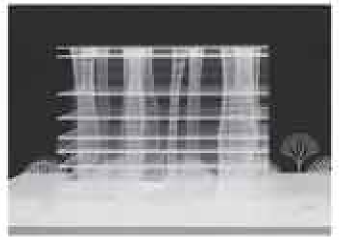
Tragwerksentwurf III

Structural Design III

Joseph Schwartz · Philippe Block

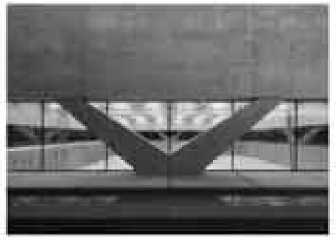


Architektur und Tragwerk

Architecture and Structure

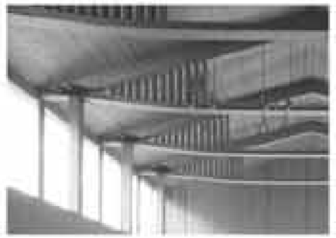
1. Stahl

1. Steel



2. Stahlbeton

2. Reinforced concrete

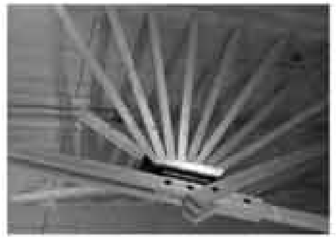


3. Holz

3. Timber

4. Mauerwerk

4. Masonry



5. Konstruktiondetails

5. Construction details

Tragwerksentwurf III

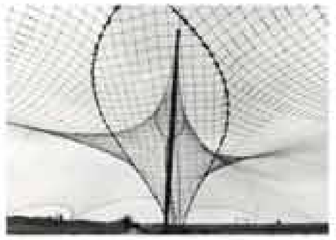
Structural Design III

Tragwerksentwurf IV

Structural Design IV

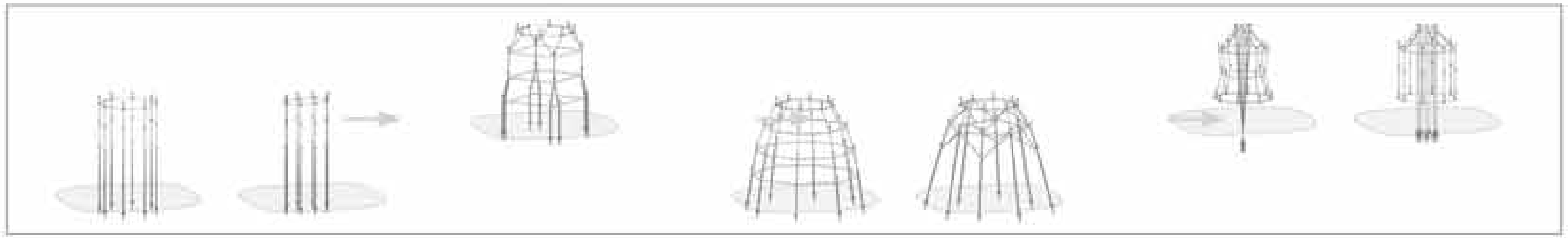
Entwerfen von Tragwerken I

Design of structures I



Entwerfen von Tragwerken II

Design of structures II



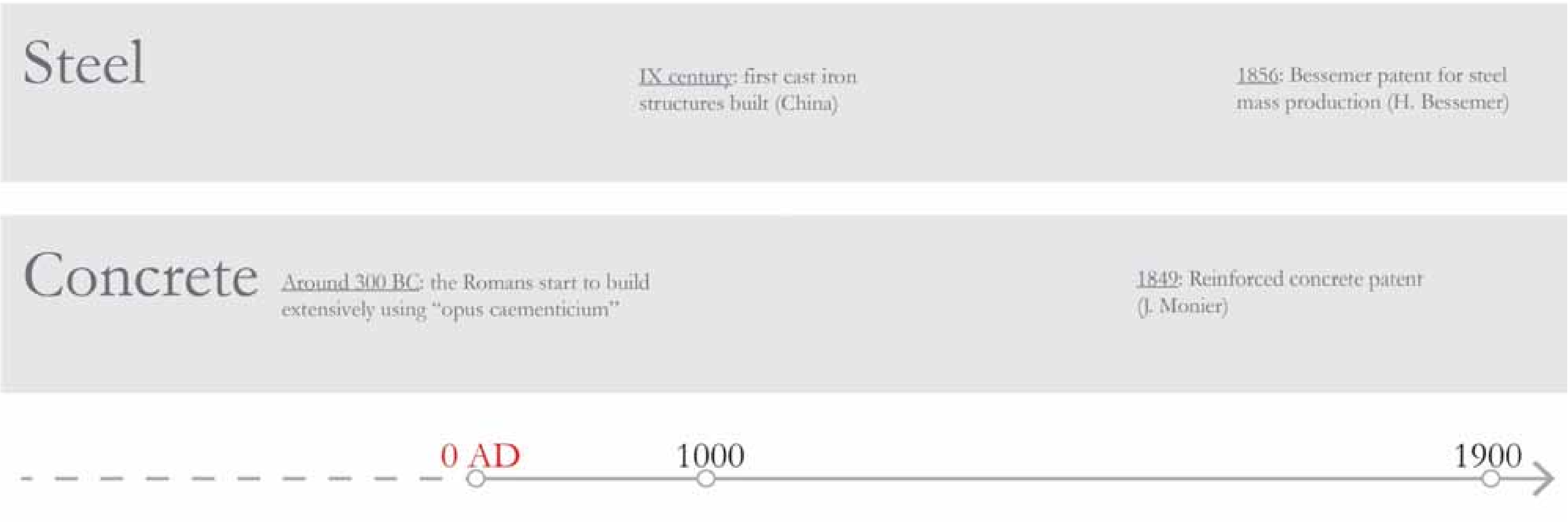
Entwurfsprojekt

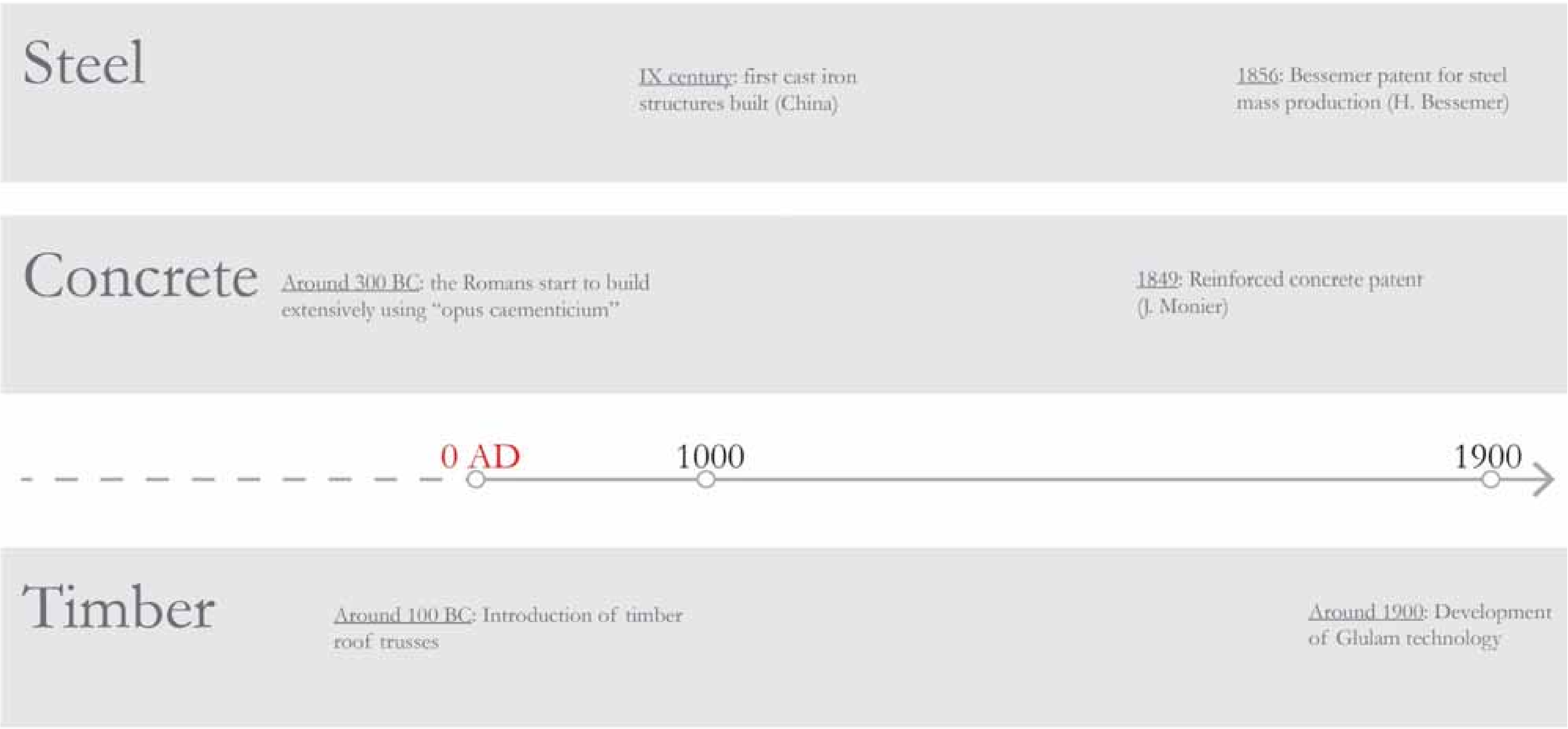
Design project

Steel

IX century: first cast iron structures built (China)

1856: Bessemer patent for steel mass production (H. Bessemer)


Steel
IX century: first cast iron structures built (China)
1856: Bessemer patent for steel mass production (H. Bessemer)
Concrete
Around 300 BC: the Romans start to build extensively using "opus caementicium"
1849: Reinforced concrete patent (J. Monier)
0 AD
1000
1900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Around 100 BC: Introduction of timber roof trusses
Around 1900: Development of Glulam technology


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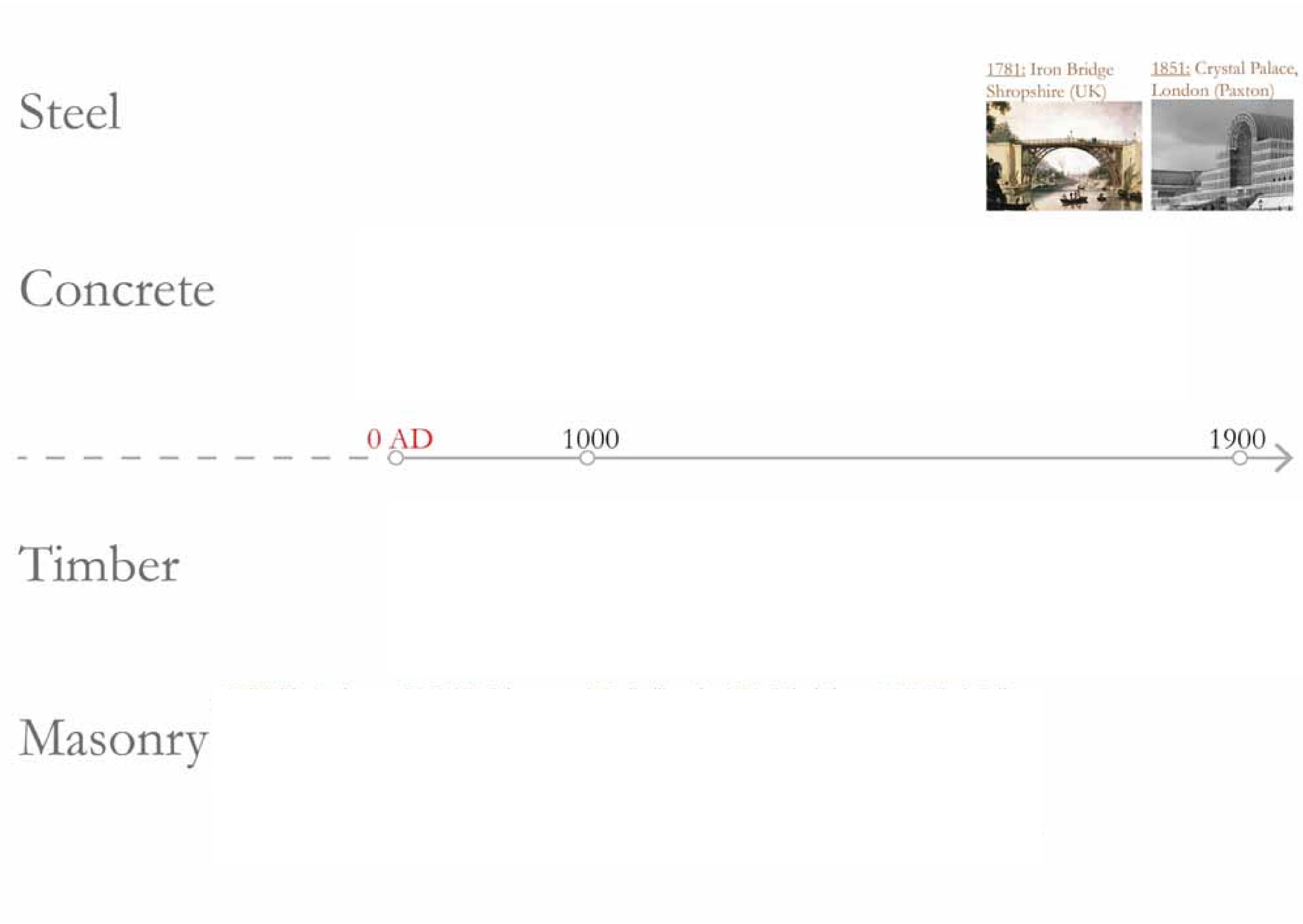
Timber
Around 100 BC: Introduction of timber roof trusses
Around 1900: Development of Glulam technology
Masonry
7500 BC: First bricks made of dried mud
Around 1250: Widespread use of masonry for civic and domestic buildings
Around 1850: First industrial brick-making machine patented in England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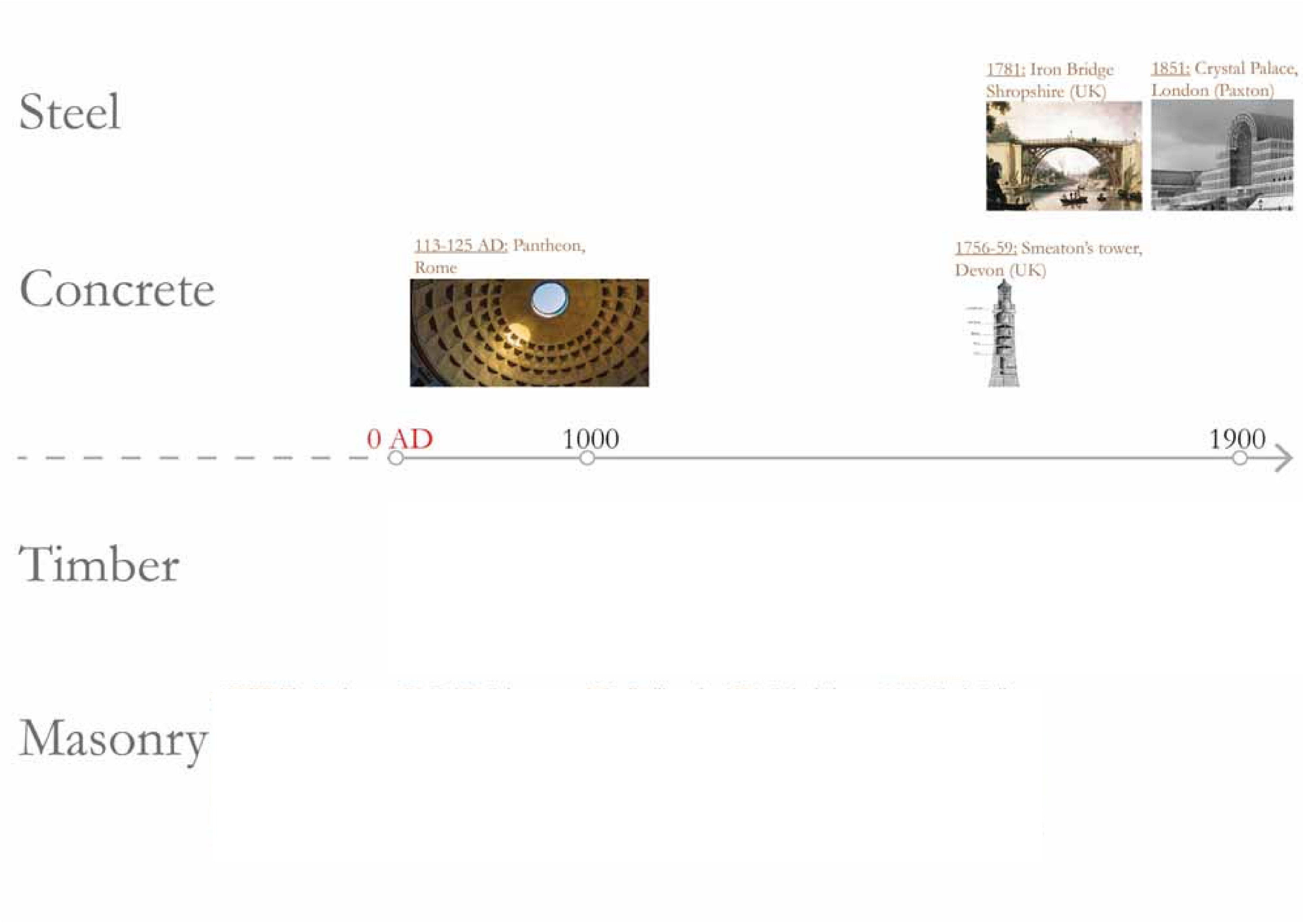
1781: Iron Bridge Shropshire (UK)
1851: Crystal Palace, London (Paxton)
Concrete
0 AD
1000
1900
Timber
Masonry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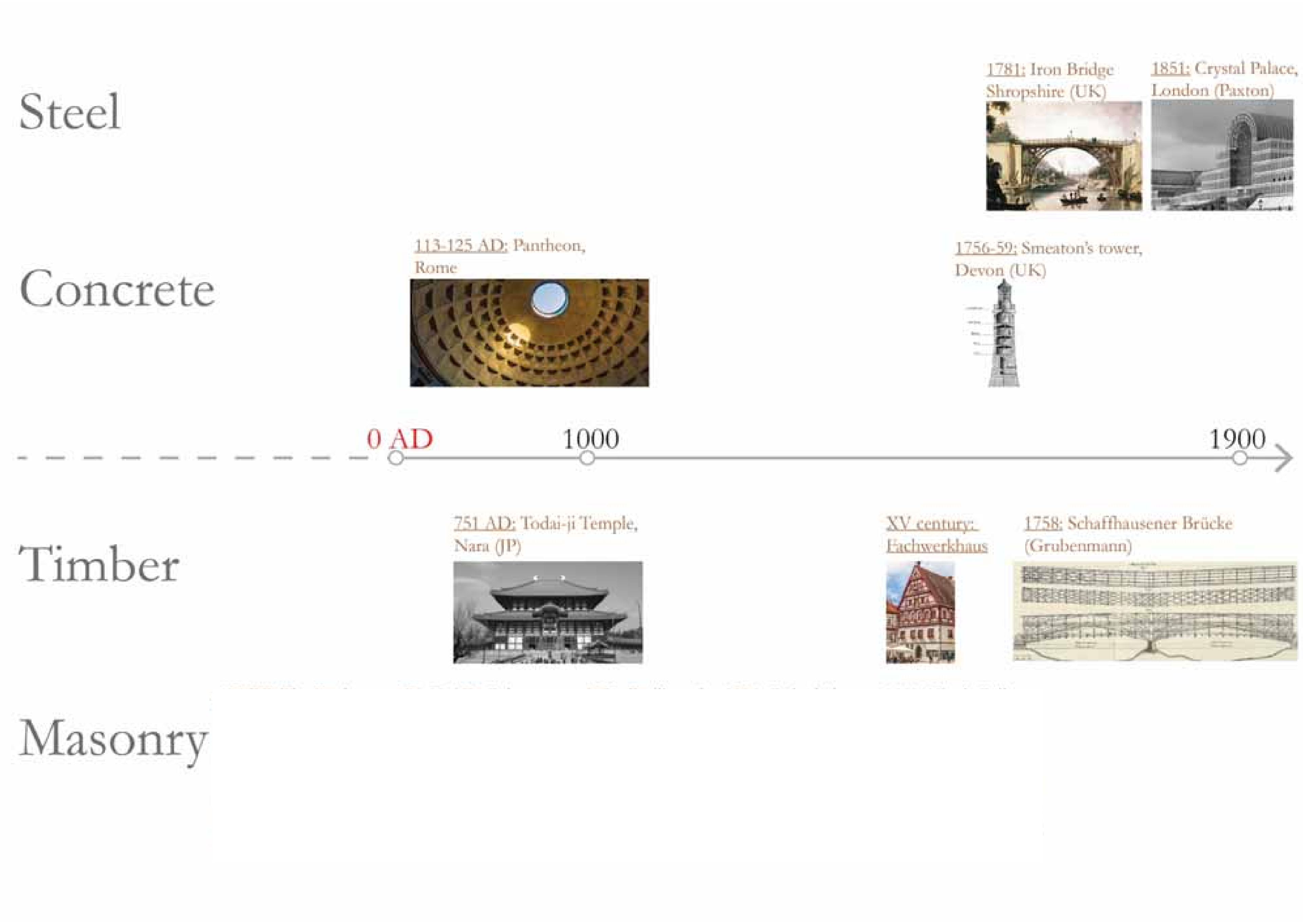
113-125 AD: Pantheon, Rome
1756-59: Smeaton's tower, Devon (UK)
0 AD
1000
1900
Timber
Masonry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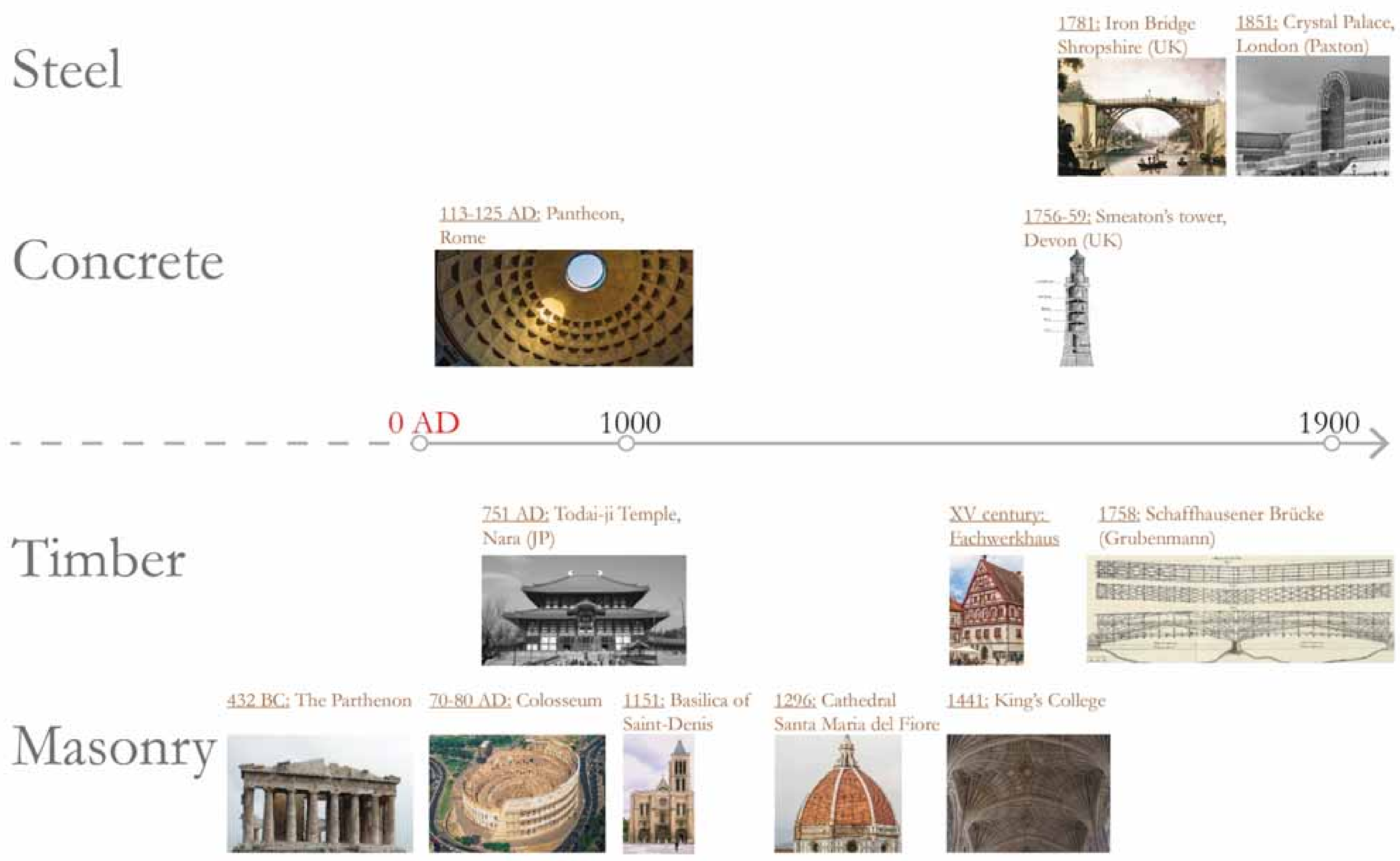
751 AD: Todai-ji Temple, Nara (JP)
XV century: Fachwerkhaus
1758: Schaffhausener Brücke (Grubenmann)
Masonry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XV century: Fachwerkhaus
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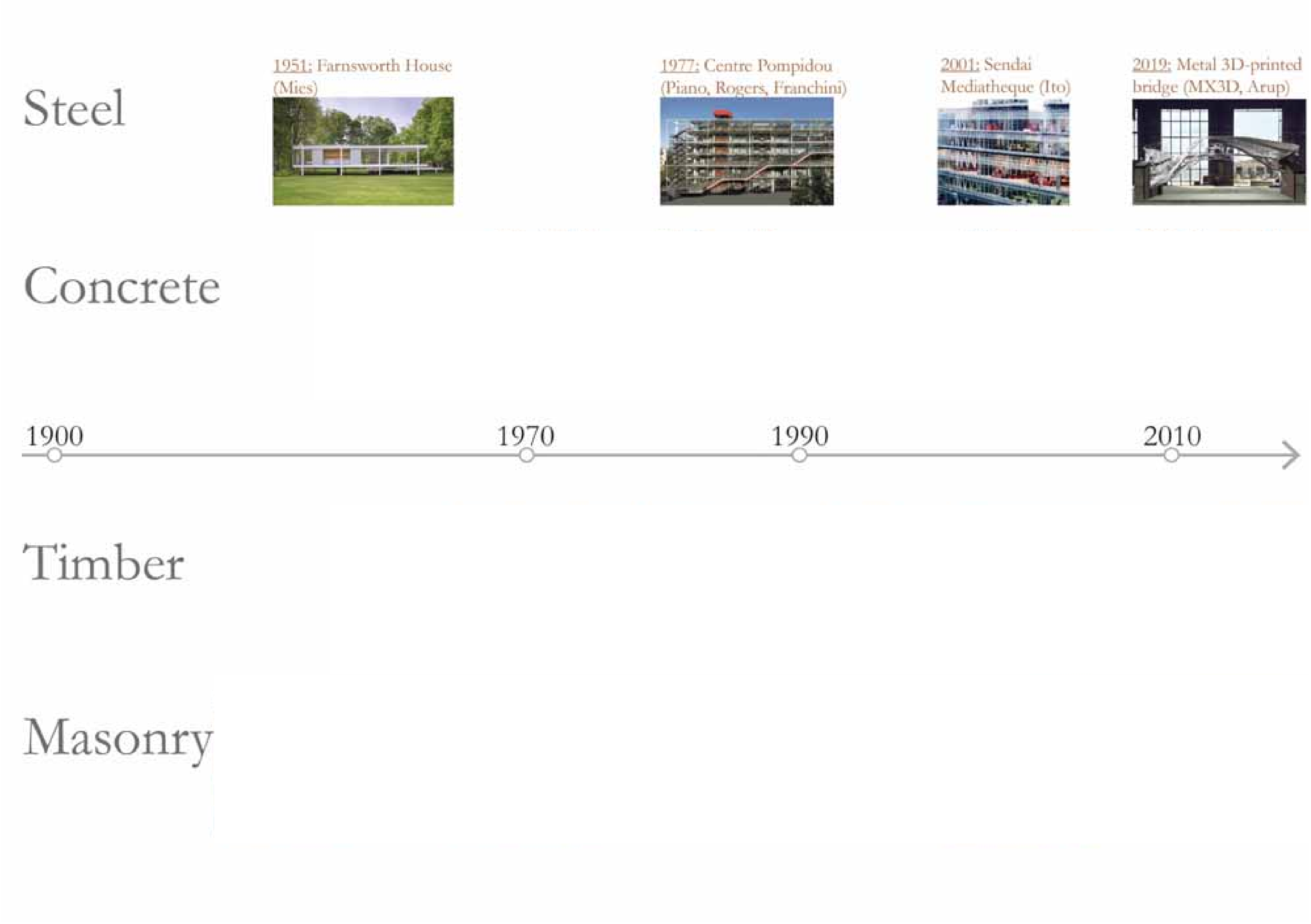
Masonry
432 BC: The Parthenon
70-80 AD: Colosseum
1151: Basilica of Saint-Denis
1296: Cathedral Santa Maria del Fiore
1441: King's College


