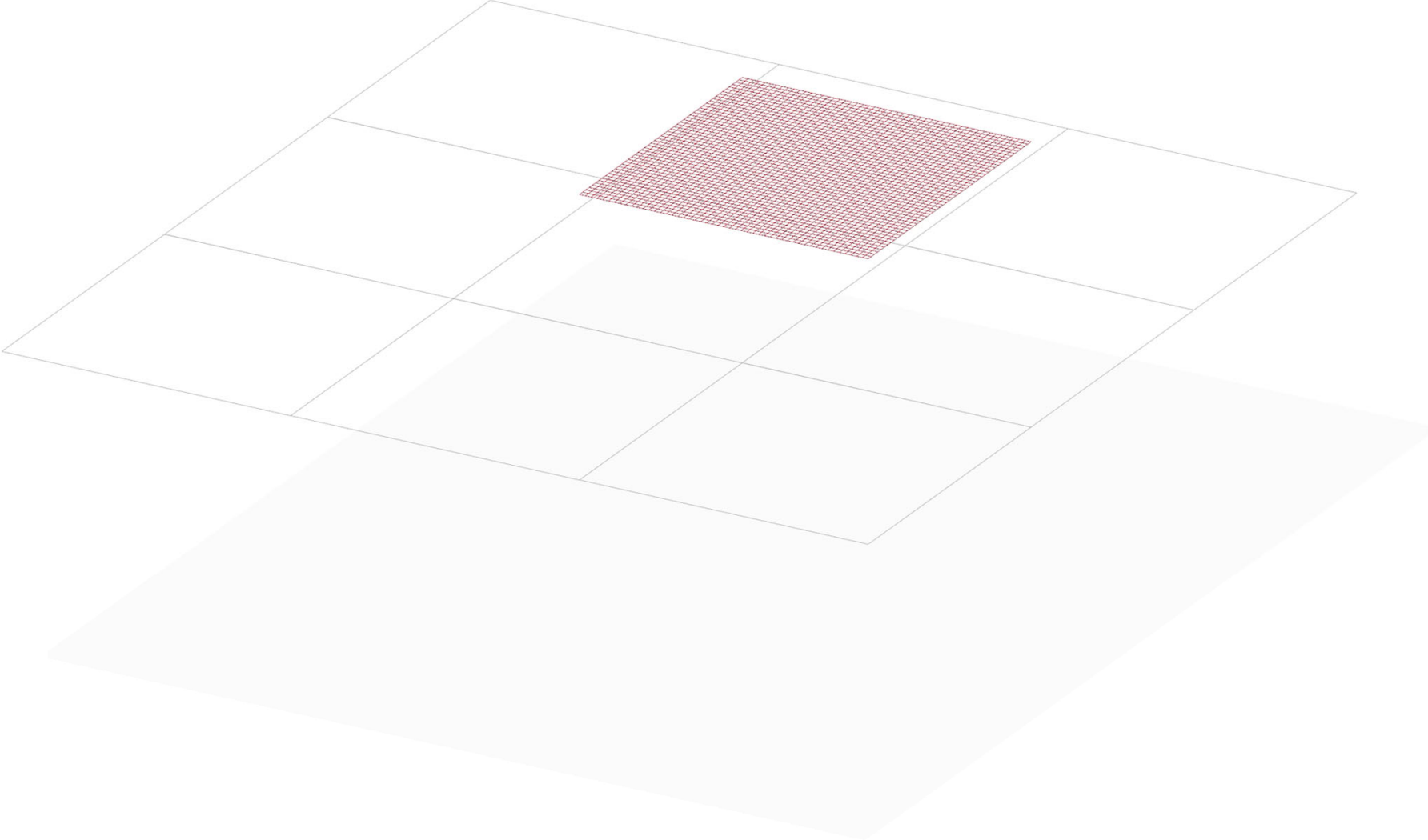


Axonometrische Ansicht

Axonometric view



Selected Projects



Form-finding principle of the module