Steel
1951: Farnsworth House (Mies)
1977: Centre Pompidou (Piano, Rogers, Franchini)
2001: Sendai Mediatheque (Ito)
2019: Metal 3D-printed bridge (MX3D, Arup)
Concrete
1900
1970
1990
2010
Timber
Masonry

Steel

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1977: Centre Pompidou (Piano, Rogers, Franchini)

2001: Sendai Mediatheque (Ito)

2019: Metal 3D-printed bridge (MX3D, Arup)

Concrete

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2006: Crematorium (Ito)

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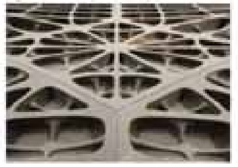
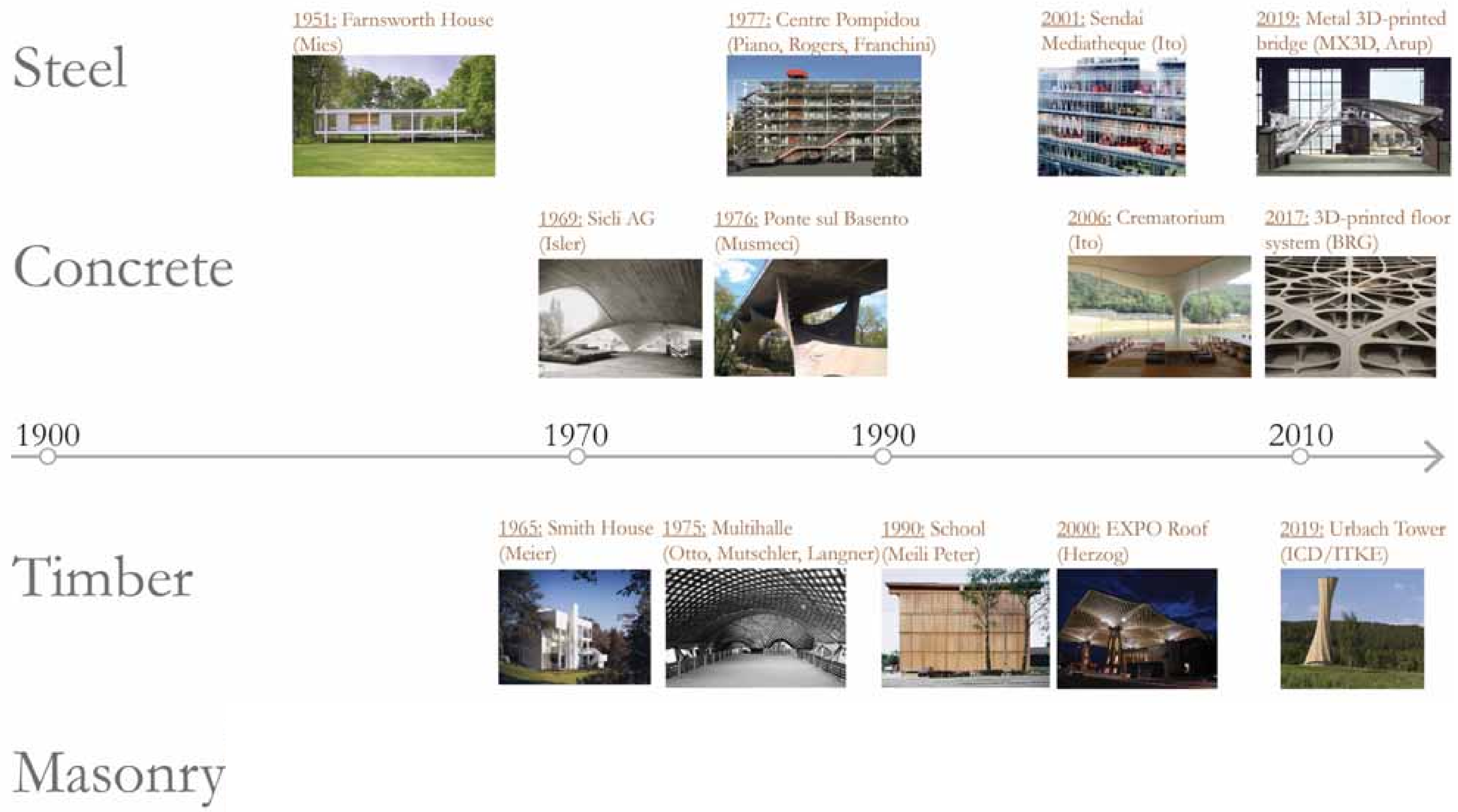


1900 — 1970 — 1990 — 2010

Timber

Masonry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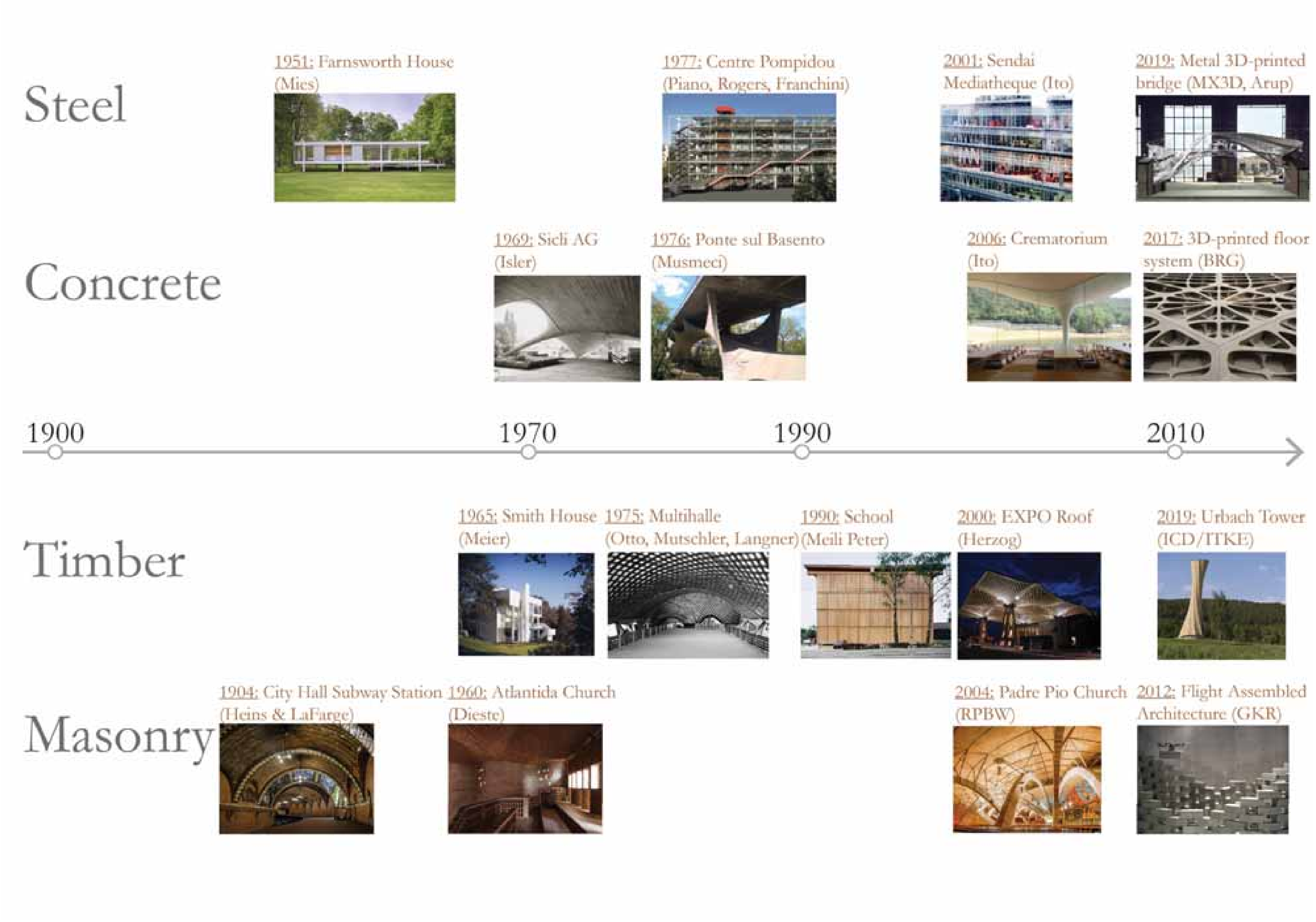
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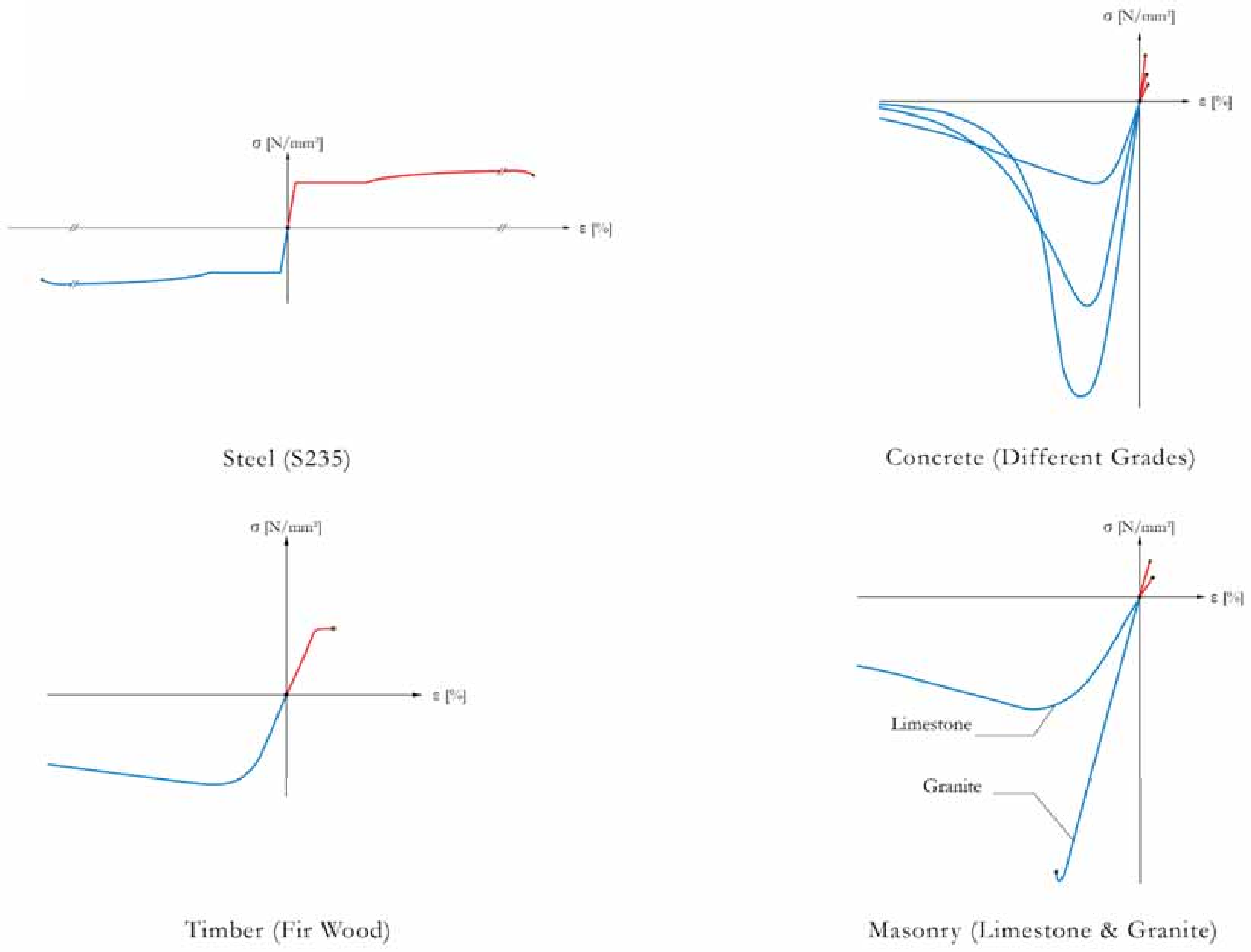
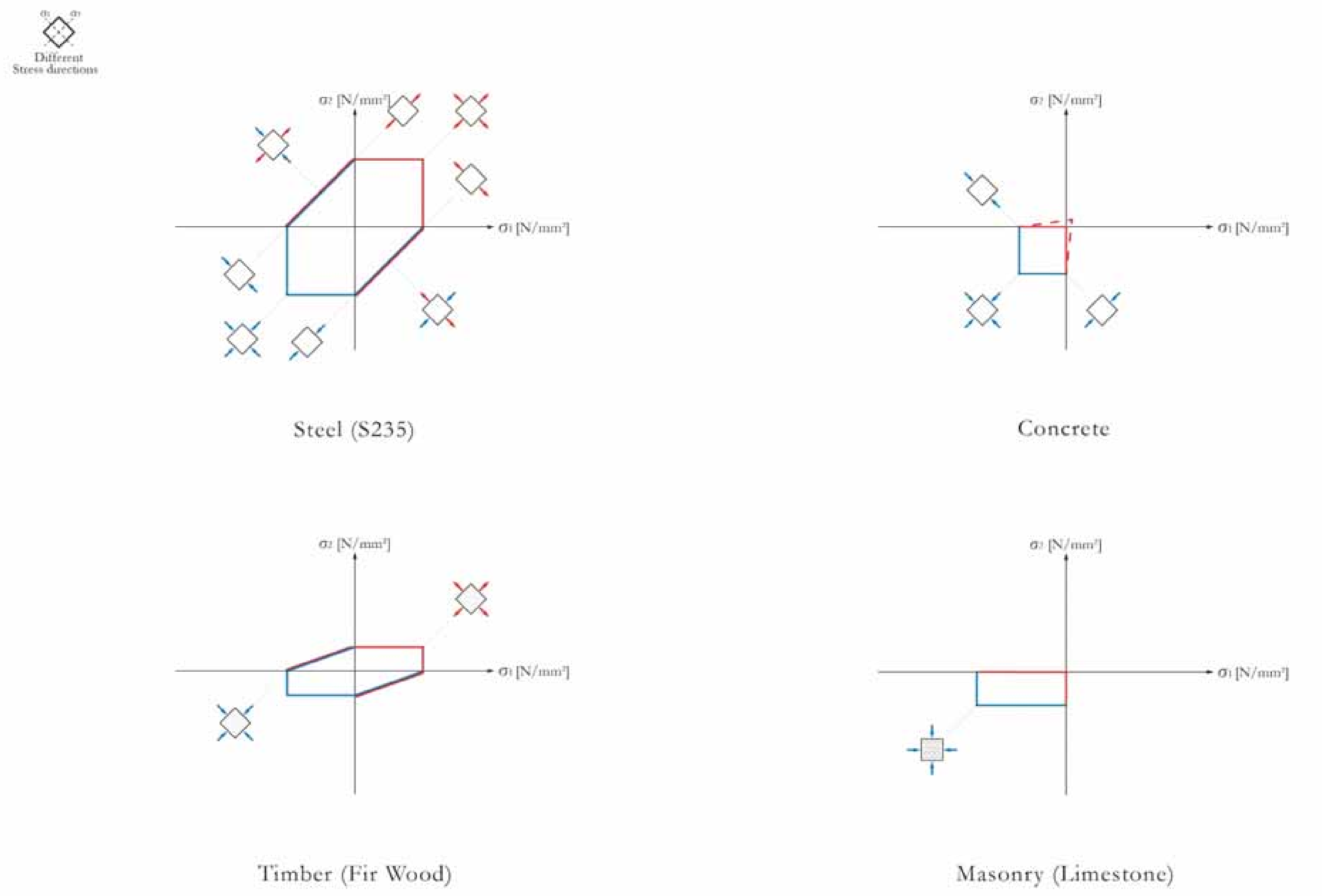
2019: Urbach Tower (ICD/ITKE)
Masonry
1904: City Hall Subway Station (Heins & LaFarge)
1960: Atlantida Church (Dieste)
2004: Padre Pio Church (RPBW)
2012: Flight Assembled Architecture (GKR)



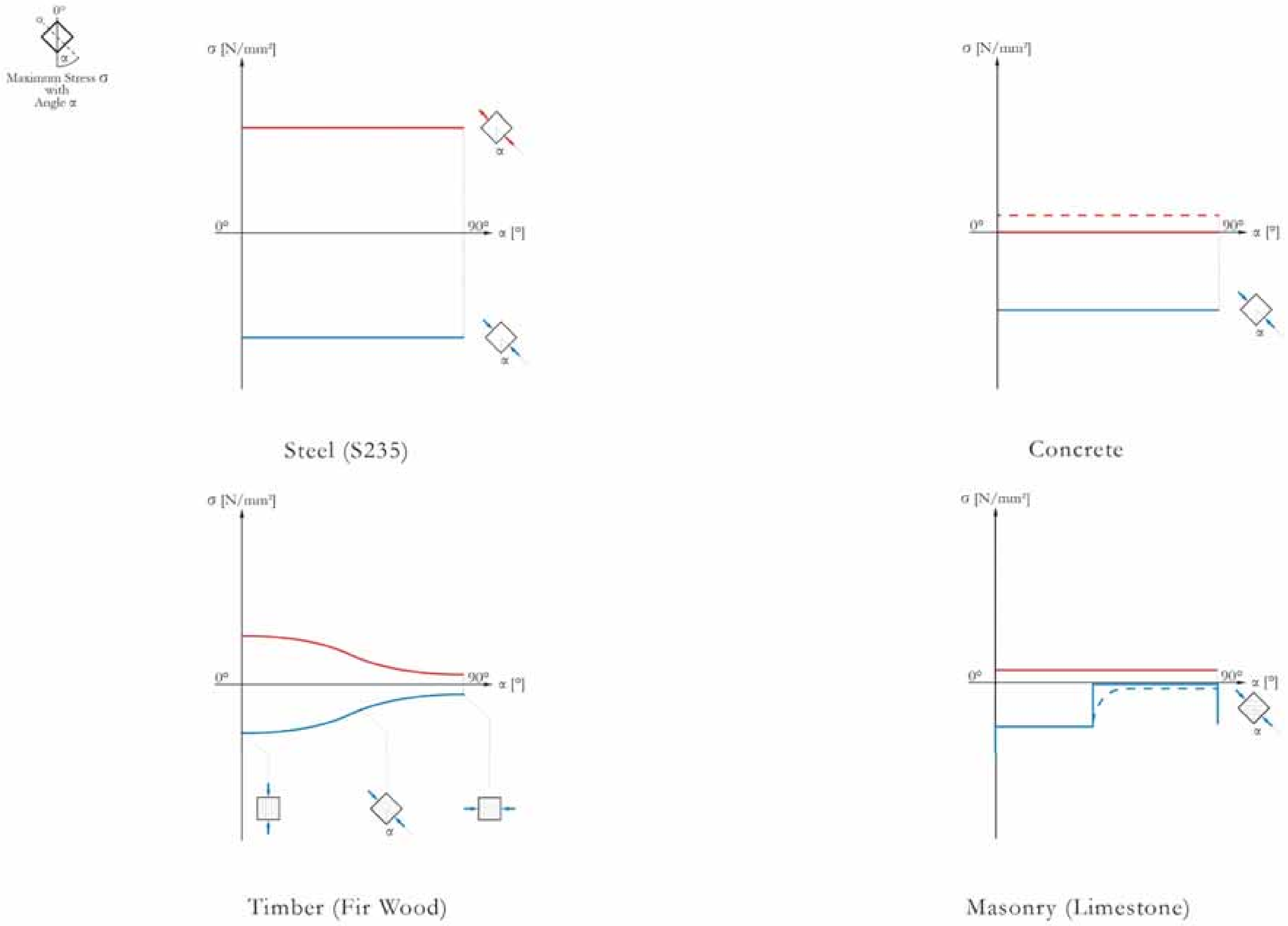
Spannungs-Dehnungs-Diagramme für die wichtigsten Baustoffe

Stress-strain diagrams for the main structural materials



Versagenskriterien für die wichtigsten Baustoffe

Failure criteria for the main structural materials



Veränderung der Festigkeit in Abhängigkeit des Spannungswinkels

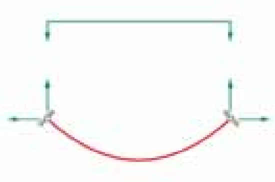
Strength variation according to the stress angle

Steel

Reinforced concrete

Timber

Masonry



Cable

Steel

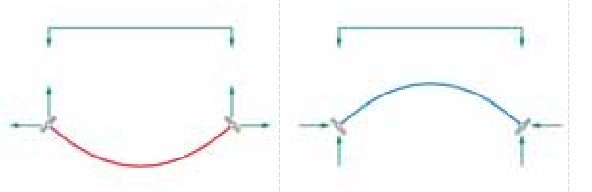
Munich Olympic Stadium

Reinforced concrete

Timber

Leisure and Sports Pool

Masonry



Cable → Arch

Steel

Munich Olympic Stadium

Reinforced concrete

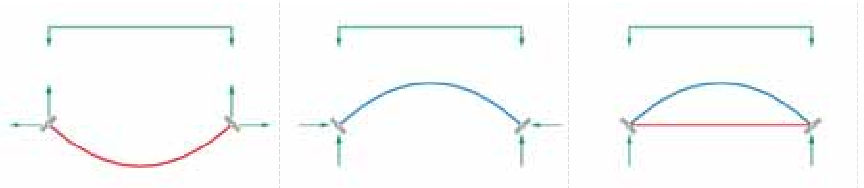
Timber

Leisure and Sports Pool

Masonry

Sean Collier Memorial

Padre Pio Pilgrimage Church



Cable → Arch → Arch-Cable

Steel


Office for Waste Management


Munich Olympic Stadium


Renault Distribution Center

Reinforced concrete

Timber


Leisure and Sports Pool

Masonry


Sean Collier Memorial


Pabellón del Futuro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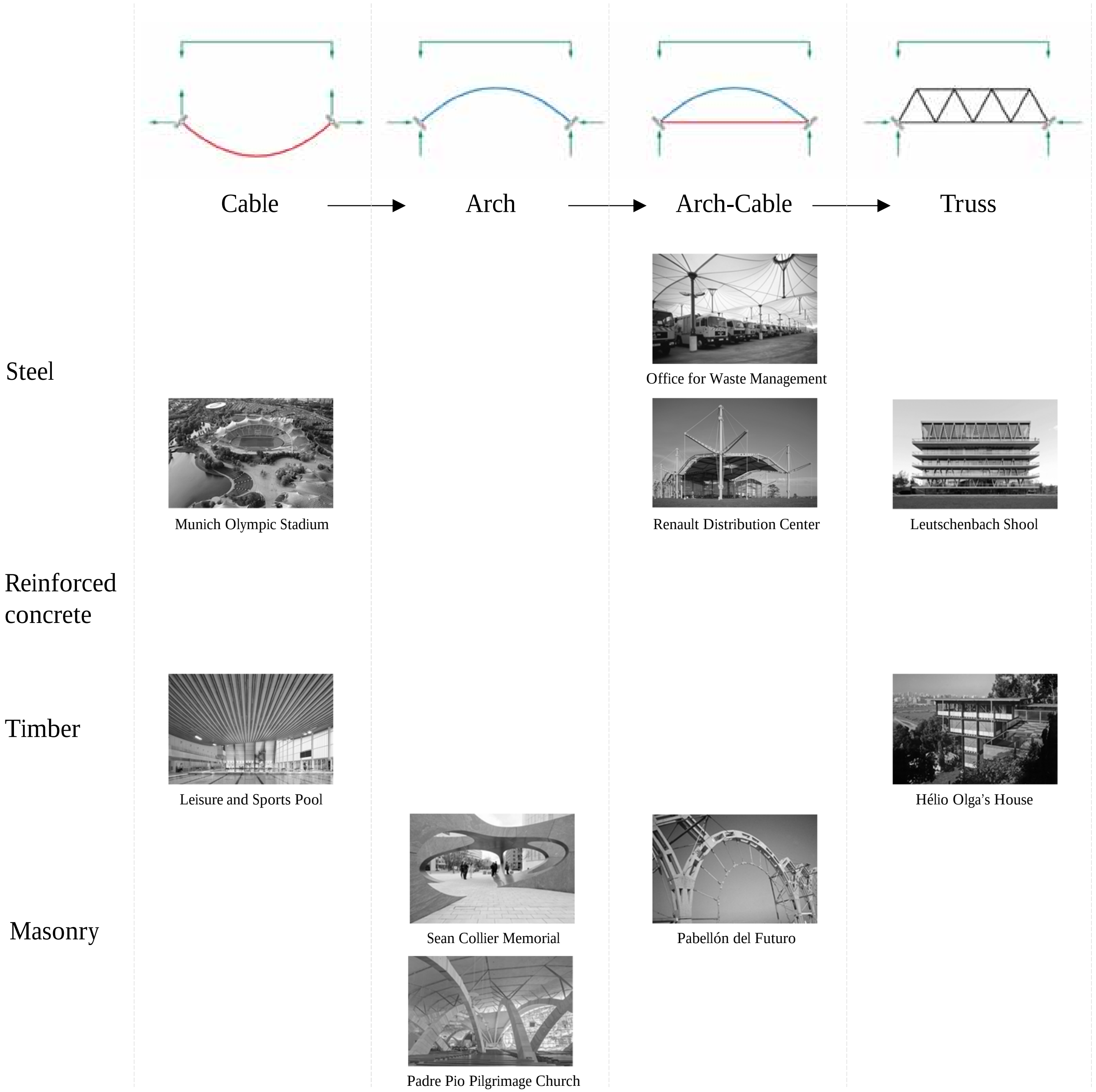
Cable
Arch
Arch-Cable
Truss
Steel
Reinforced concrete
Timber
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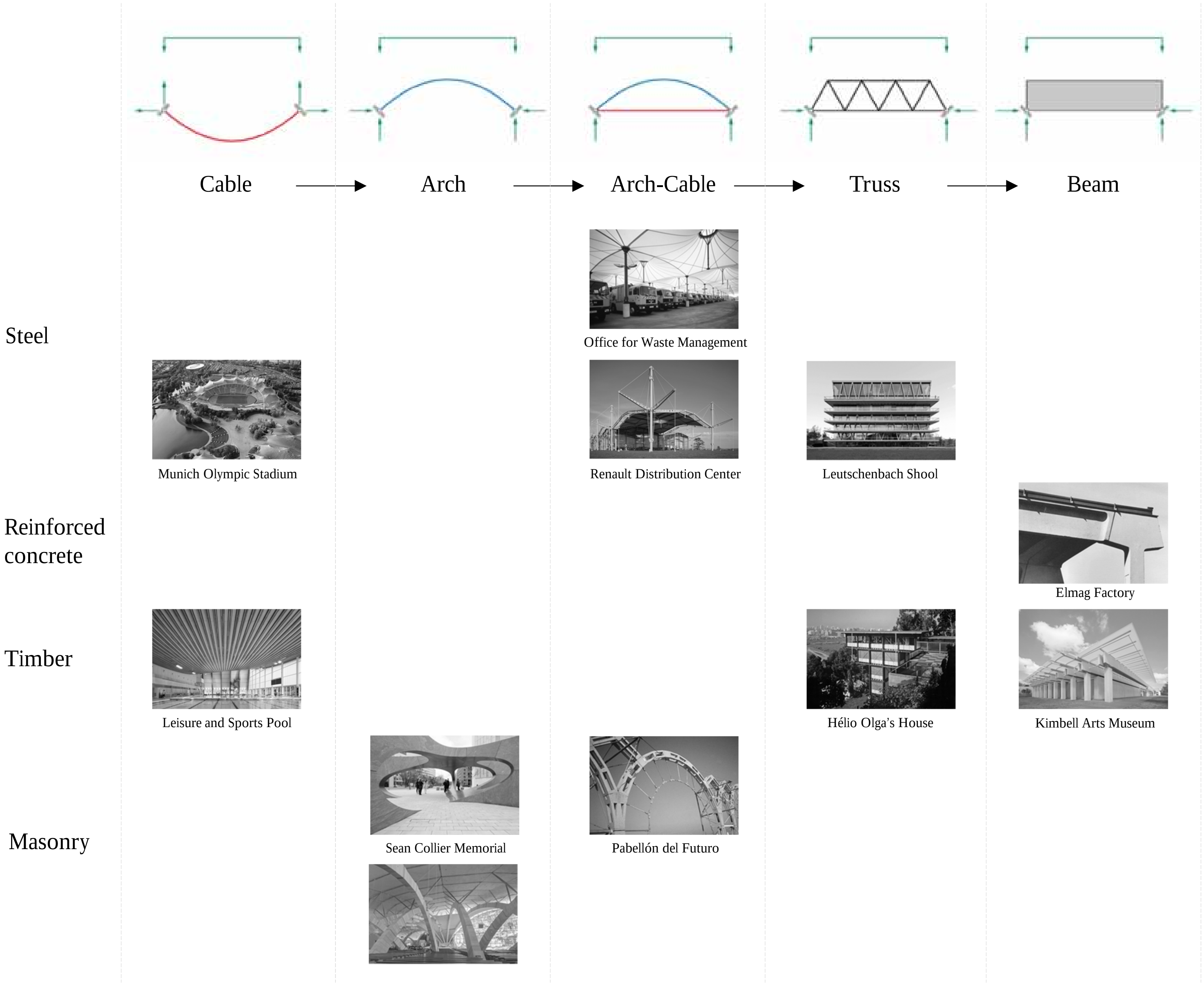
Cable
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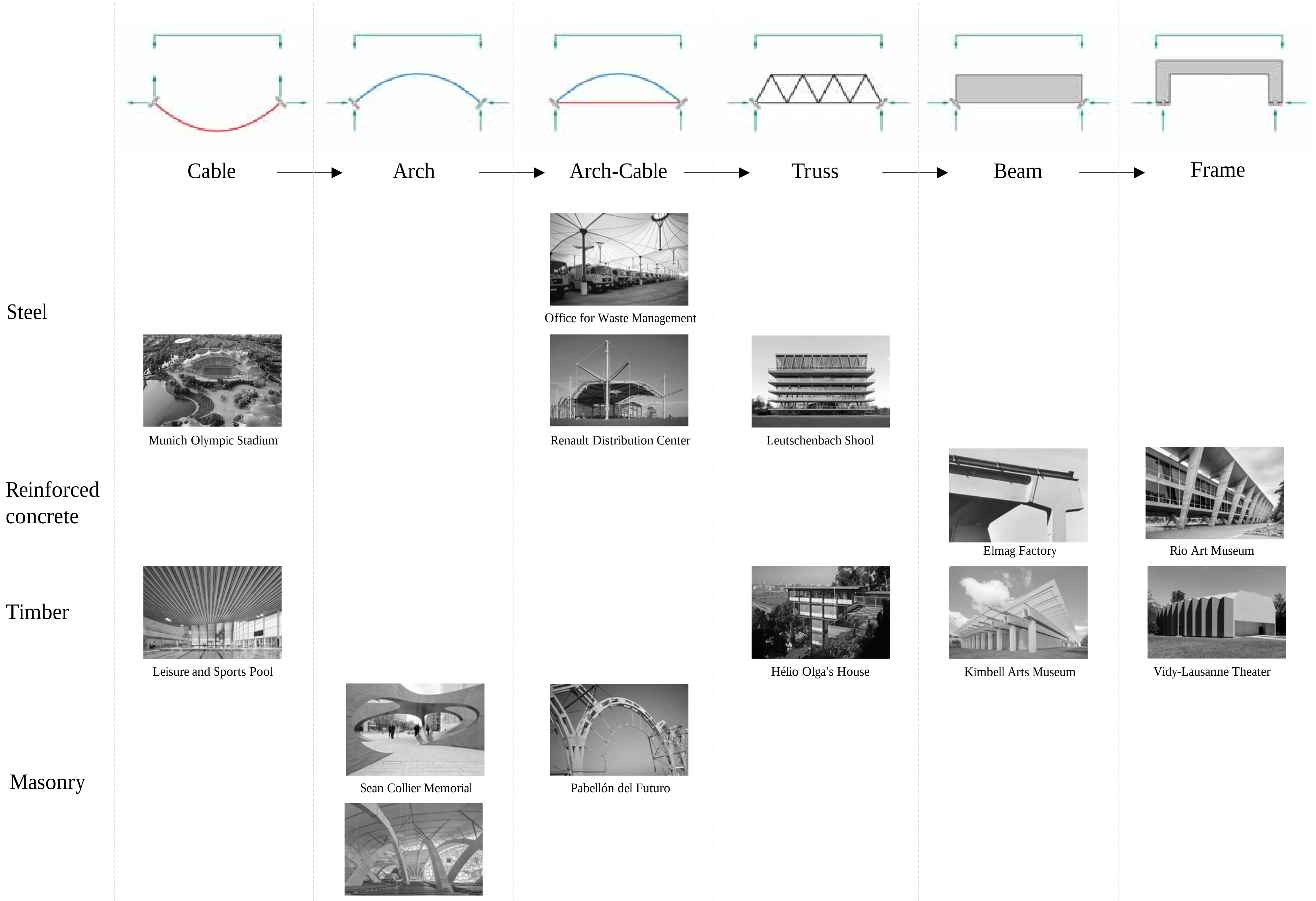
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Renault Distribution Center
Leutschenbach Shool
Elmag Factory
Rio Art Museum
Leisure and Sports Pool
Hélio Olga's House
Kimbell Arts Museum
Vidy-Lausanne Theater
Sean Collier Memorial
Pabellón del Futuro

Konstruktionsdetails
Construction details

>> Seiltragwerke
Cable structures

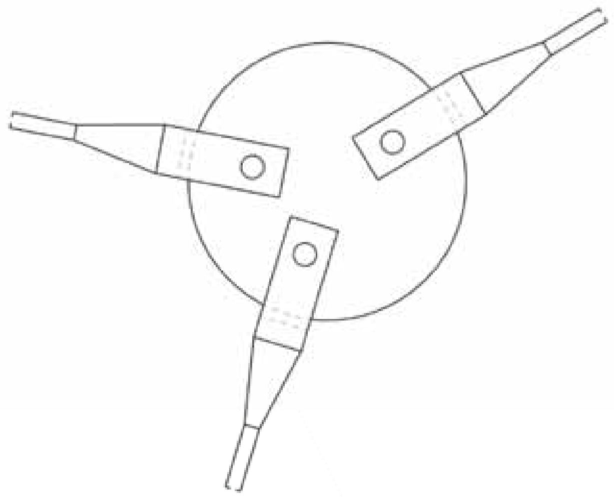
Bogenkonstruktionen
Arch structures

Bogenseilkonstruktionen
Arch-cable structures

Fachwerkstrukturen
Trusses

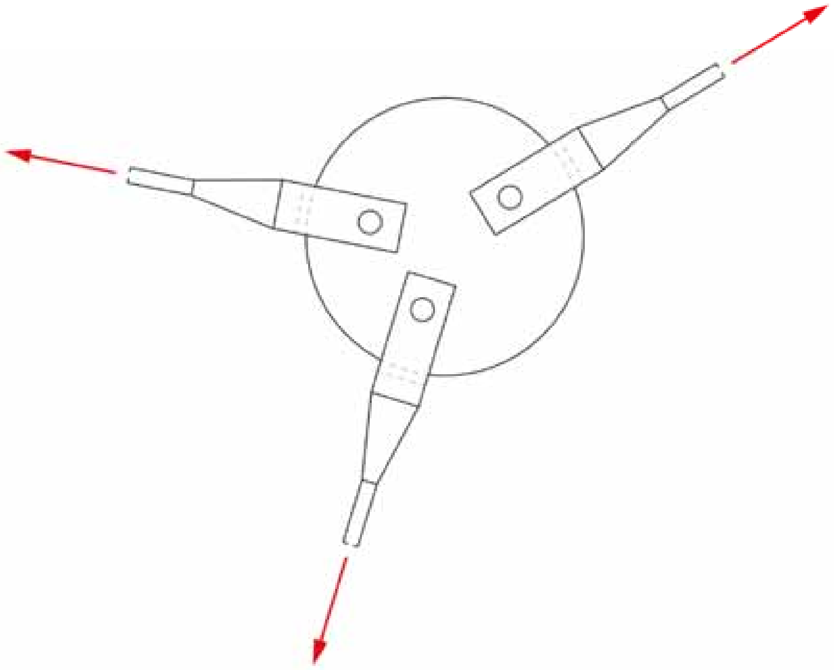
Balken
Beams

Rahmen
Frames



Beispiele für Stahlseilverbindungen (rechts: Patscentre, 1985, Arch. Richard Rogers)

Examples of steel cables connection (right: Patscentre, 1985, arch. Richard Rogers)



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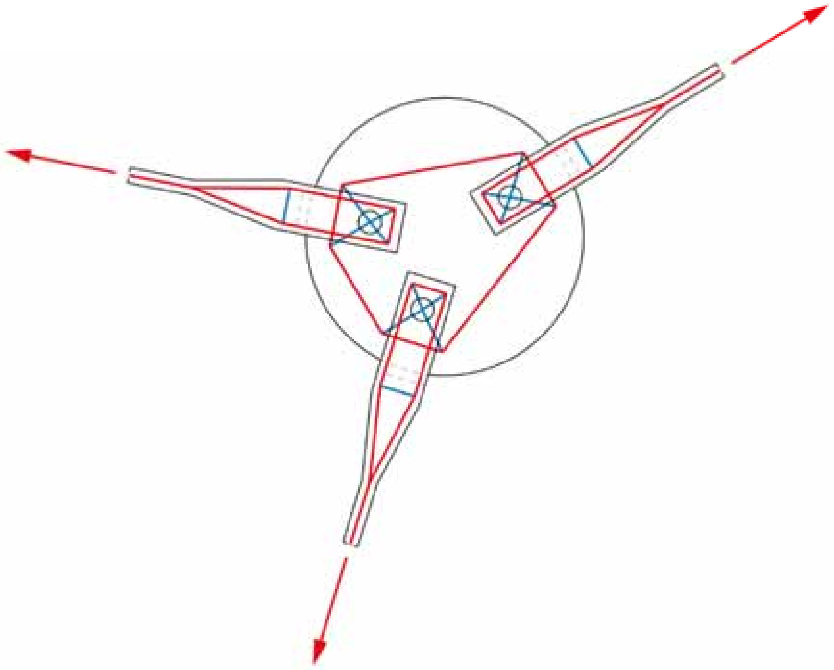

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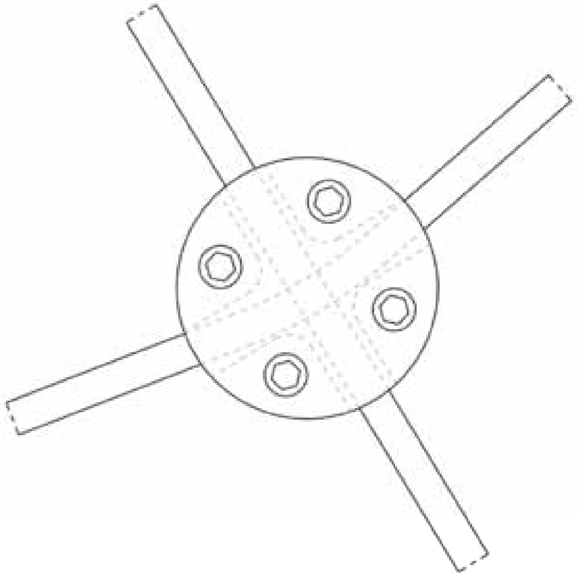

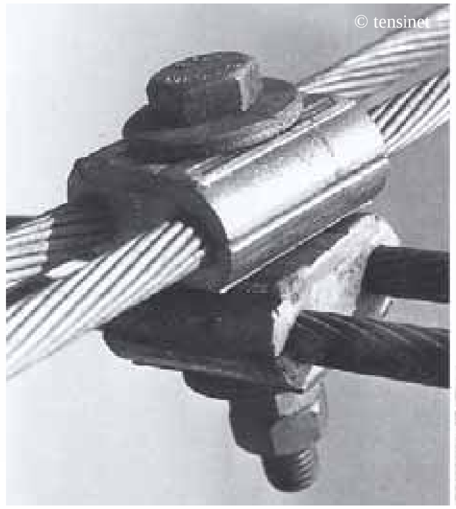

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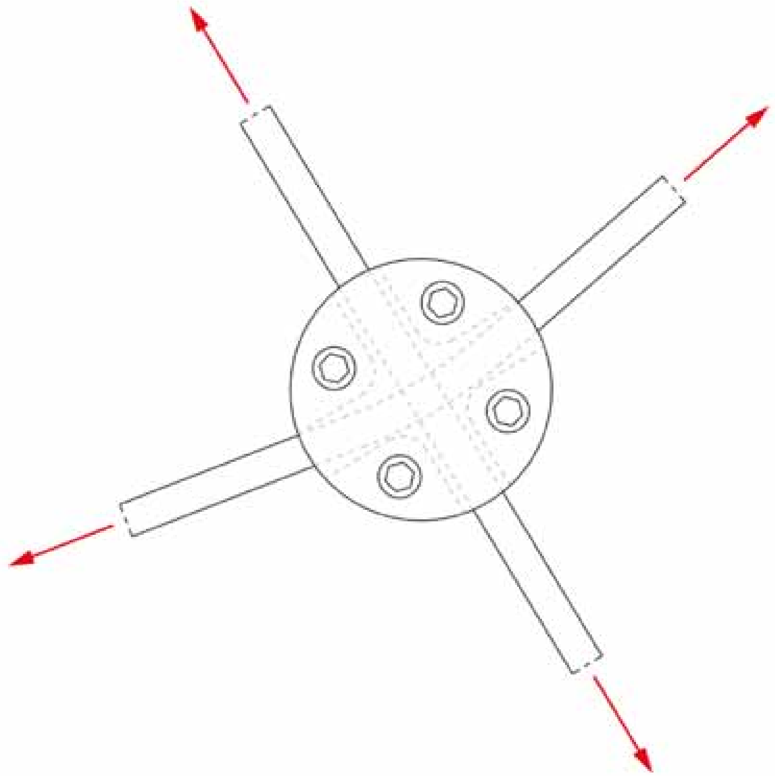

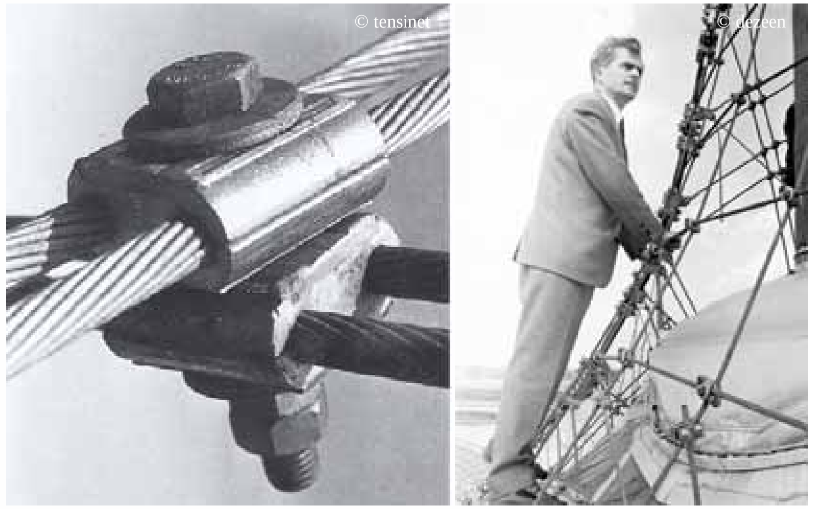

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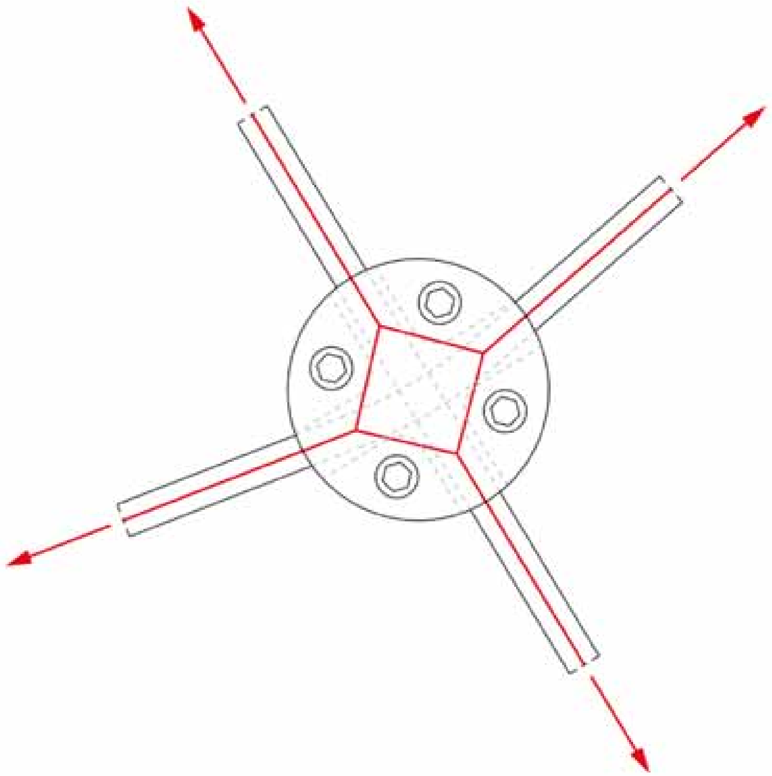

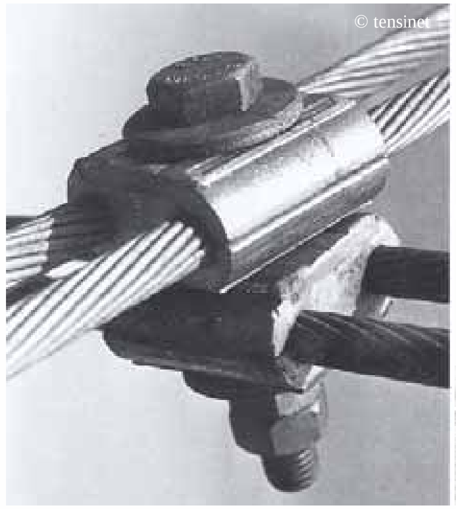

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Olympic Stadium

Munich, 1972

Architect: Günter Behnisch, Frei Otto

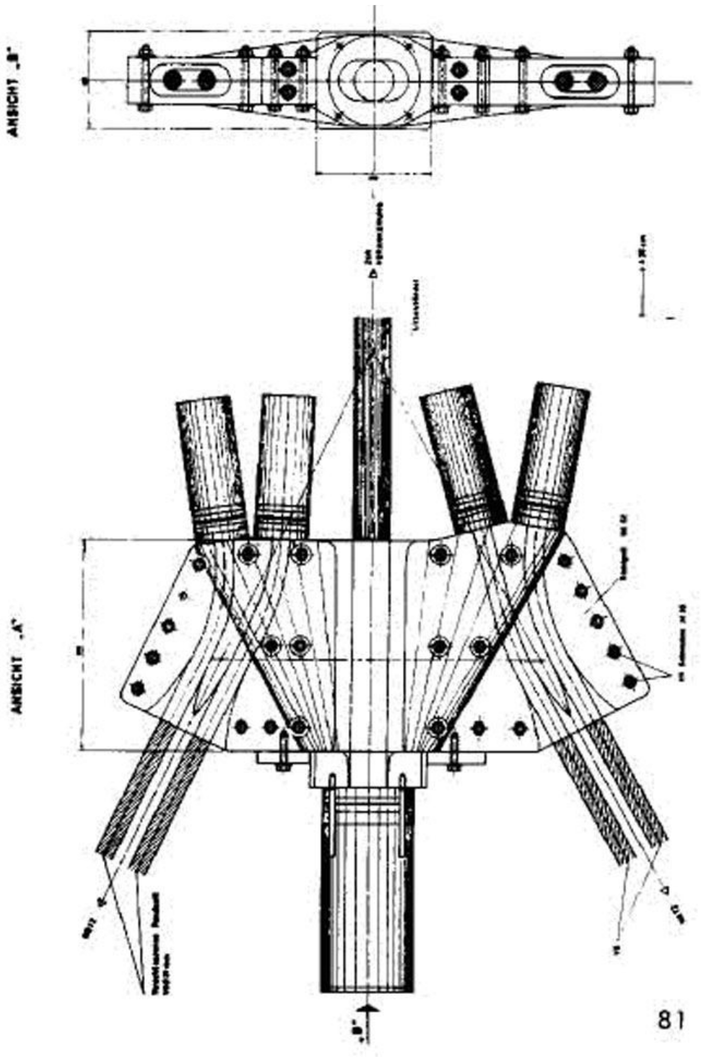
Engineer: Leonhardt, Andrä und Partner

Kabelnetzdächer

Cable net roofs

Auflagerbereiche von Kabelnetztragwerken

Cable net supports



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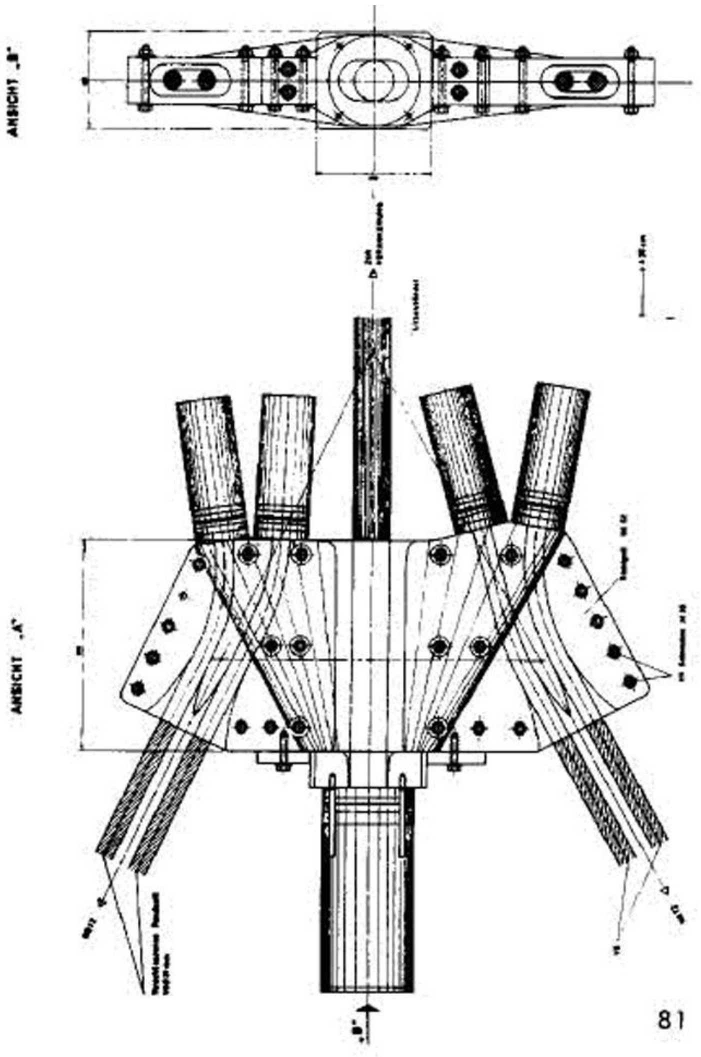
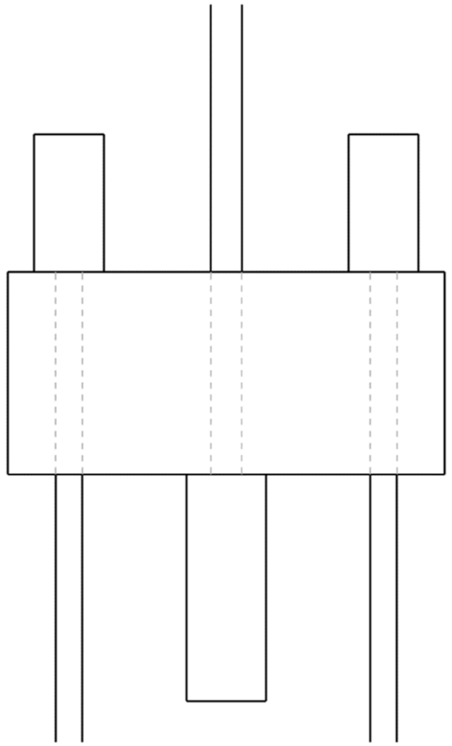
Cable net supports





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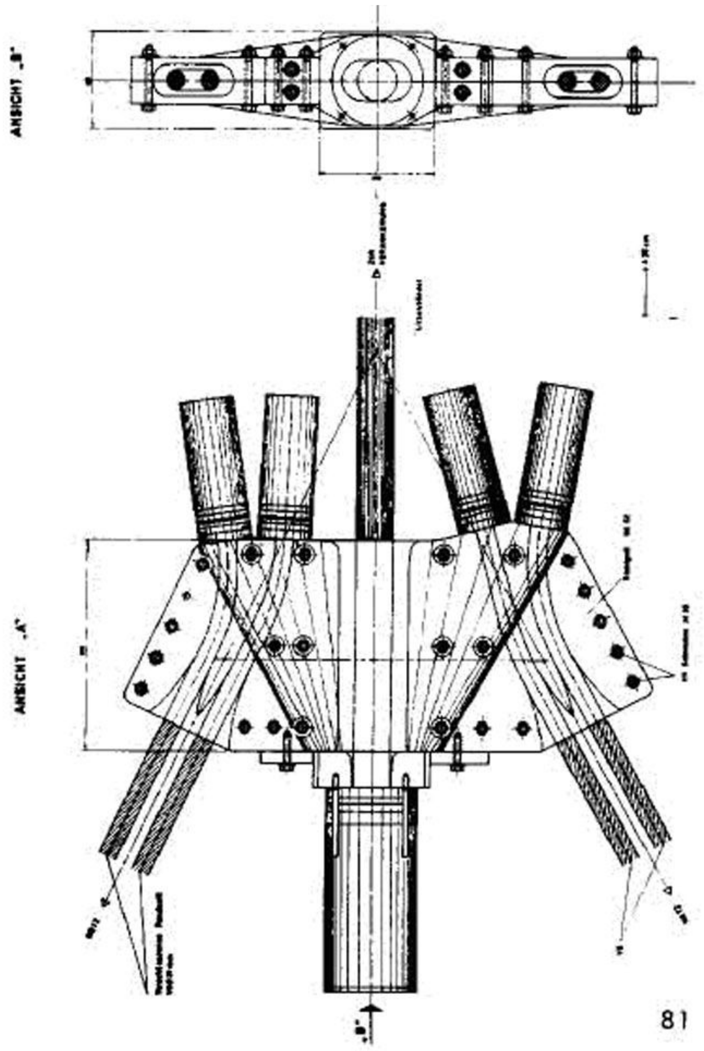

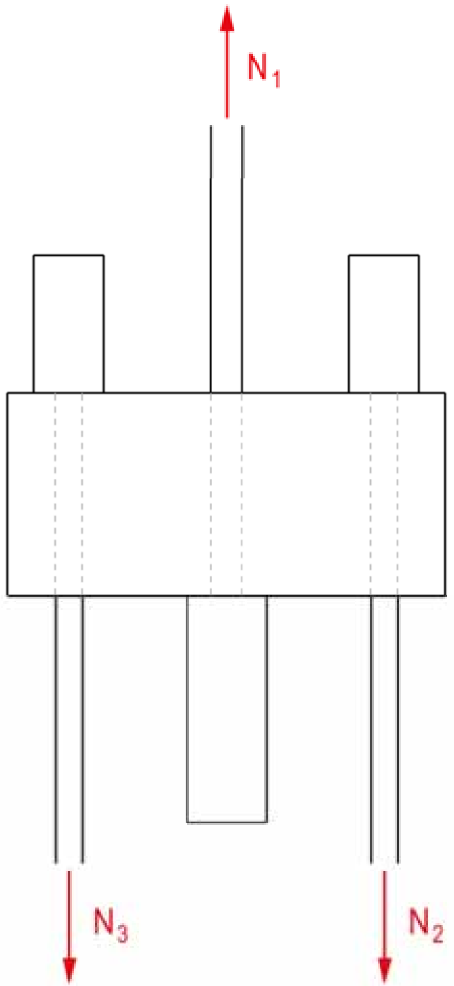

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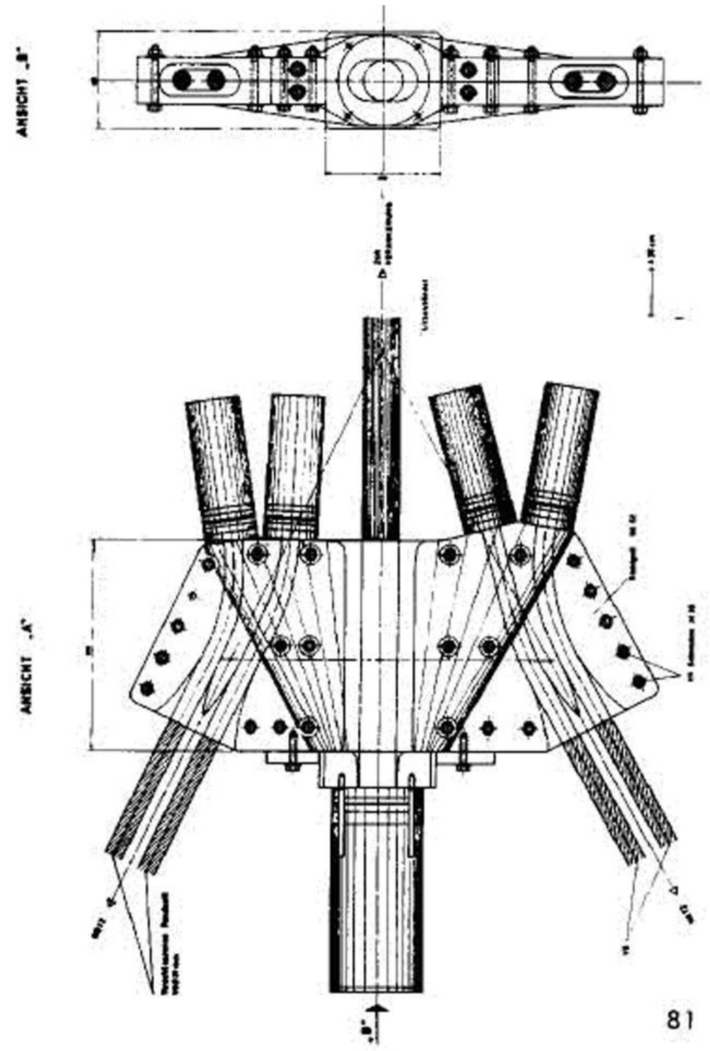

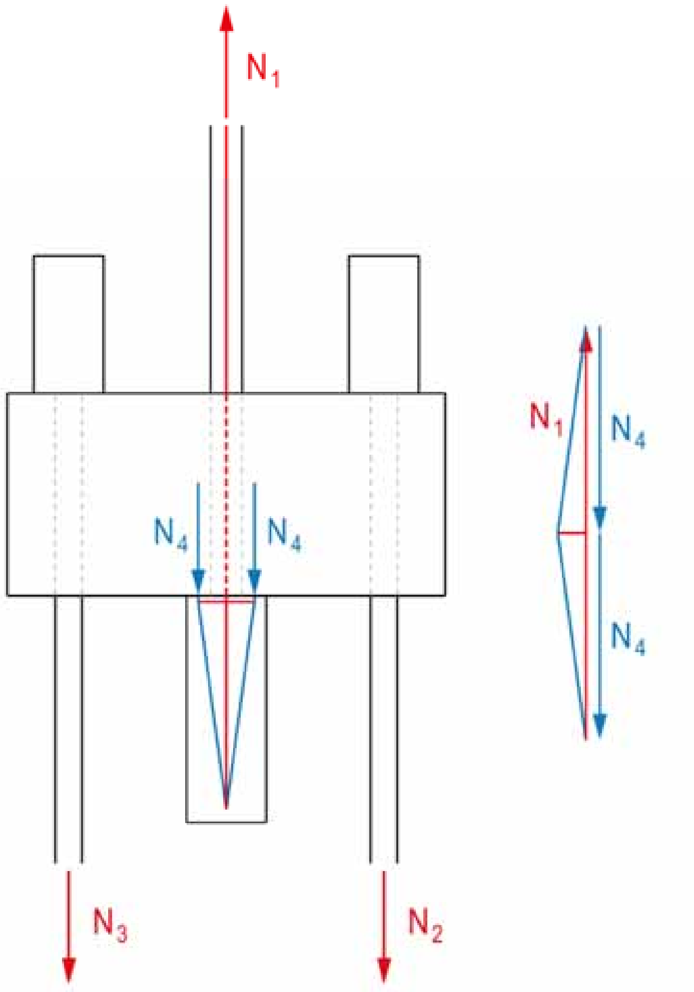

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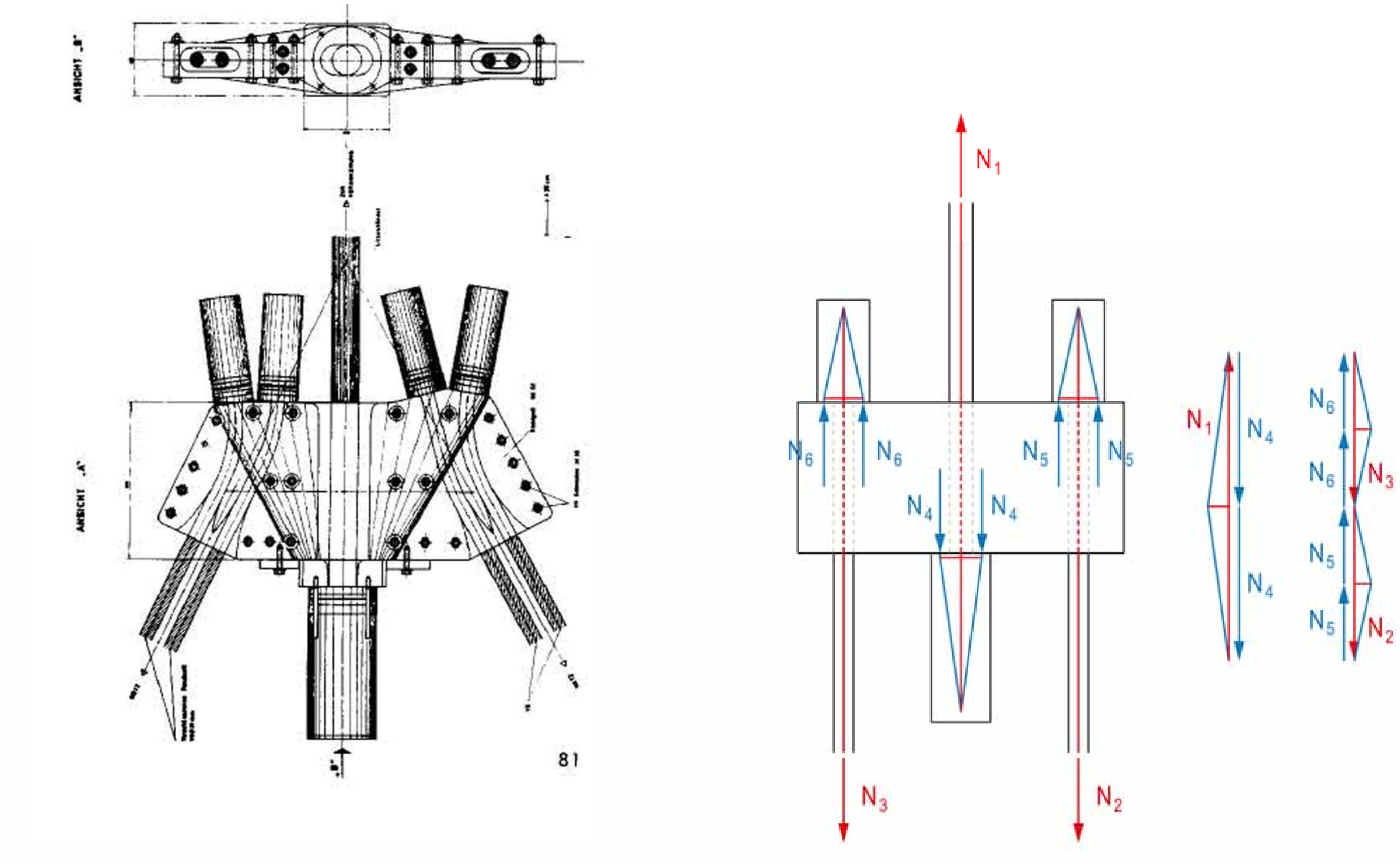

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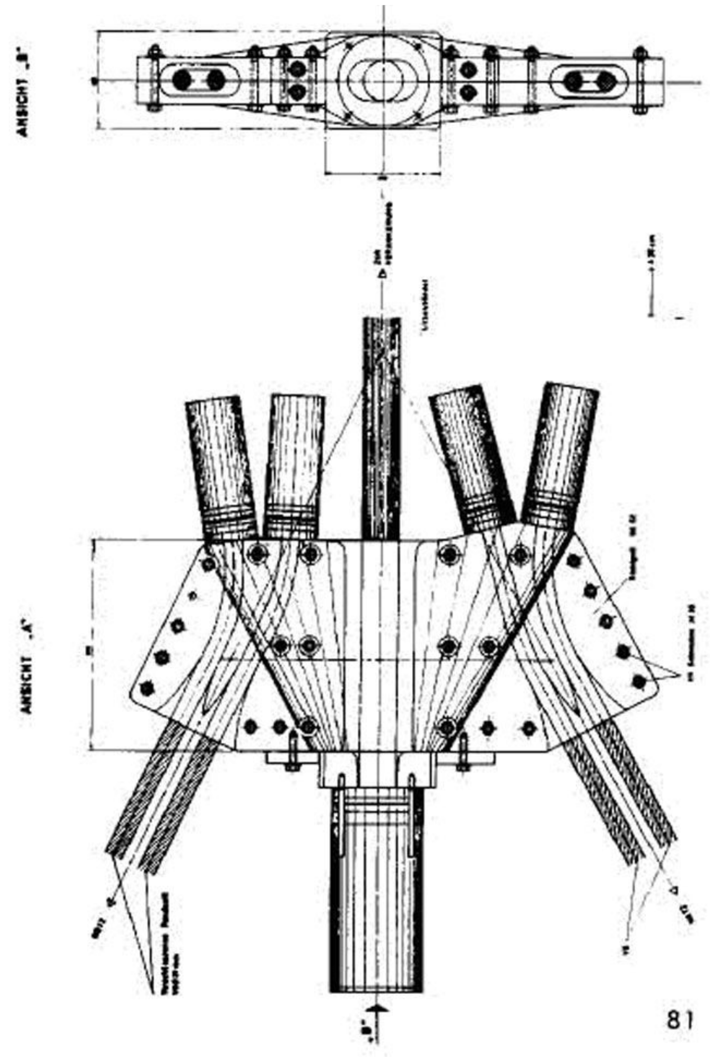

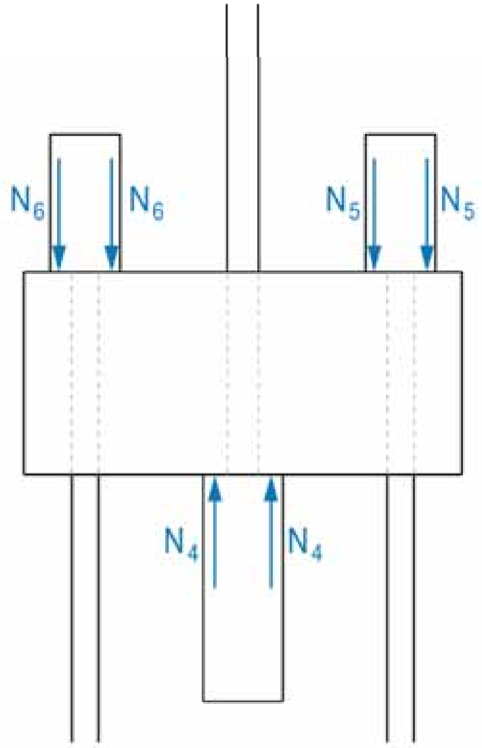

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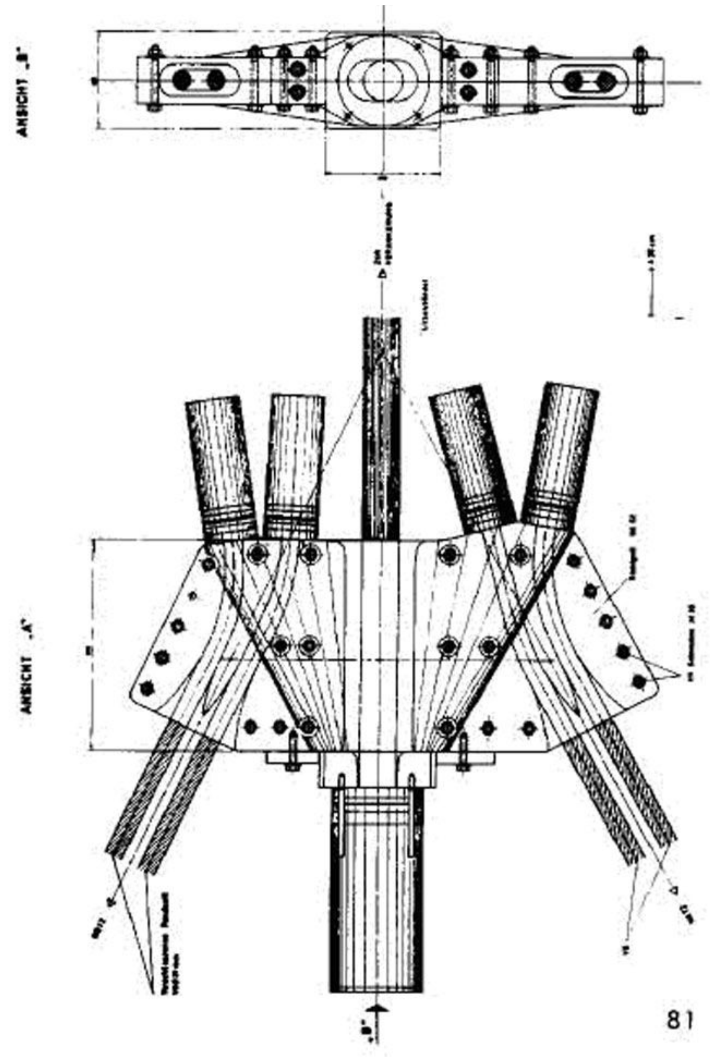
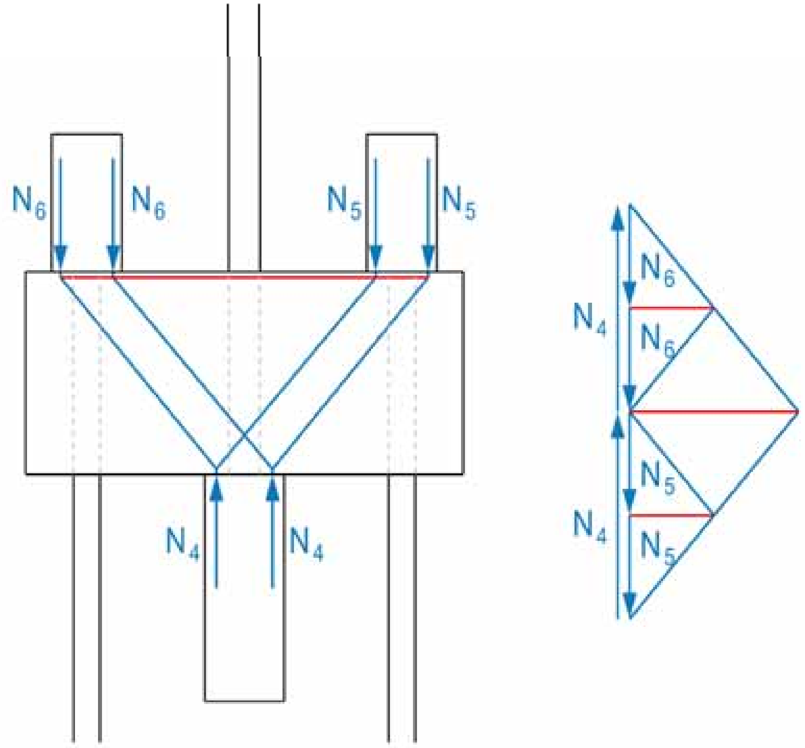
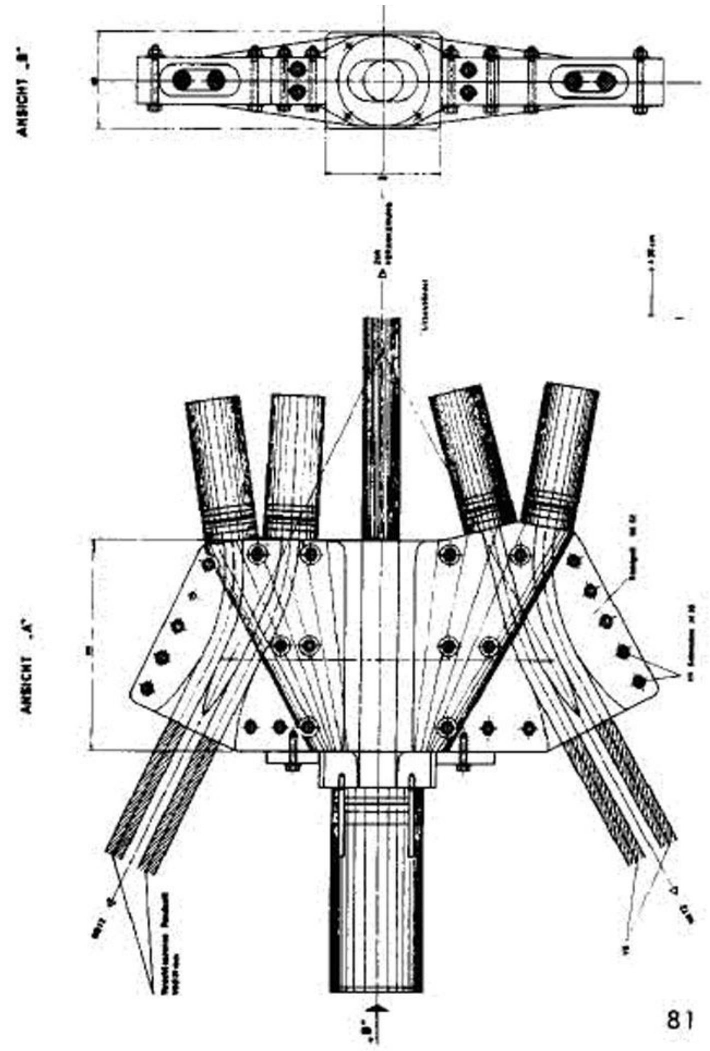
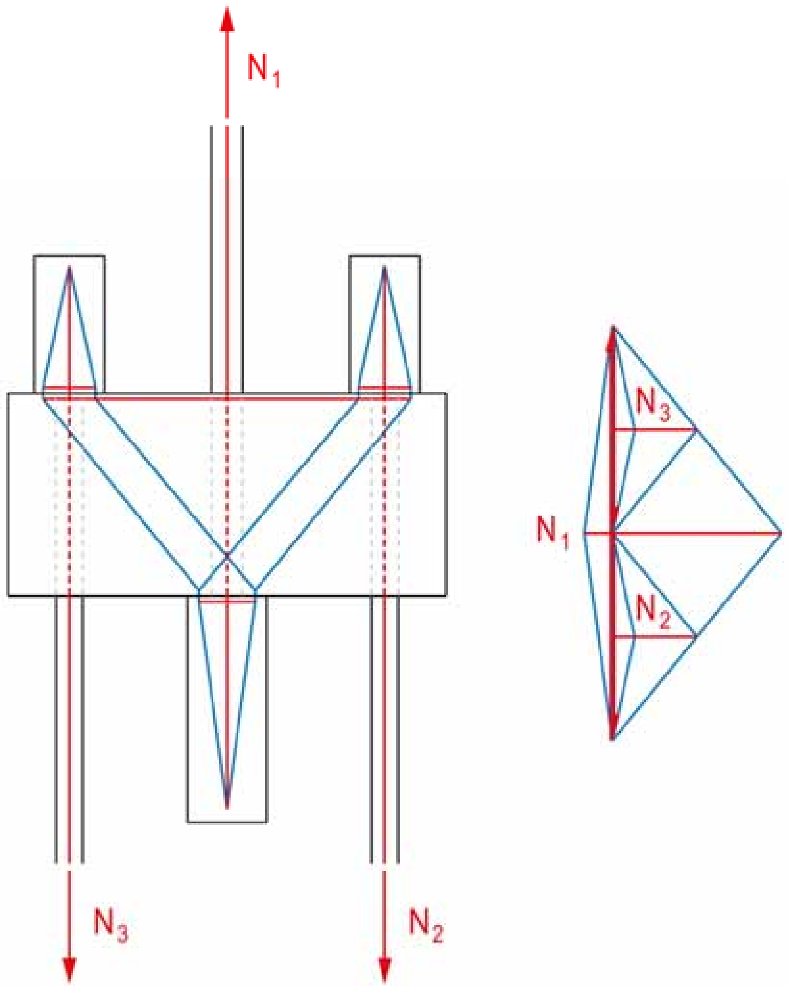




Auflagerbereiche von Kabelnetztragwerken
Cable net supports





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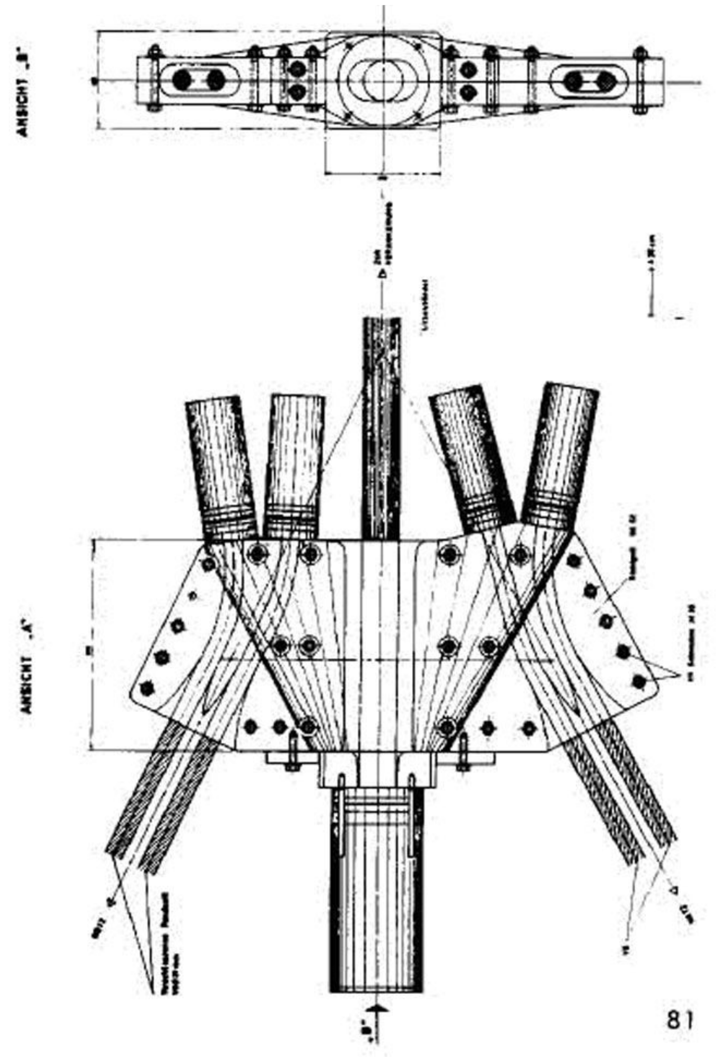
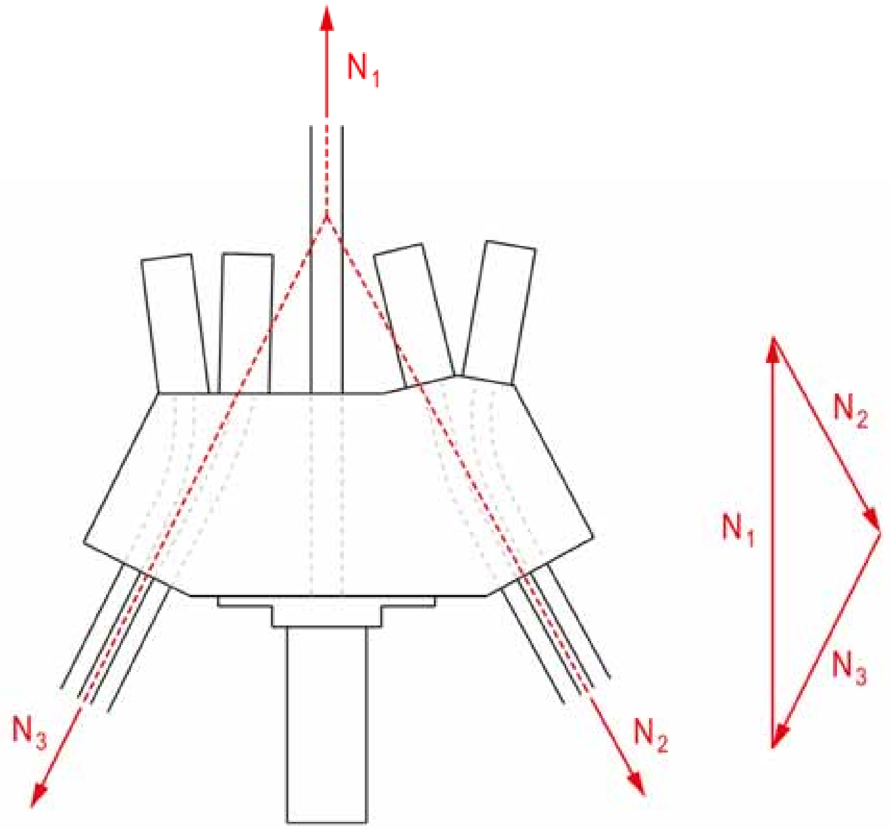




Auflagerbereiche von Kabelnetztragwerken
Cable net supports

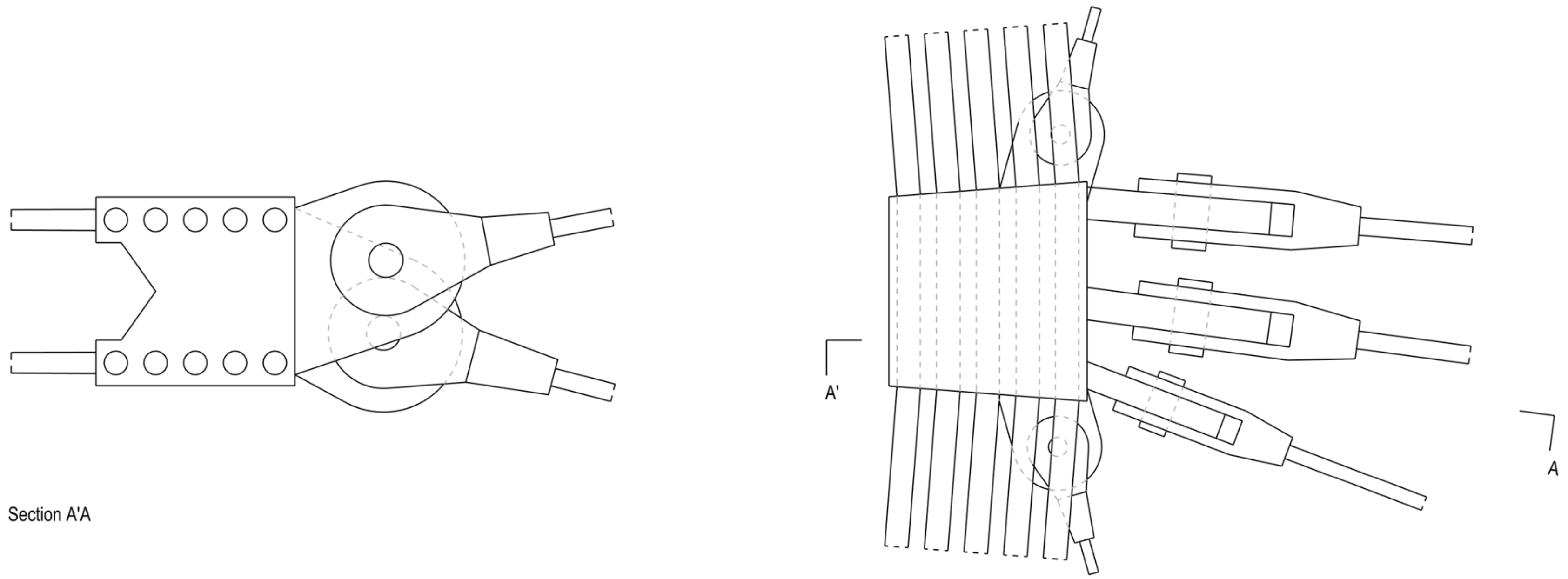
Auflagerbereiche von Kabelnetztragwerken
Cable net supports

Randkabel

Edge cables

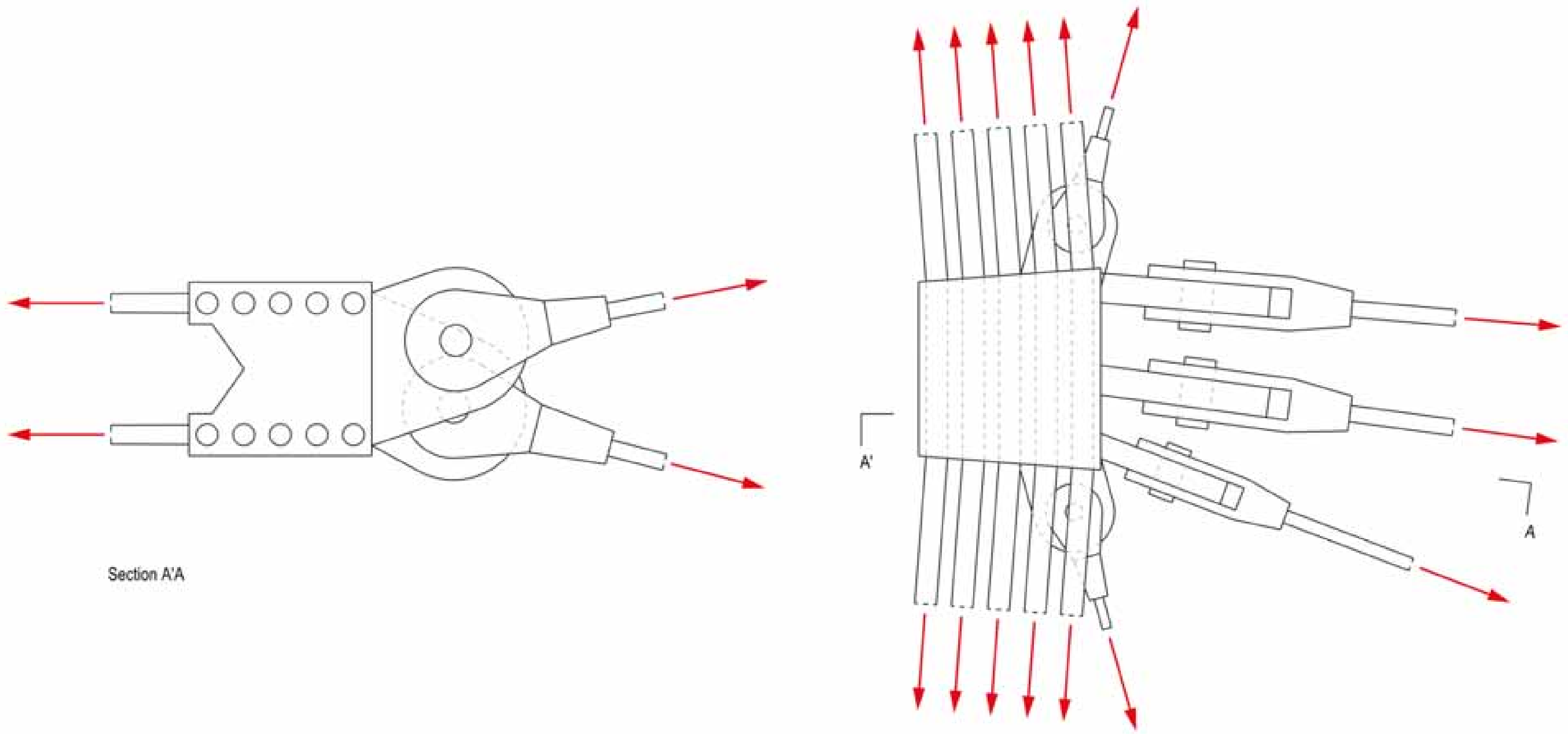
Randkabel

Edge cables



Randkabel

Edge cables



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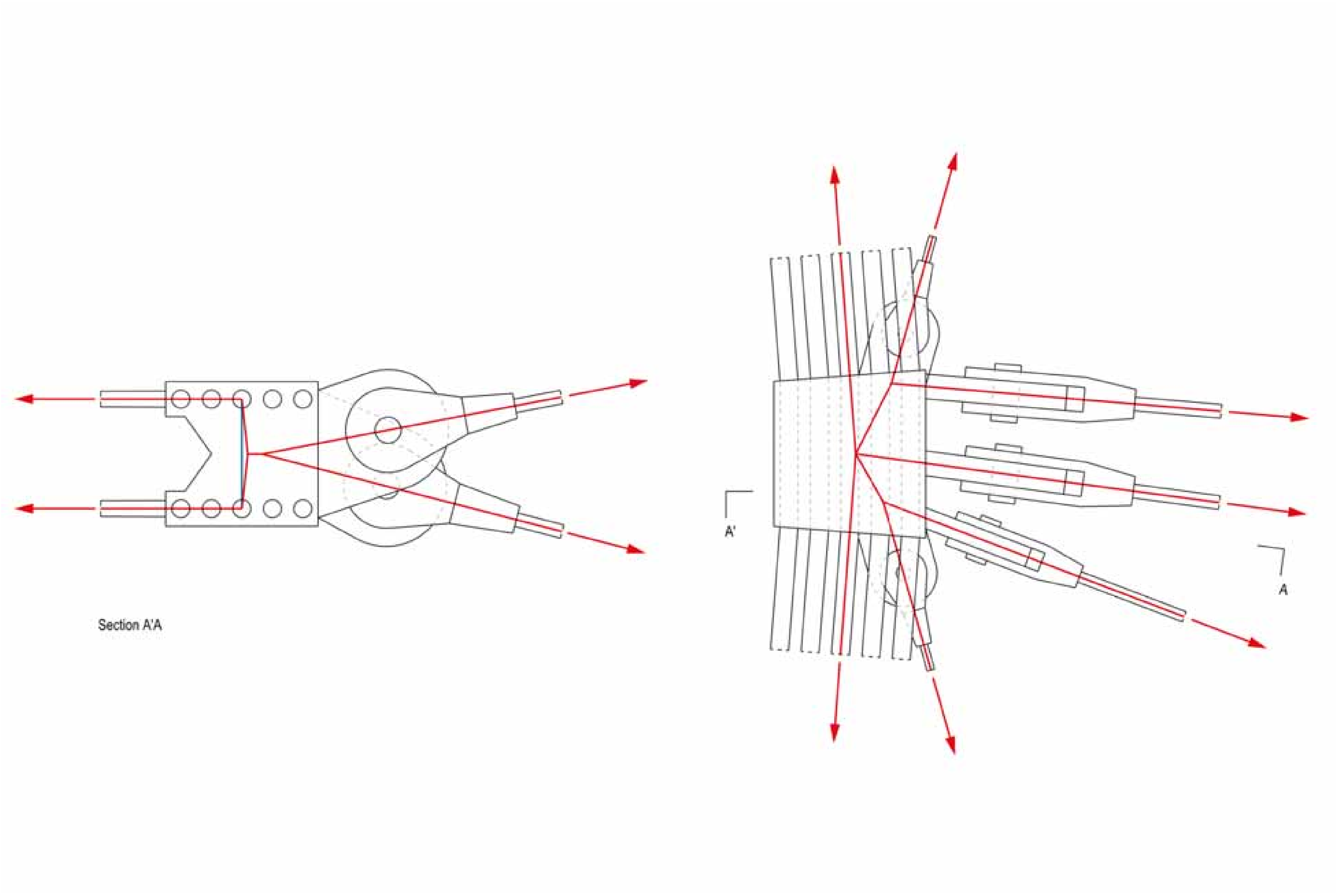
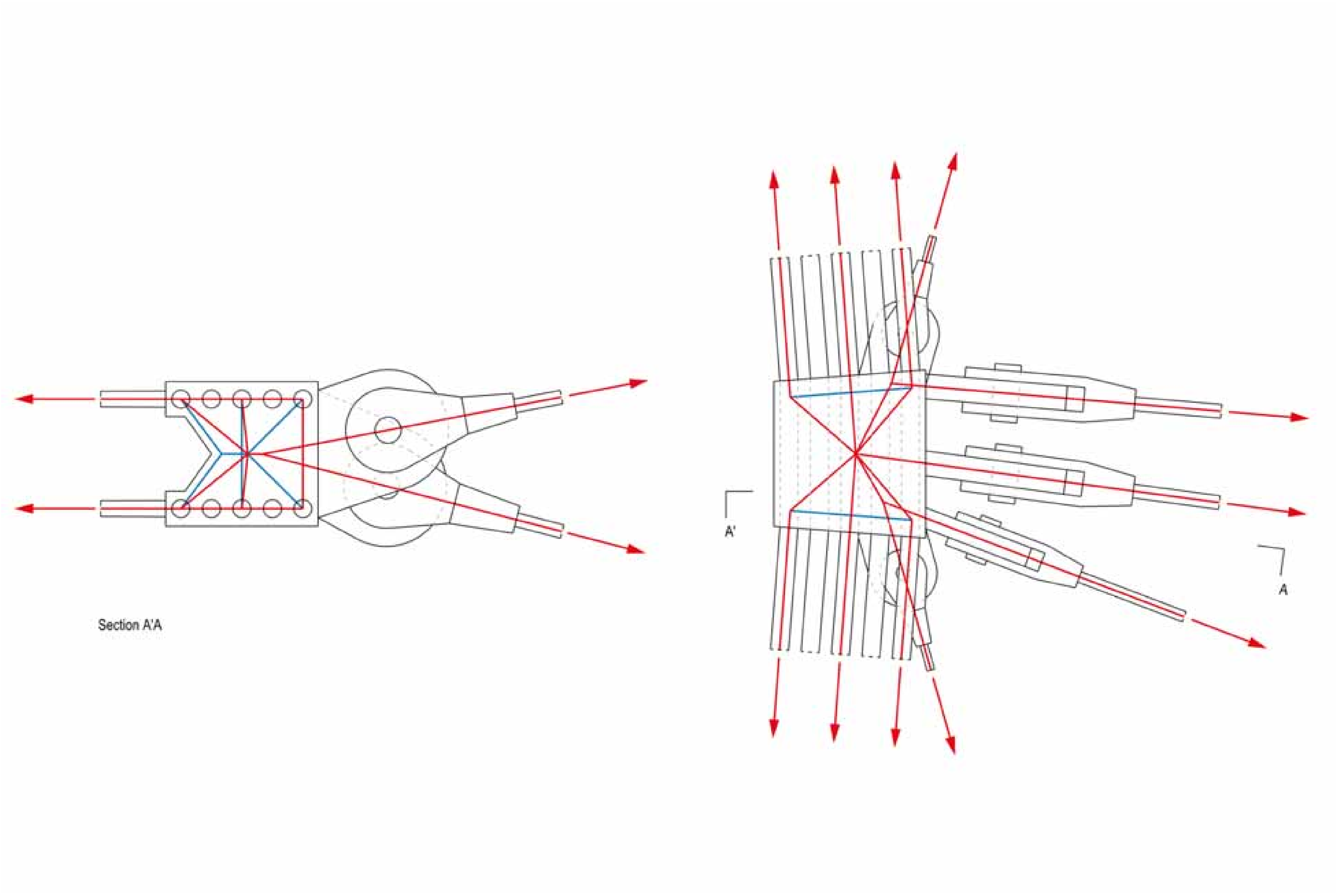
Edge cables

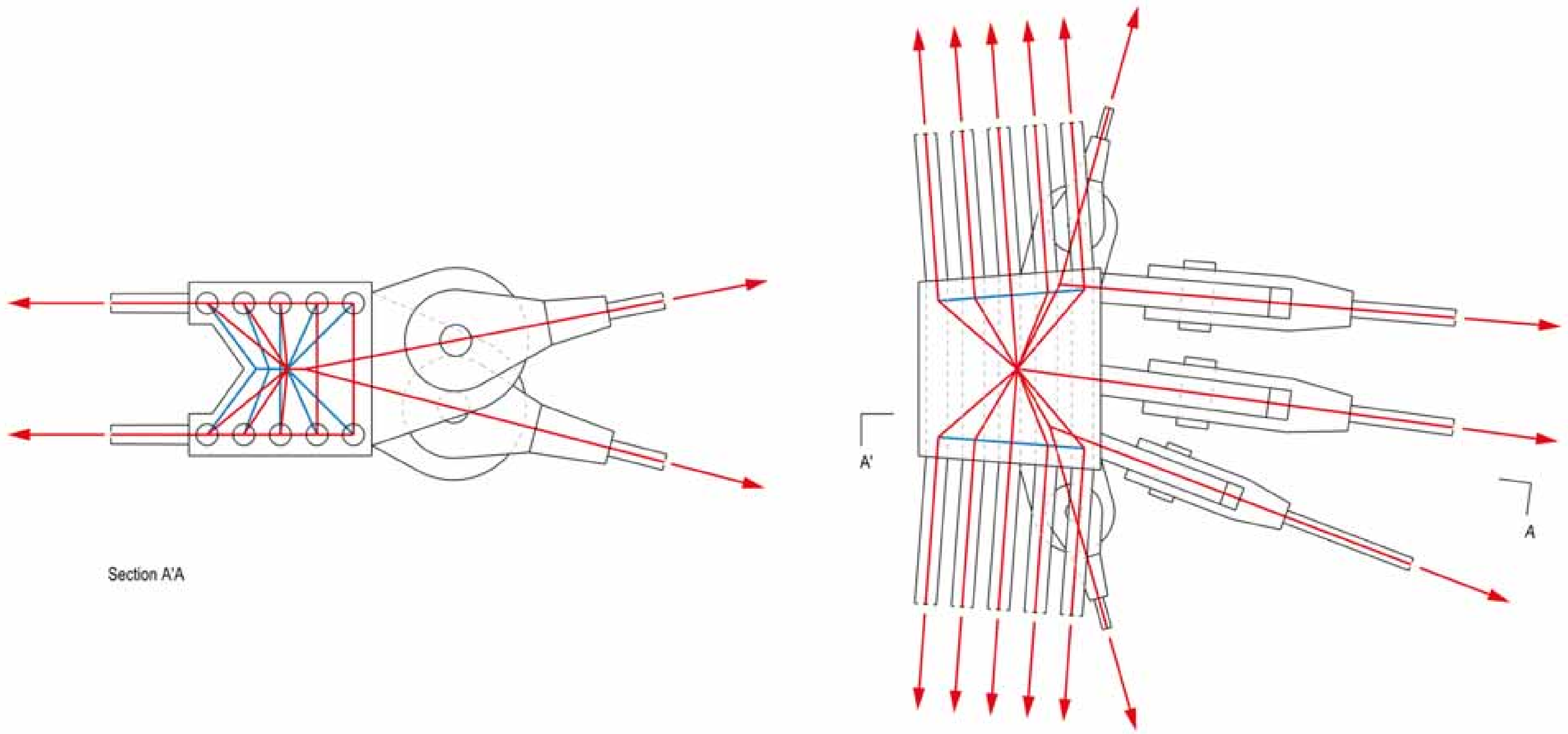


Randkabel

Edge cables



Randkabel
Edge cables



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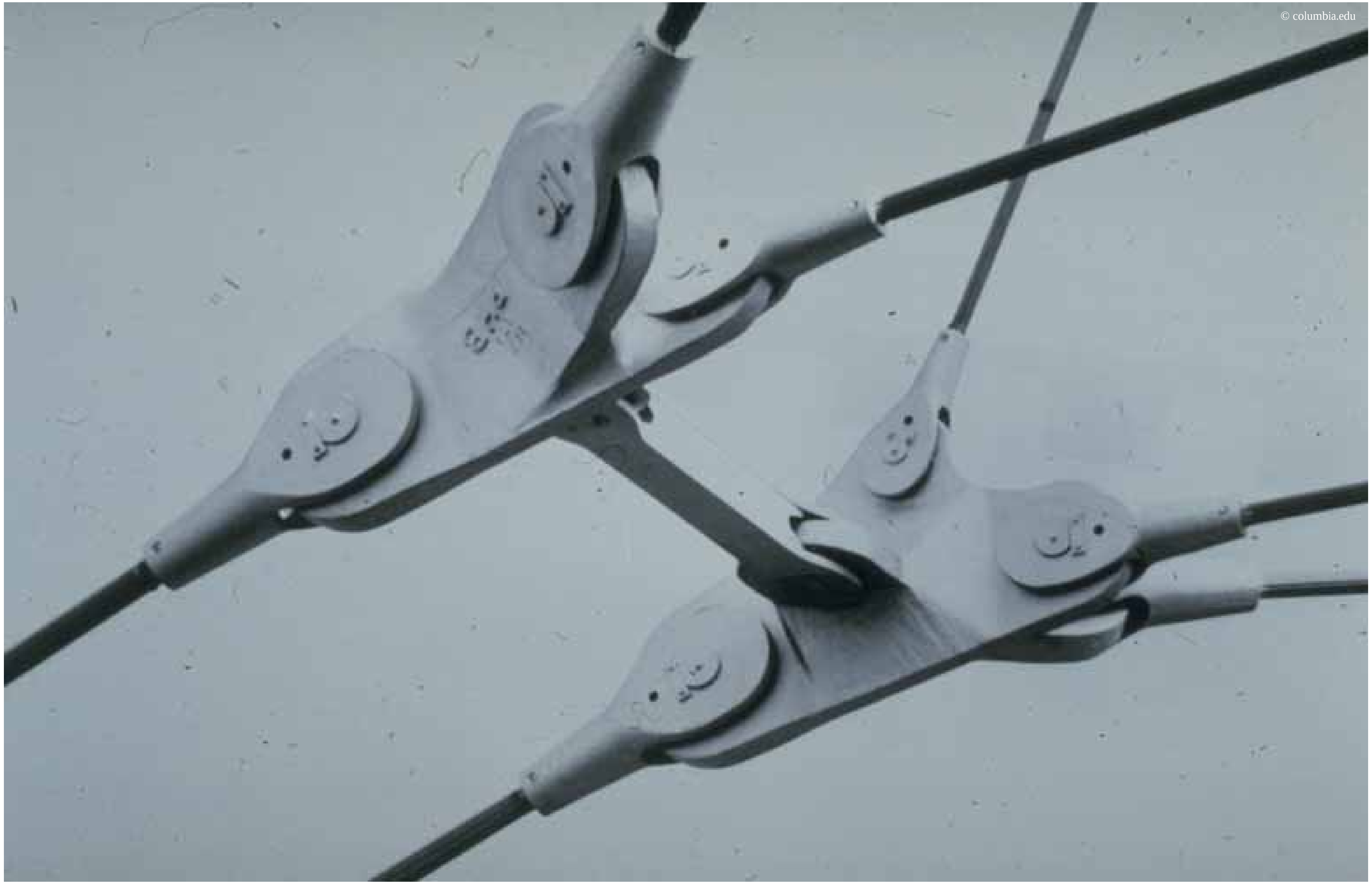
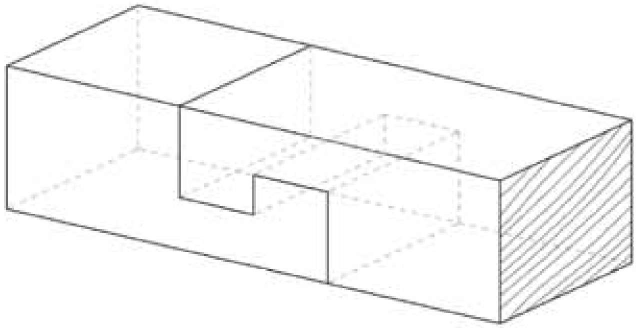
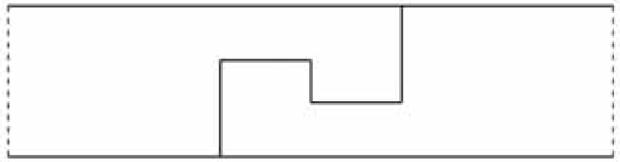
Edge cables



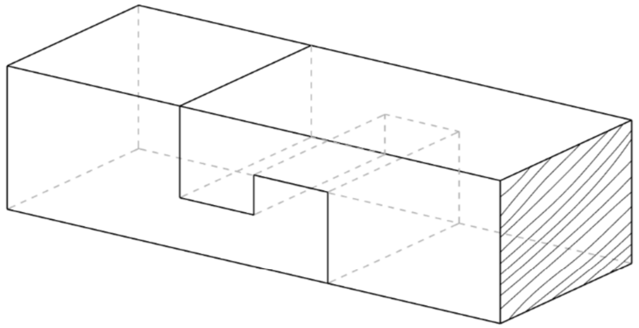
Randkabel
Edge cables

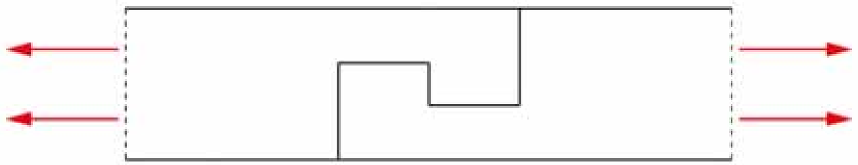




Beispiele für zugbelastete Verbindungen im Holzbau

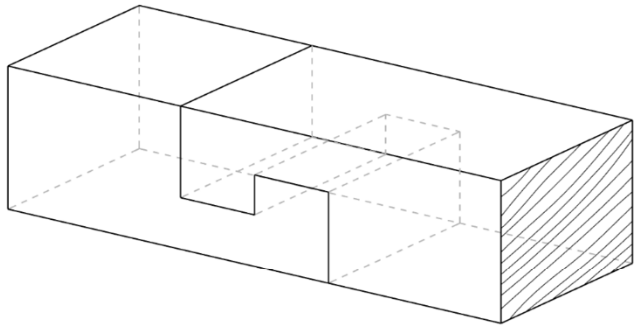
Examples of connections resisting tension in timber construction

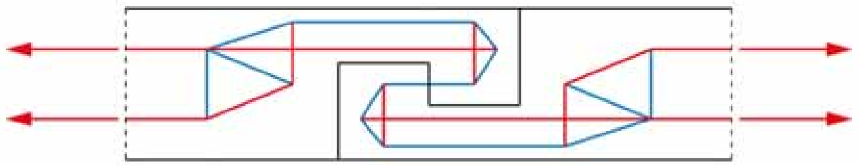




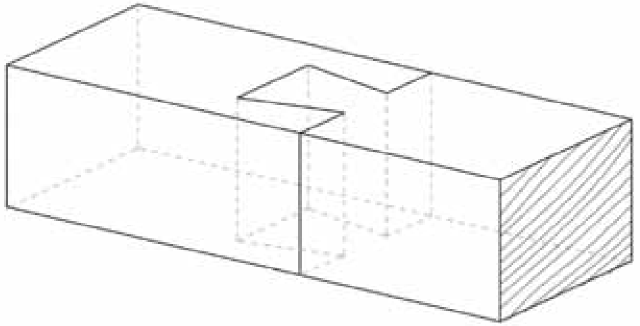
Beispiele für zugbelastete Verbindungen im Holzbau

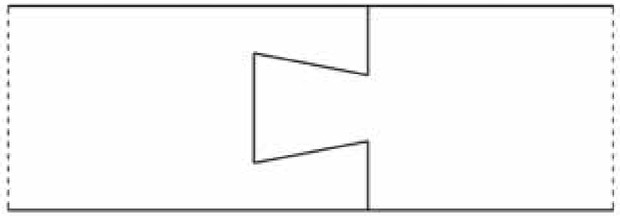
Examples of connections resisting tension in timber construction





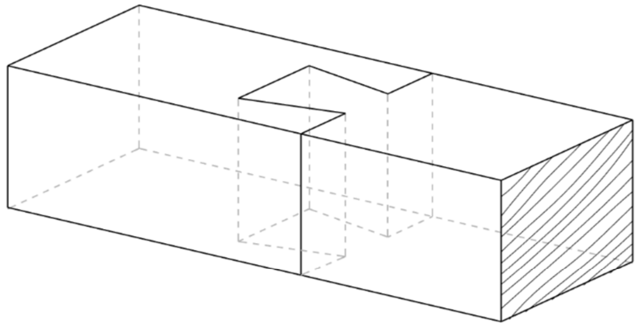
Beispiele für zugbelastete Verbindungen im Holzbau
Examples of connections resisting tension in timber construction

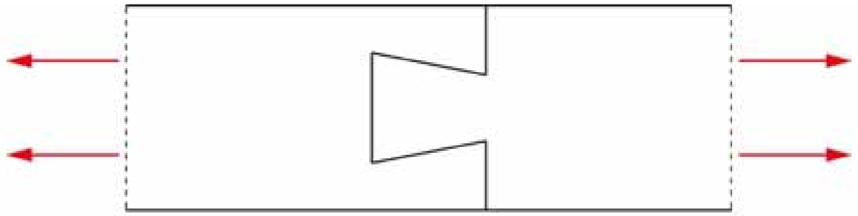




Beispiele für zugbelastete Verbindungen im Holzbau

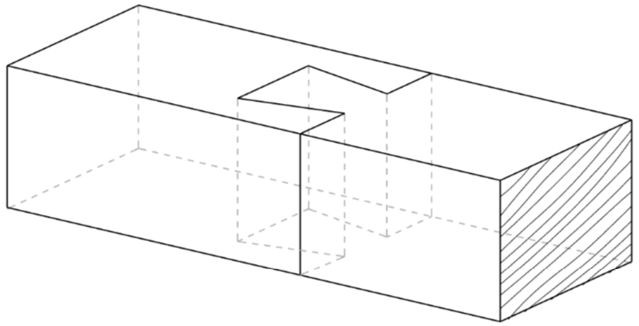
Examples of connections resisting tension in timber construction

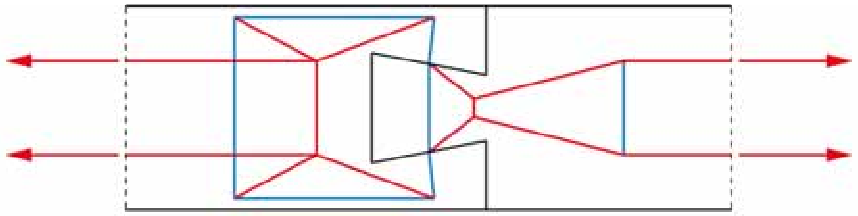




Beispiele für zugbelastete Verbindungen im Holzbau

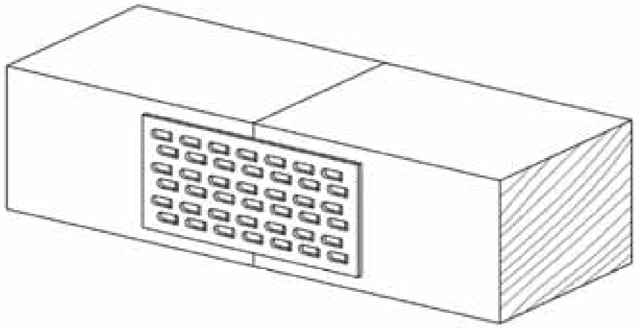
Examples of connections resisting tension in timber construction

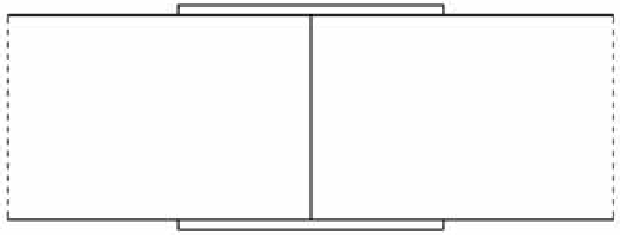




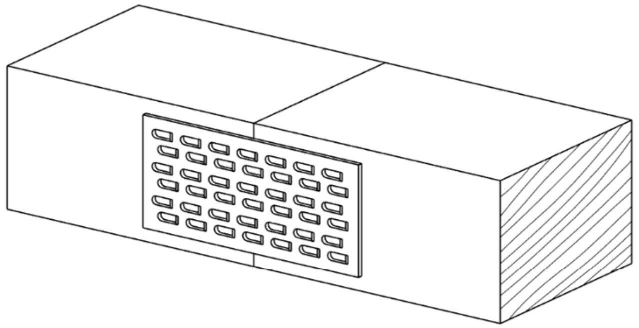
Beispiele für zugbelastete Verbindungen im Holzbau

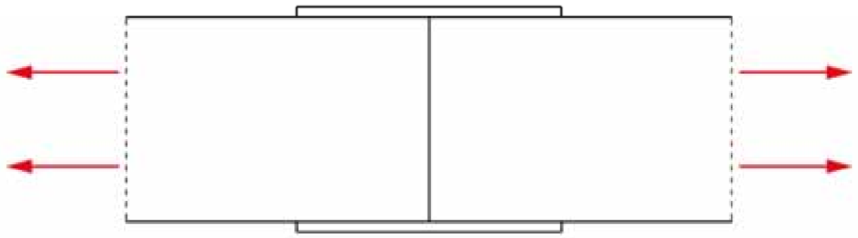
Examples of connections resisting tension in timber construction





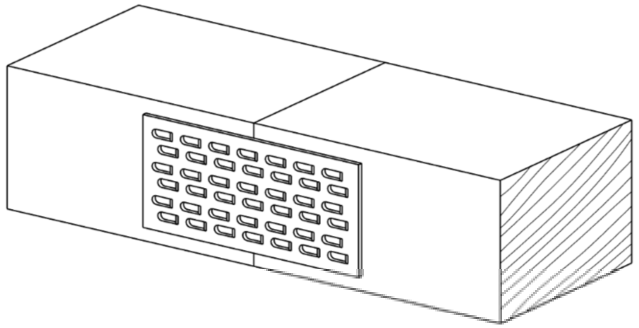
Beispiele für zugbelastete Verbindungen im Holzbau
Examples of connections resisting tension in timber construction

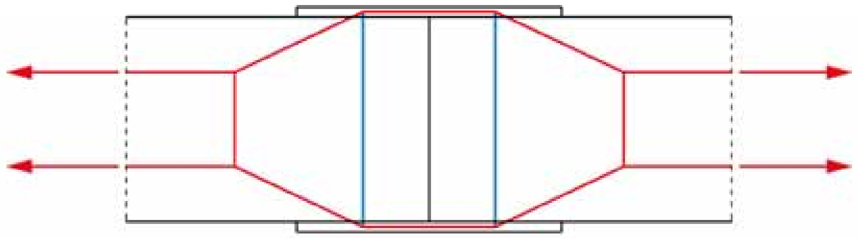




Beispiele für zugbelastete Verbindungen im Holzbau

Examples of connections resisting tension in timber construction





Beispiele für zugbelastete Verbindungen im Holzbau

Examples of connections resisting tension in timber construction

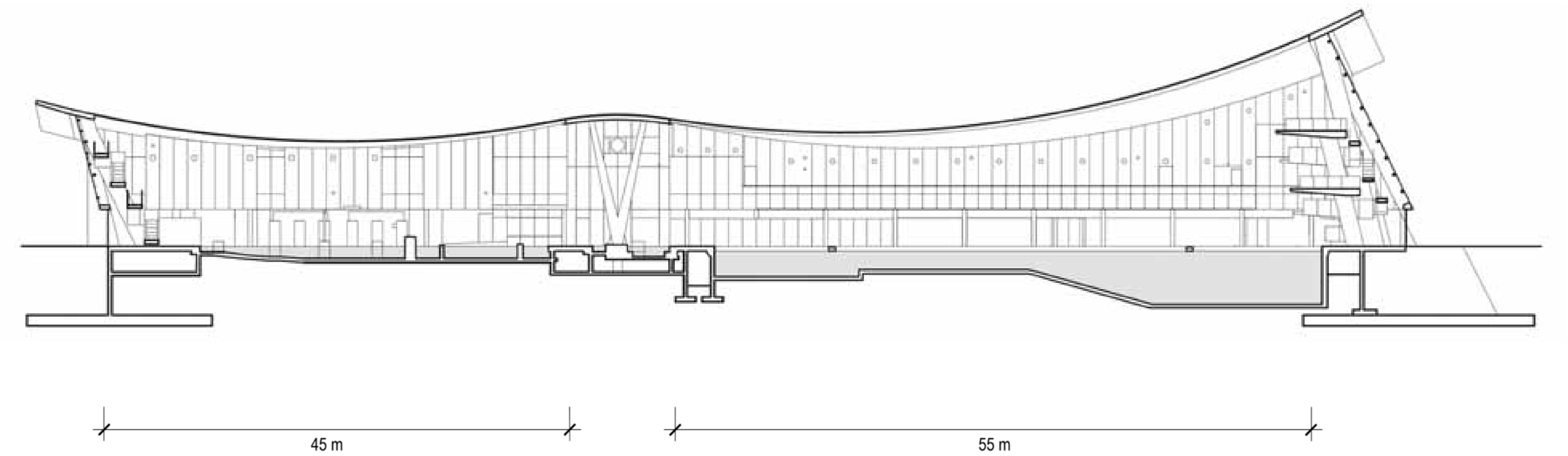
Sports and Leisure Pool

Surrey (Canada), 2016

Architect: HCMA

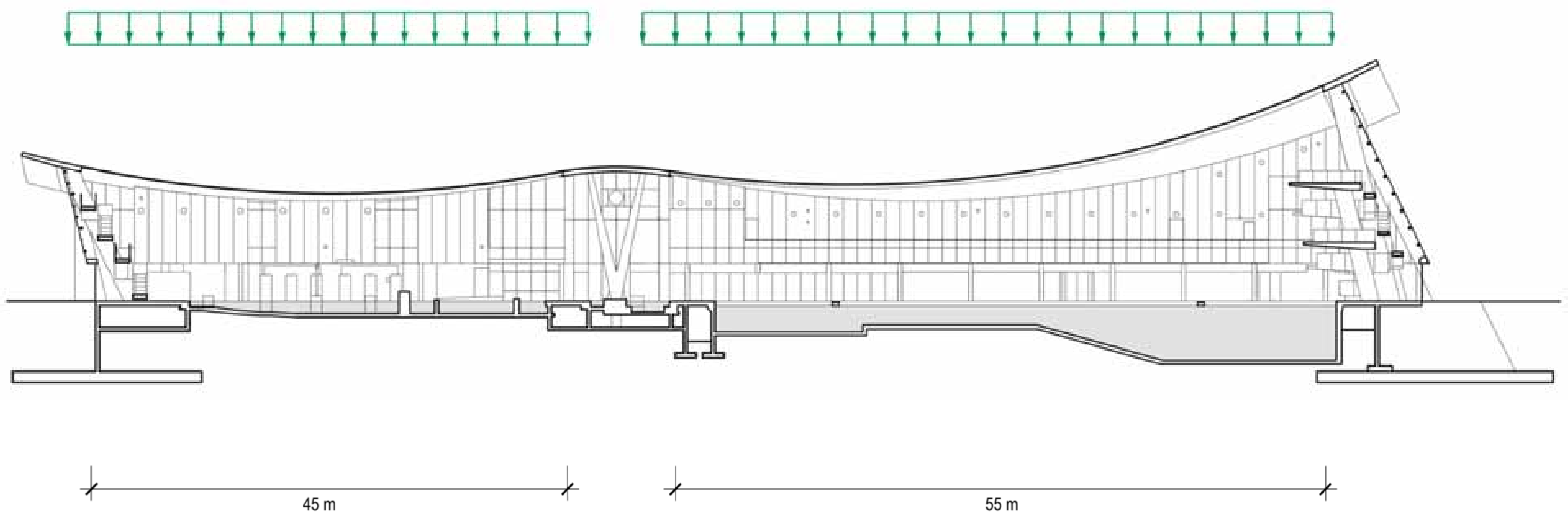
Engineer: Fast+Epp

Ansicht
General view



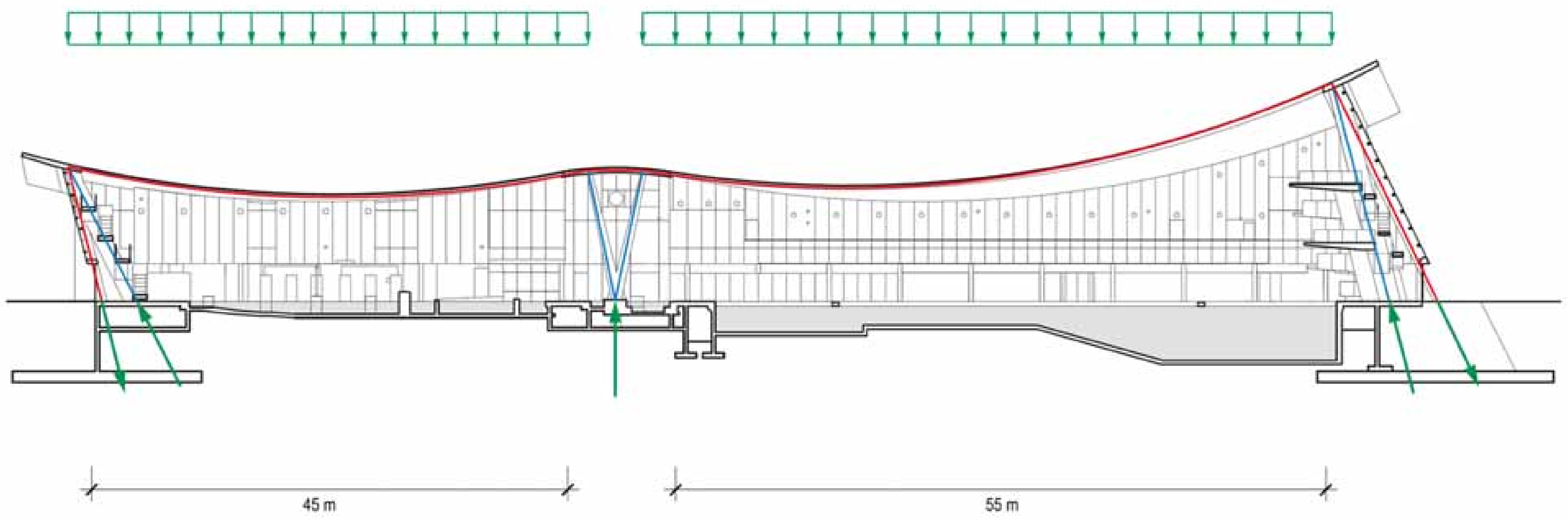
Statisches Gleichgewicht

Static equilibrium



Statisches Gleichgewicht

Static equilibrium

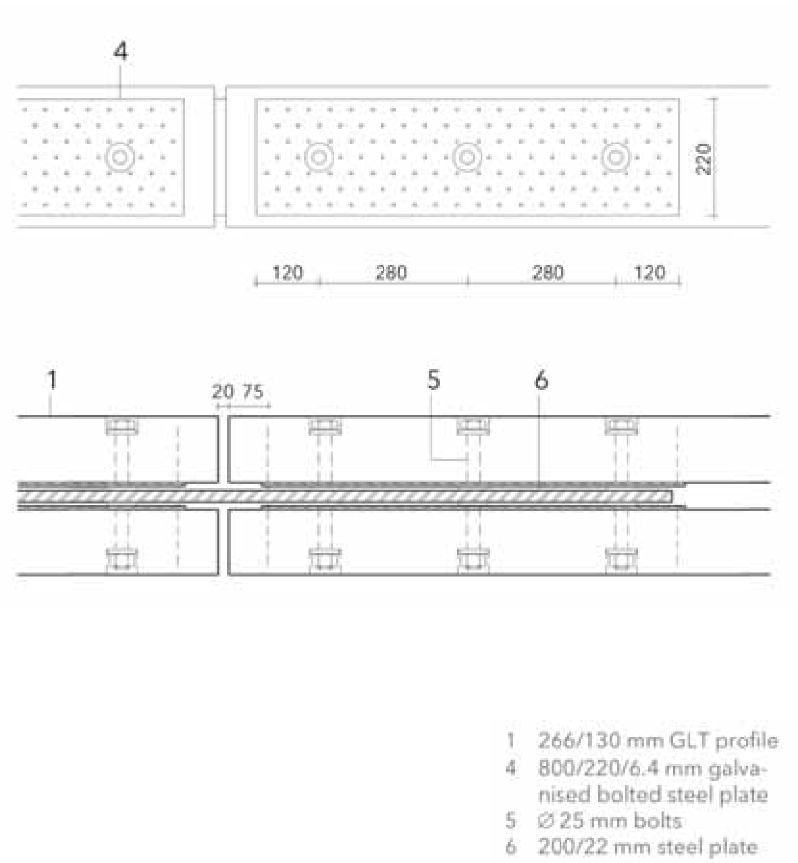


Statisches Gleichgewicht

Static equilibrium

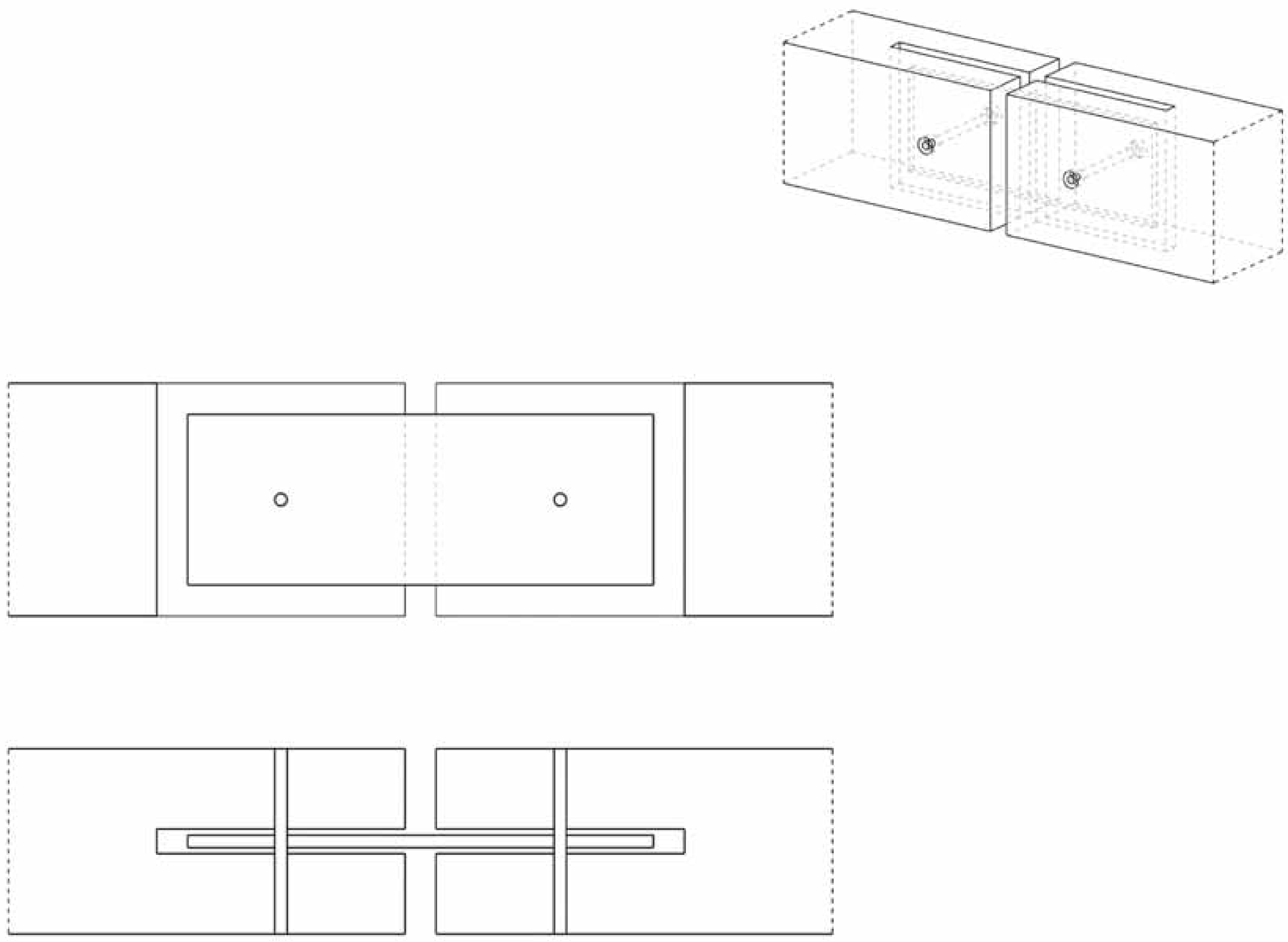
Abgehängtes Holzdach

Suspended timber roof

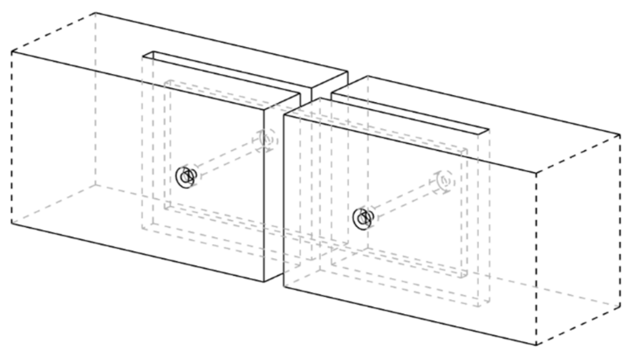


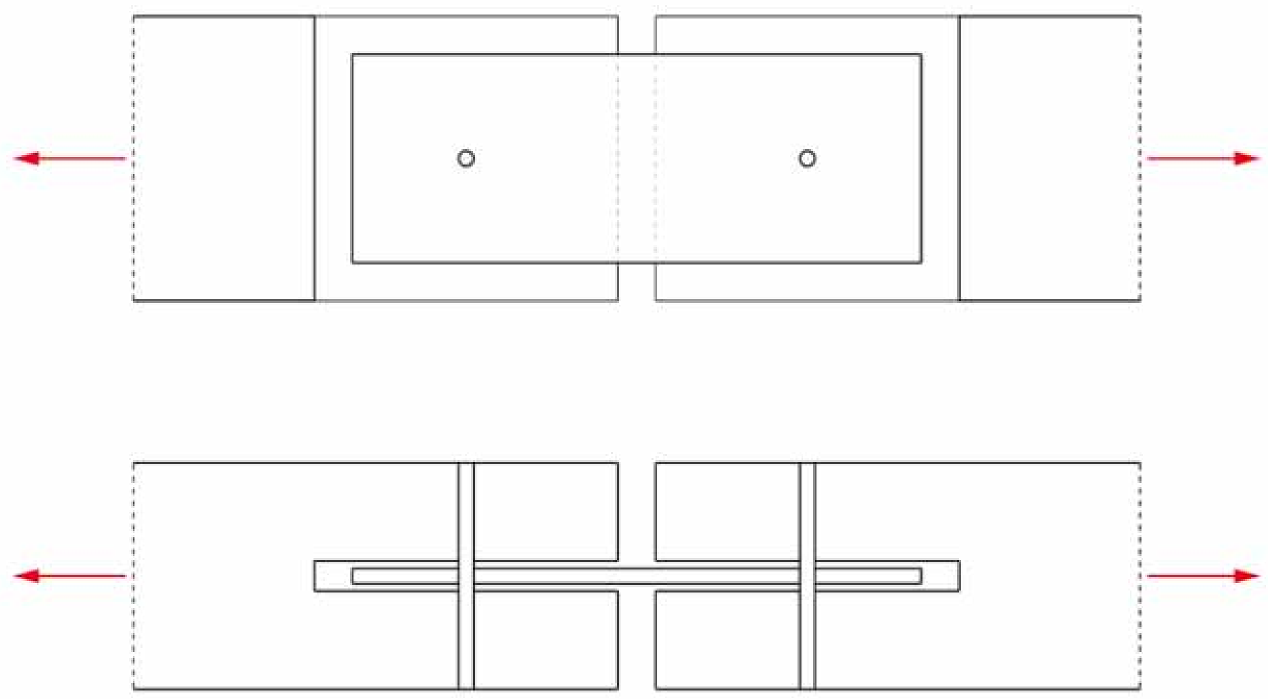
Verbindungsdetails der Balken

Details of the beams' connection



Verbindungsdetails der Balken
Details of the beams' connection





Verbindungsdetails der Balken

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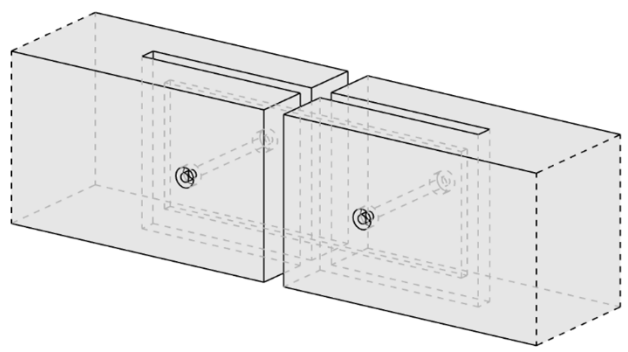
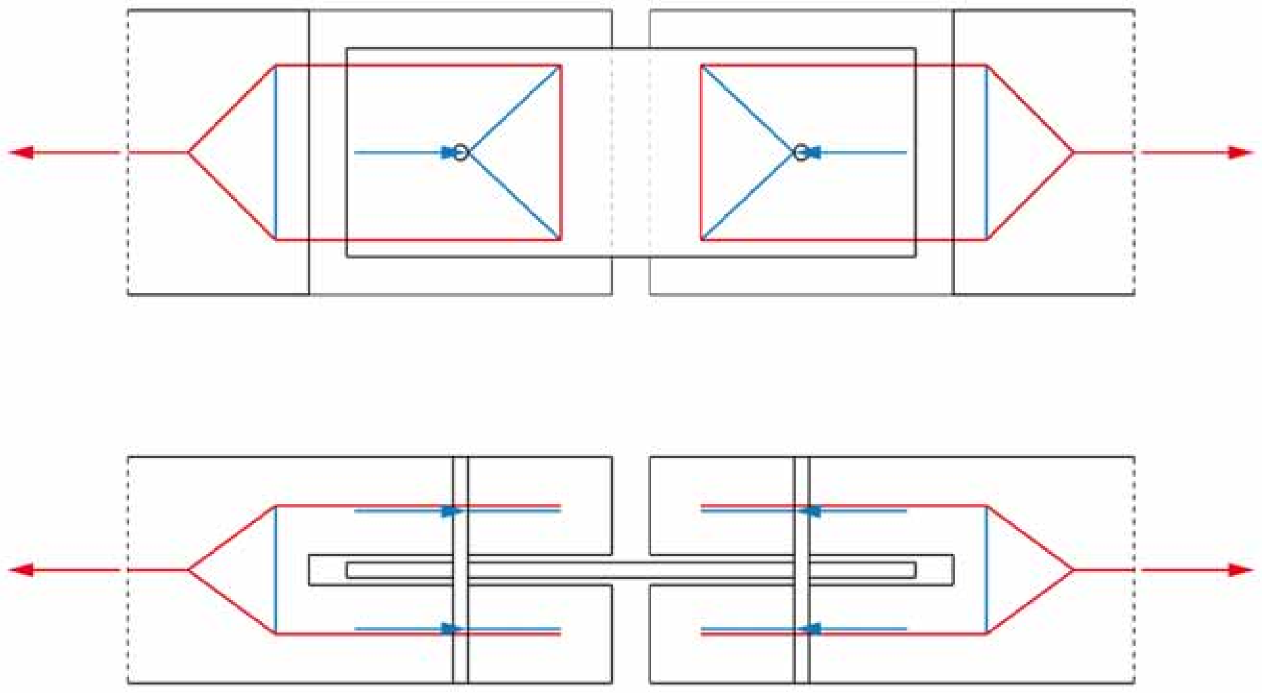
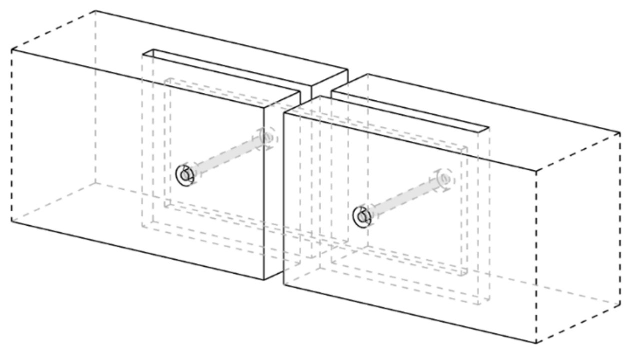
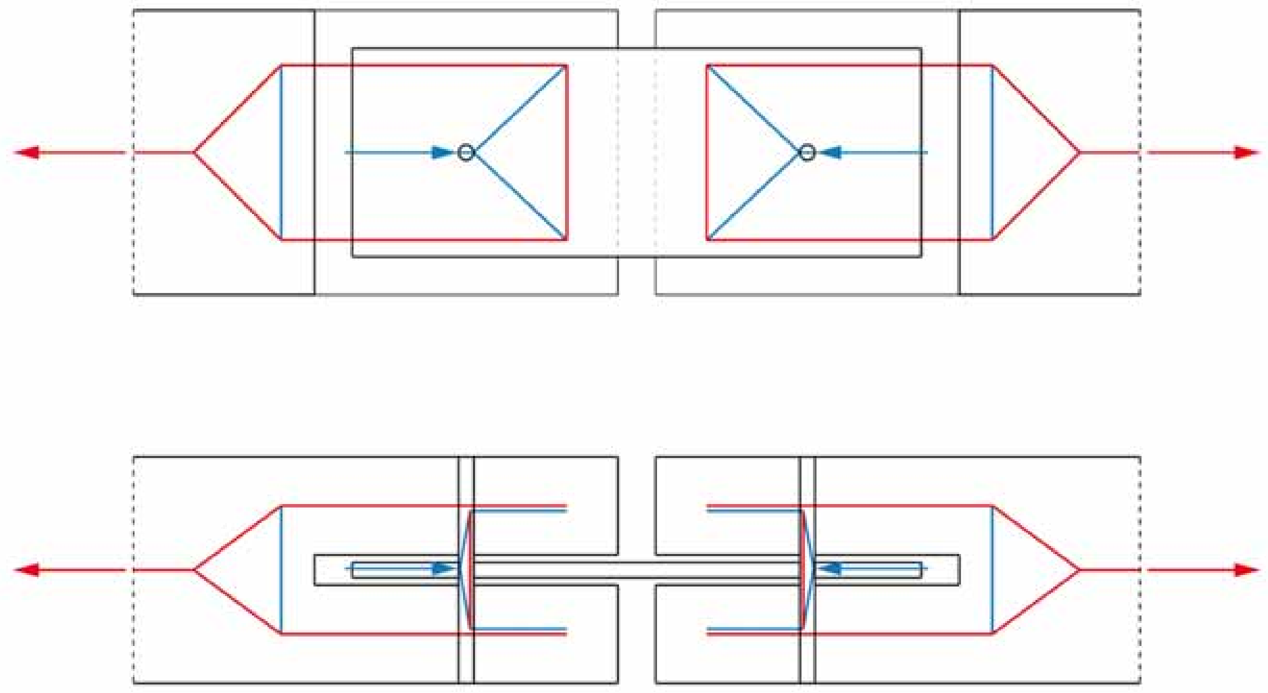


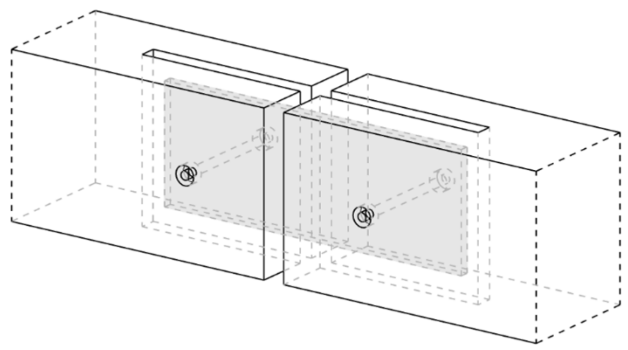


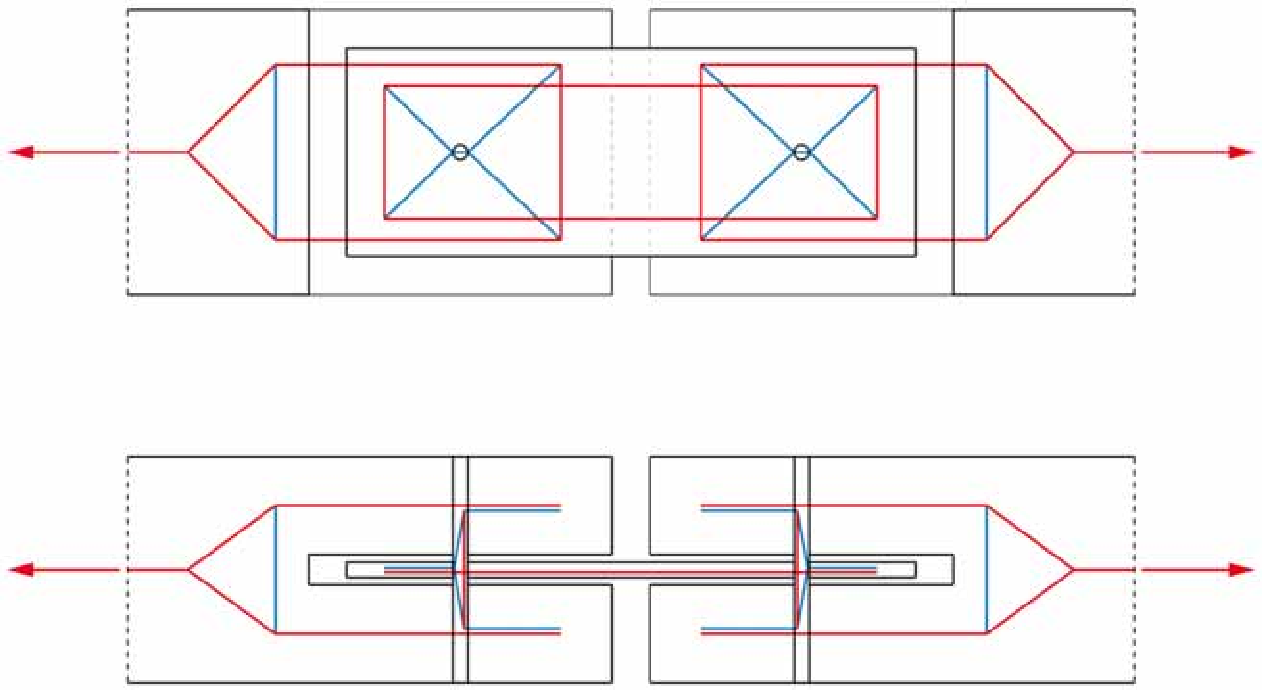
Verbindungsdetails der Balken
Details of the beams' connection



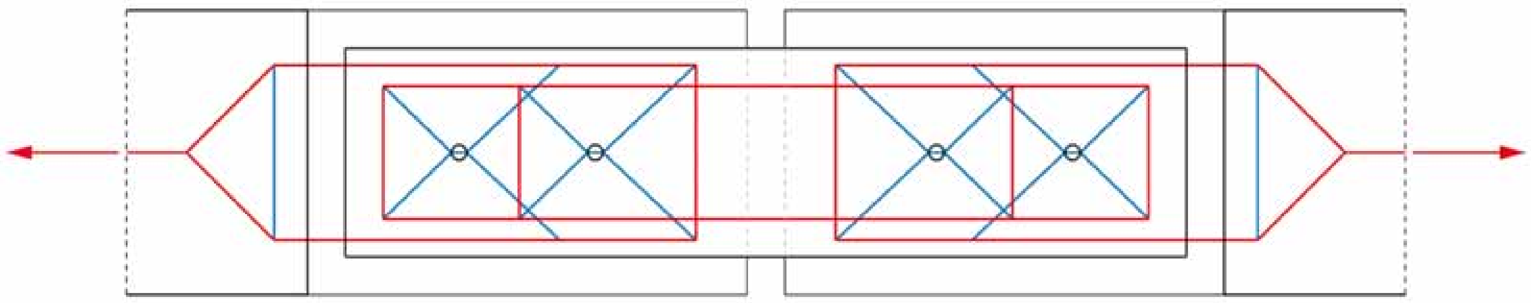


Verbindungsdetails der Balken
Details of the beams' connection

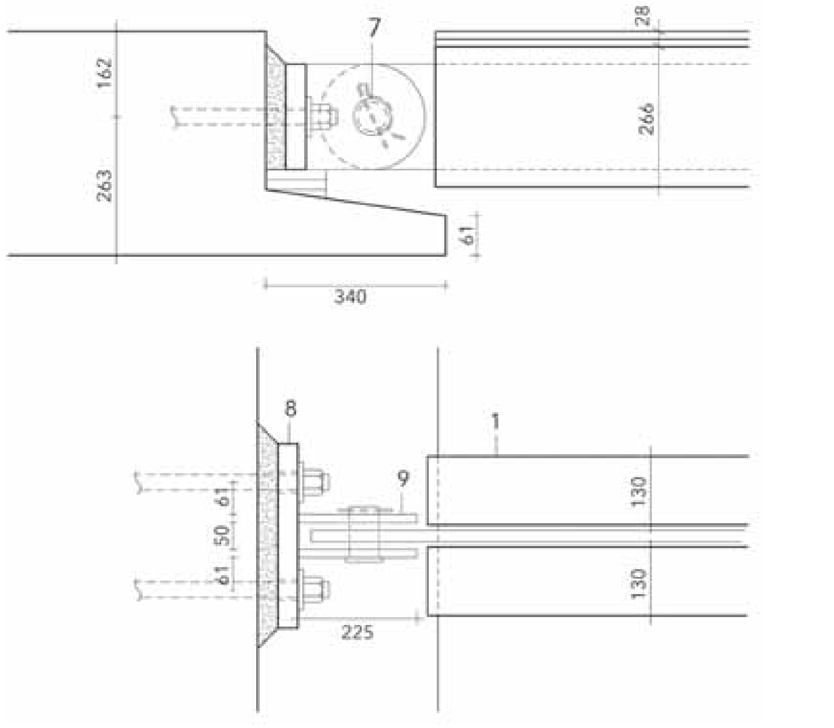




Verbindungsdetails der Balken
Details of the beams' connection



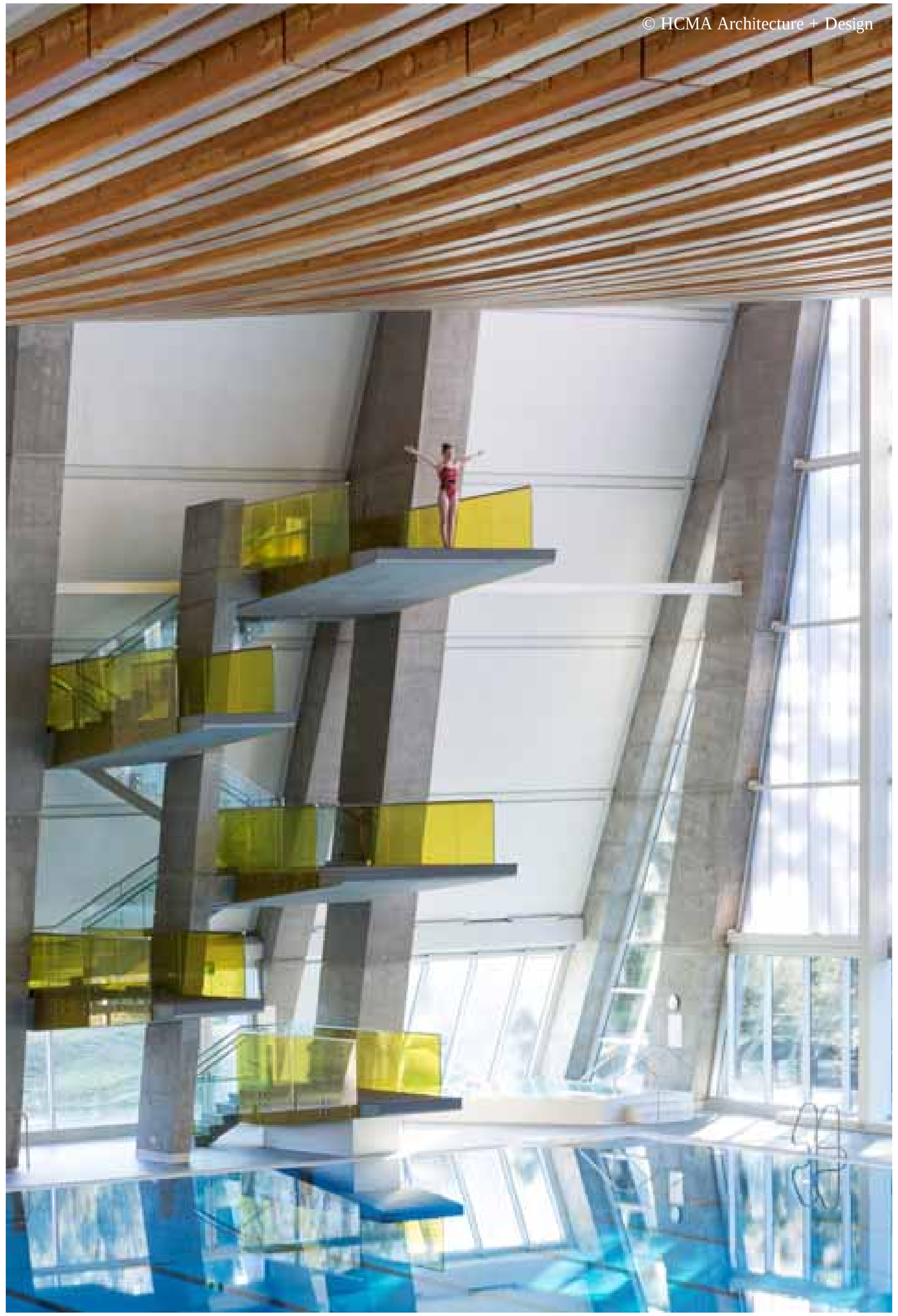
Verbindungsdetails der Balken
Details of the beams' connection



1 266/130 mm GLT profile
7 Ø 57 mm bolts
8 350/280/30 mm steel plate
9 225/200/16 mm steel plate

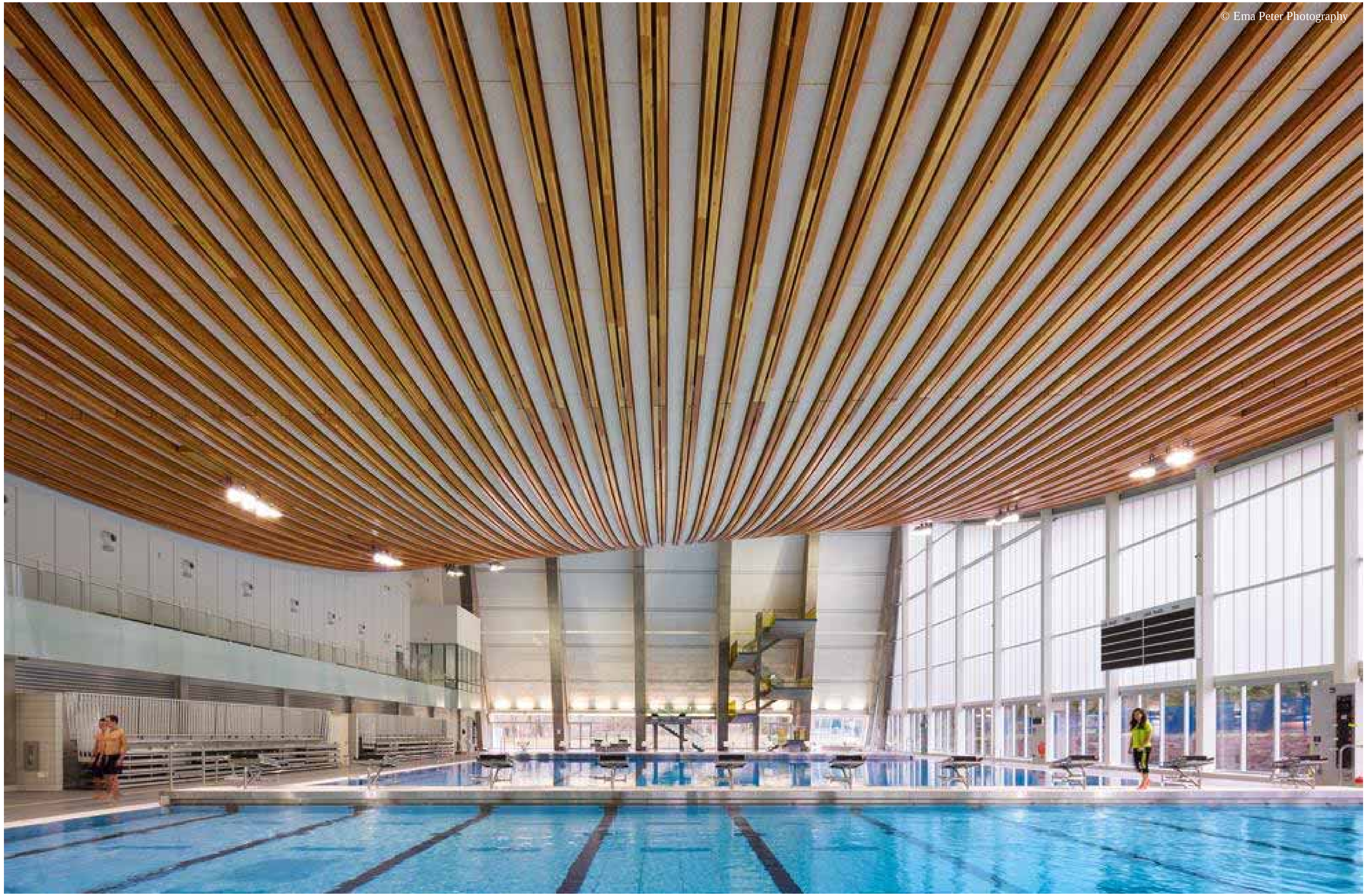
Verbindungsdetails der Balken

Details of the beams' connection



Innenansicht

Interior view



Innenansicht
Interior view

Konstruktionsdetails
Construction details

Seiltragwerke
Cable structures

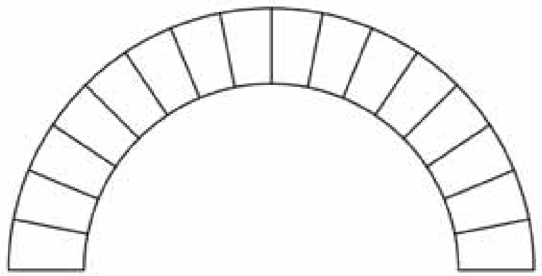
\>> Bogenkonstruktionen
Arch structures

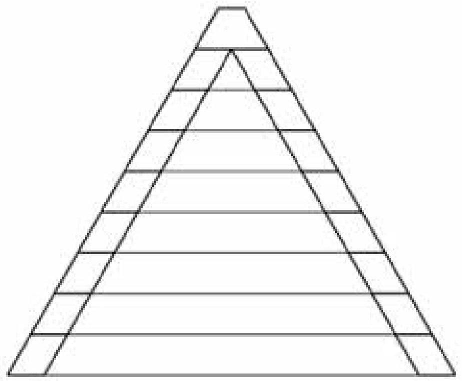
Bogenseilkonstruktionen
Arch-cable structures

Fachwerkstrukturen
Trusses

Balken
Beams

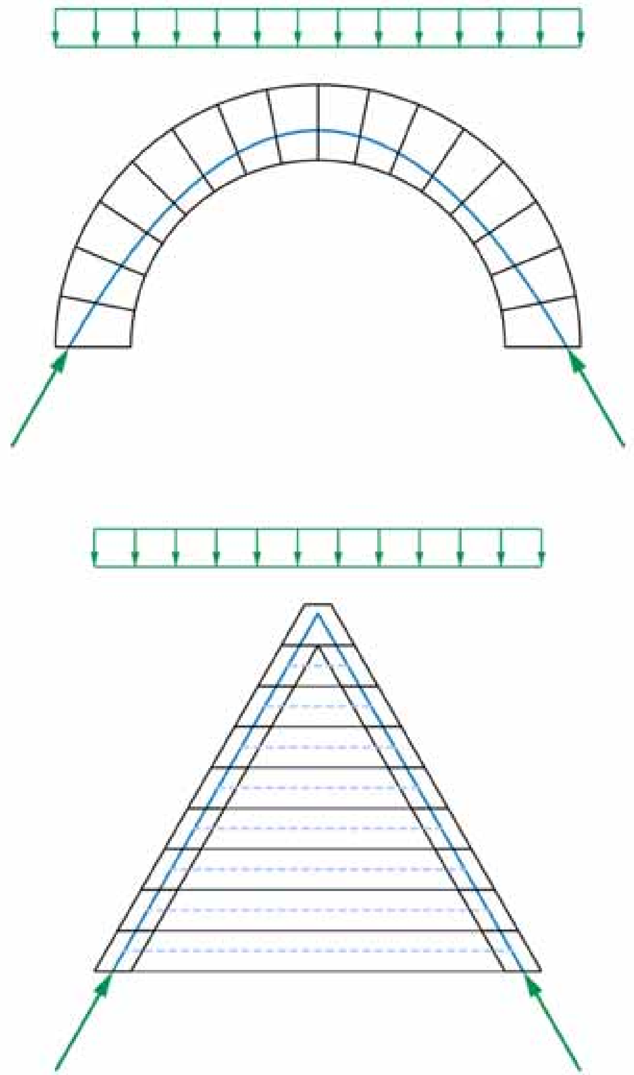
Rahmen
Frames





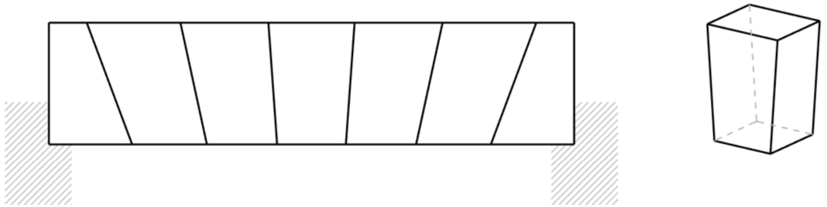
Stereotomie im Mauerwerksbau (oben: Chiesa San Giovanni Battista, 1996, Mario Botta, unten: Trulli, Italien)

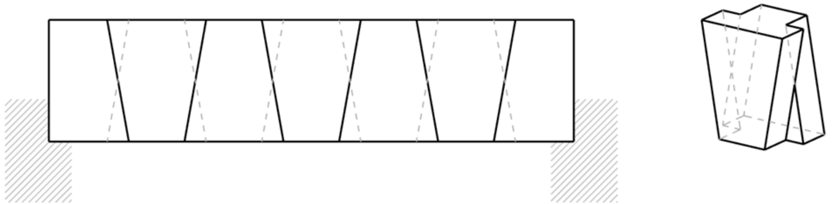
Stereotomy in masonry construction (top: Chiesa San Giovanni Battista, 1996, Mario Botta, bottom: Trulli, Italy)



Stereotomie im Mauerwerksbau (oben: Chiesa San Giovanni Battista, 1996, Mario Botta, unten: Trulli, Italien)

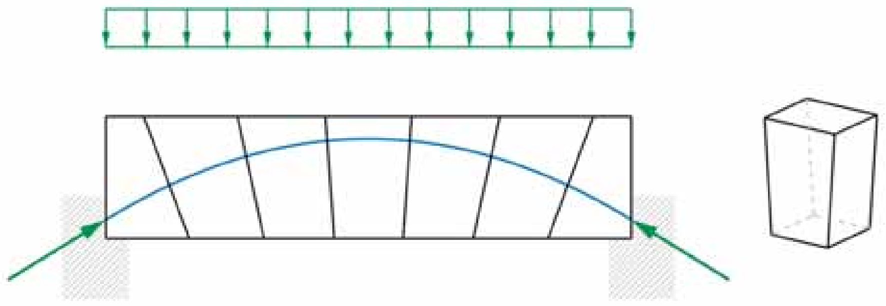
Stereotomy in masonry construction (top: Chiesa San Giovanni Battista, 1996, Mario Botta, bottom: Trulli, Italy)

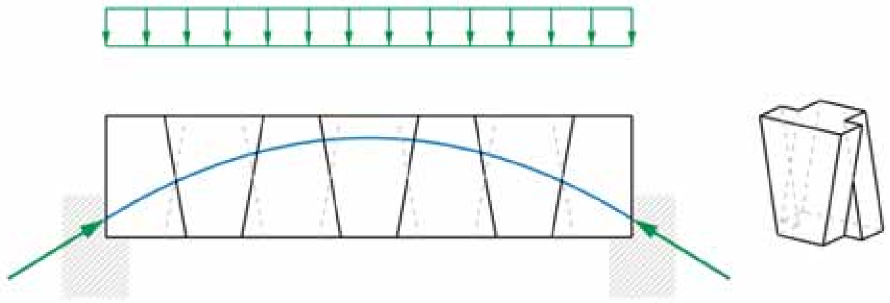




Beispiele für Stereotomie im Mauerwerksbau (Dom von Prato, 14./15. Jahrhundert)

Examples of stereotomy in masonry construction (Duomo di Prato, 14th/15th century)





Beispiele für Stereotomie im Mauerwerksbau (Dom von Prato, 14./15. Jahrhundert)

Examples of stereotomy in masonry construction (Duomo di Prato, 14th/15th century)

Padre Pio Pilgrimage Church

San Giovanni Rotondo, 2004

Architects: Renzo Piano Building Workshop

Engineers: Ove Arup & Partners, Favero & Milan

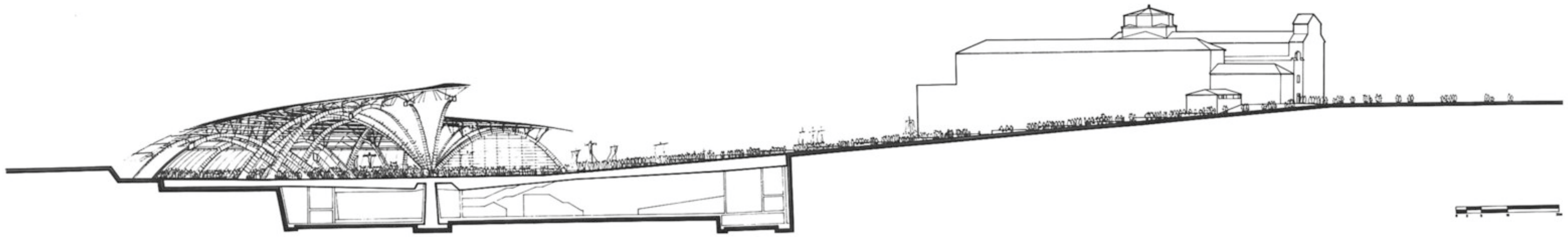
Ansicht
General view

Blick auf das Dach und den Haupteingang

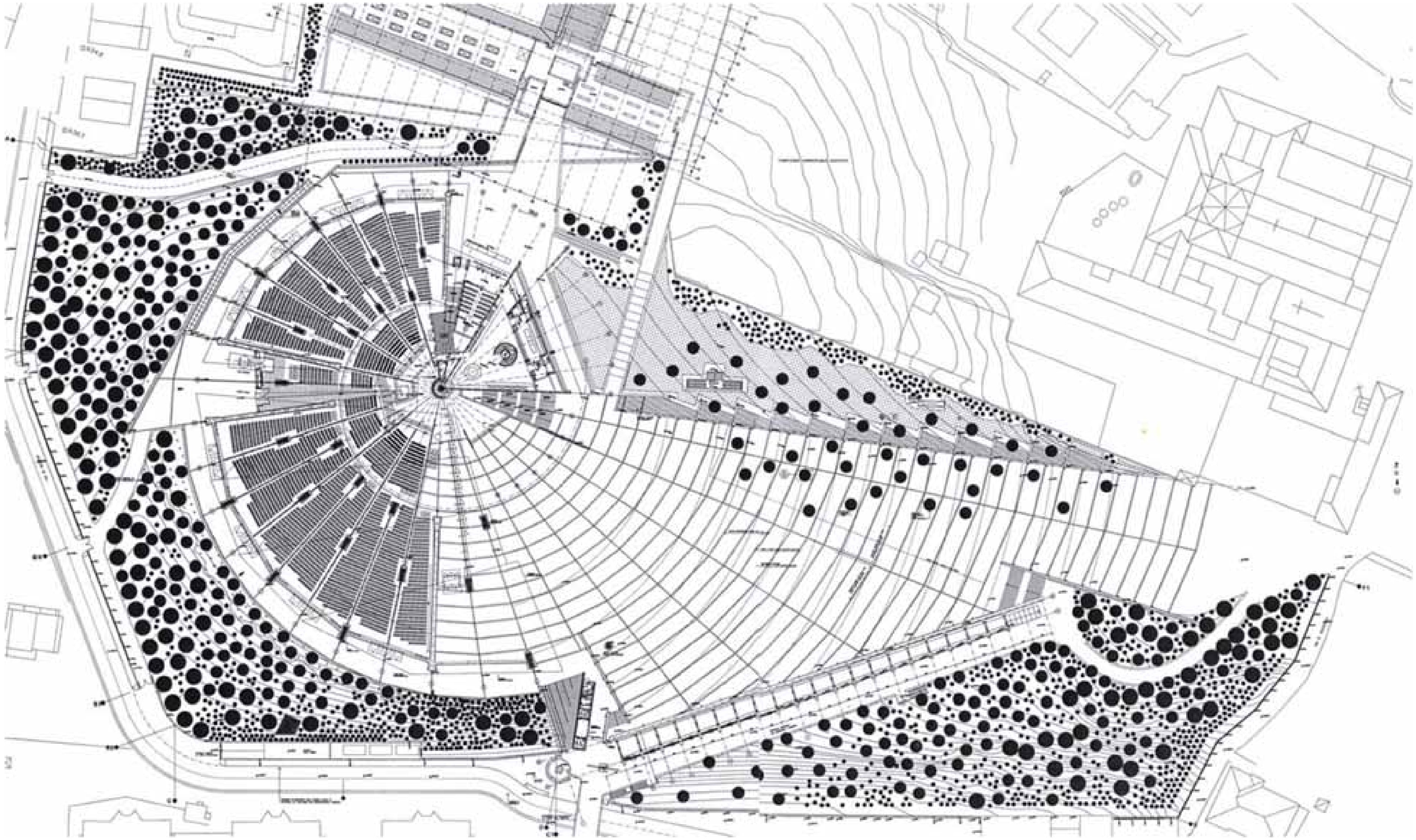
View on the roof and the main entrance

Innenansicht

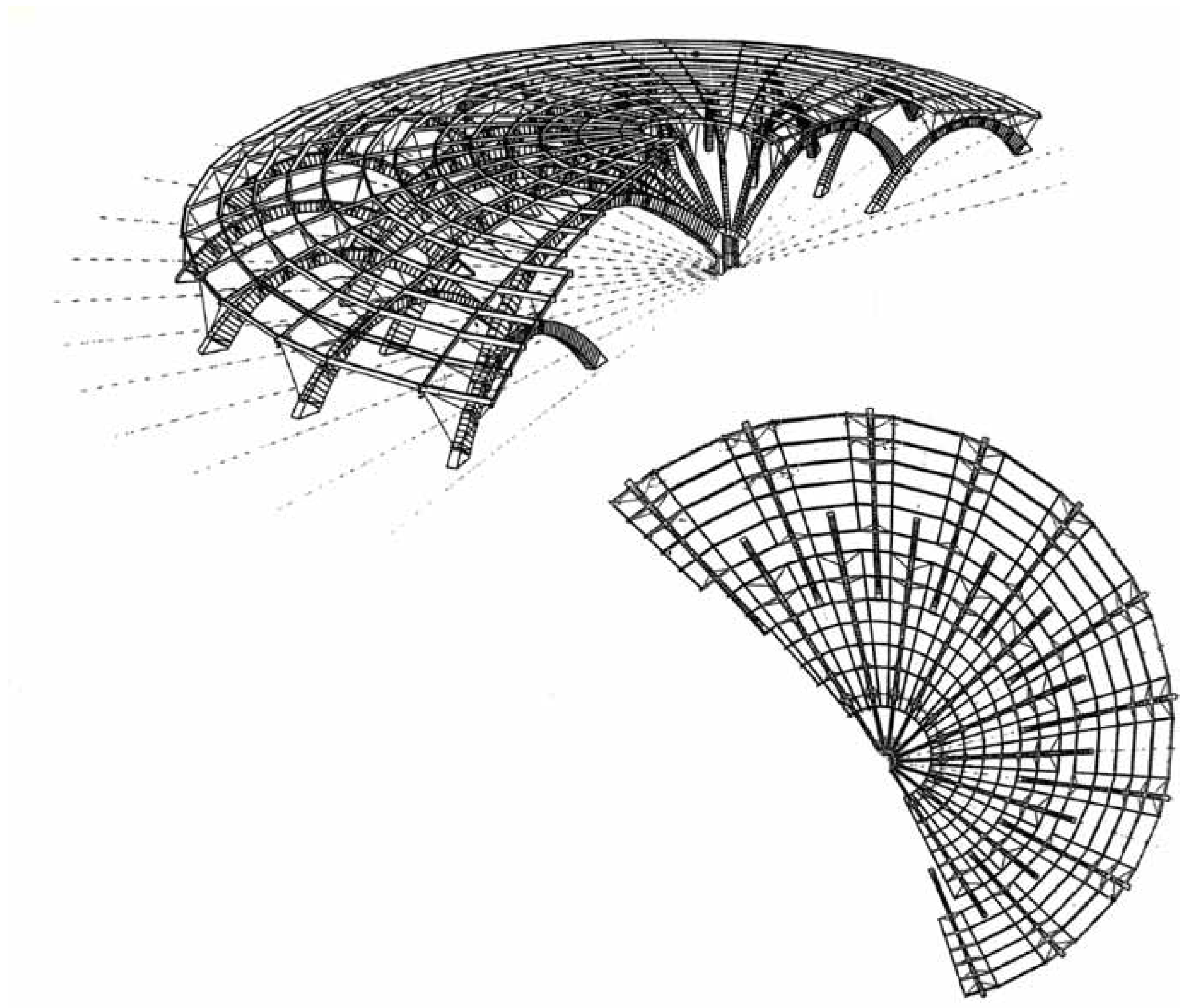
Interior view



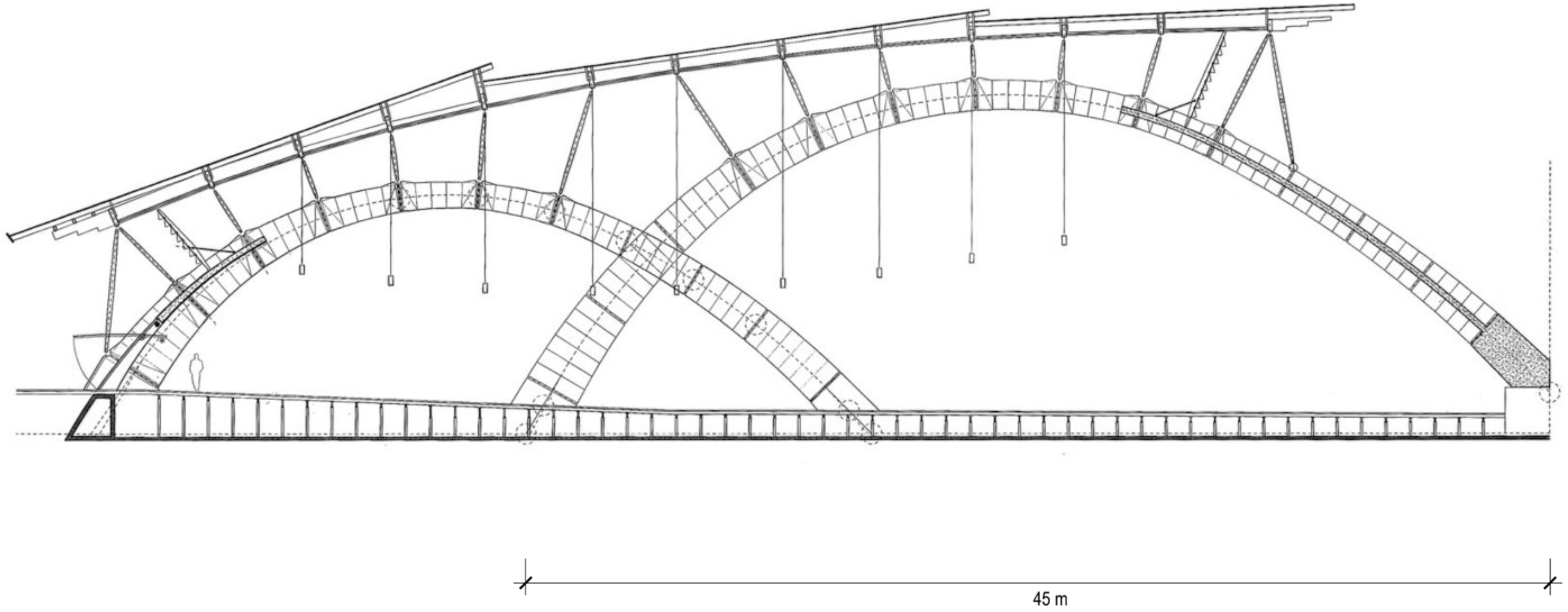
Schnitt
Section



Grundriss
Plan



Grundriss und Axonometrie
Plan and axonometry



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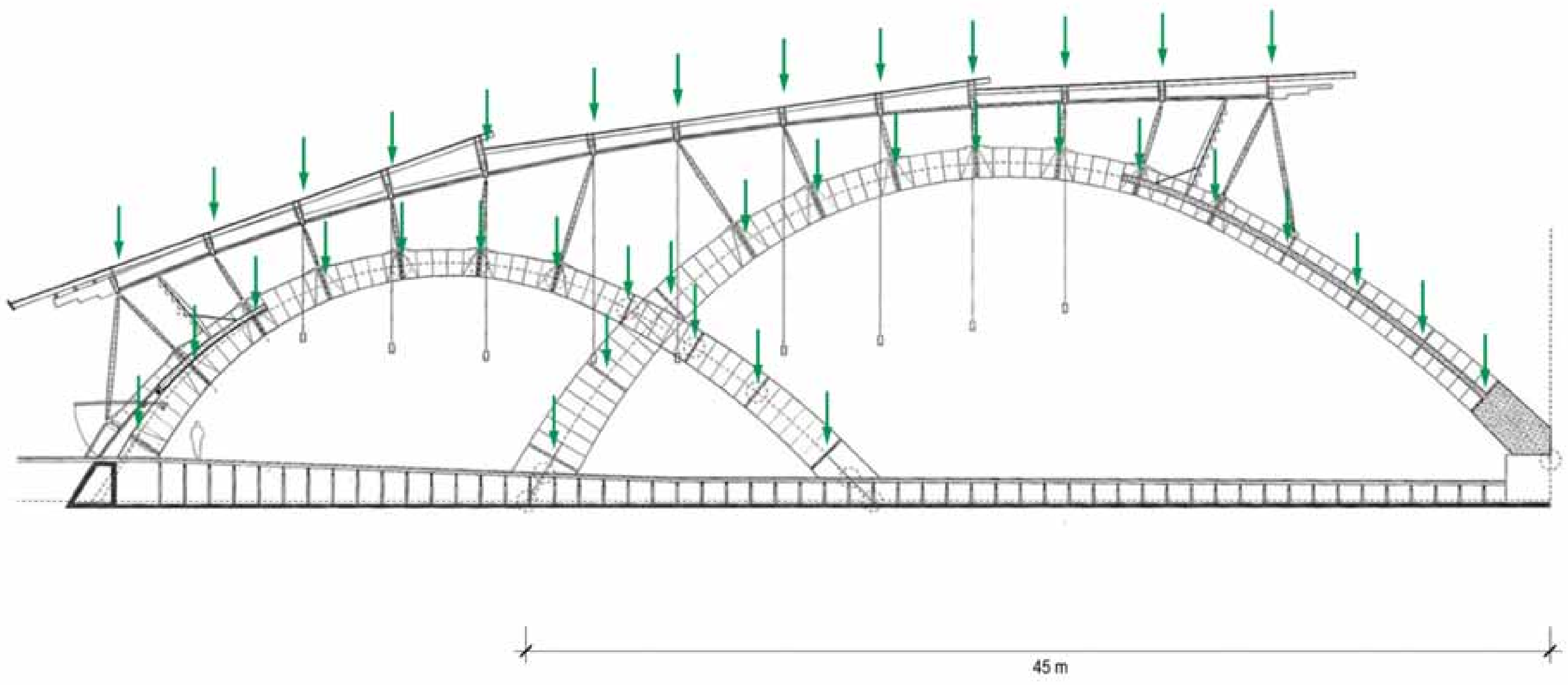
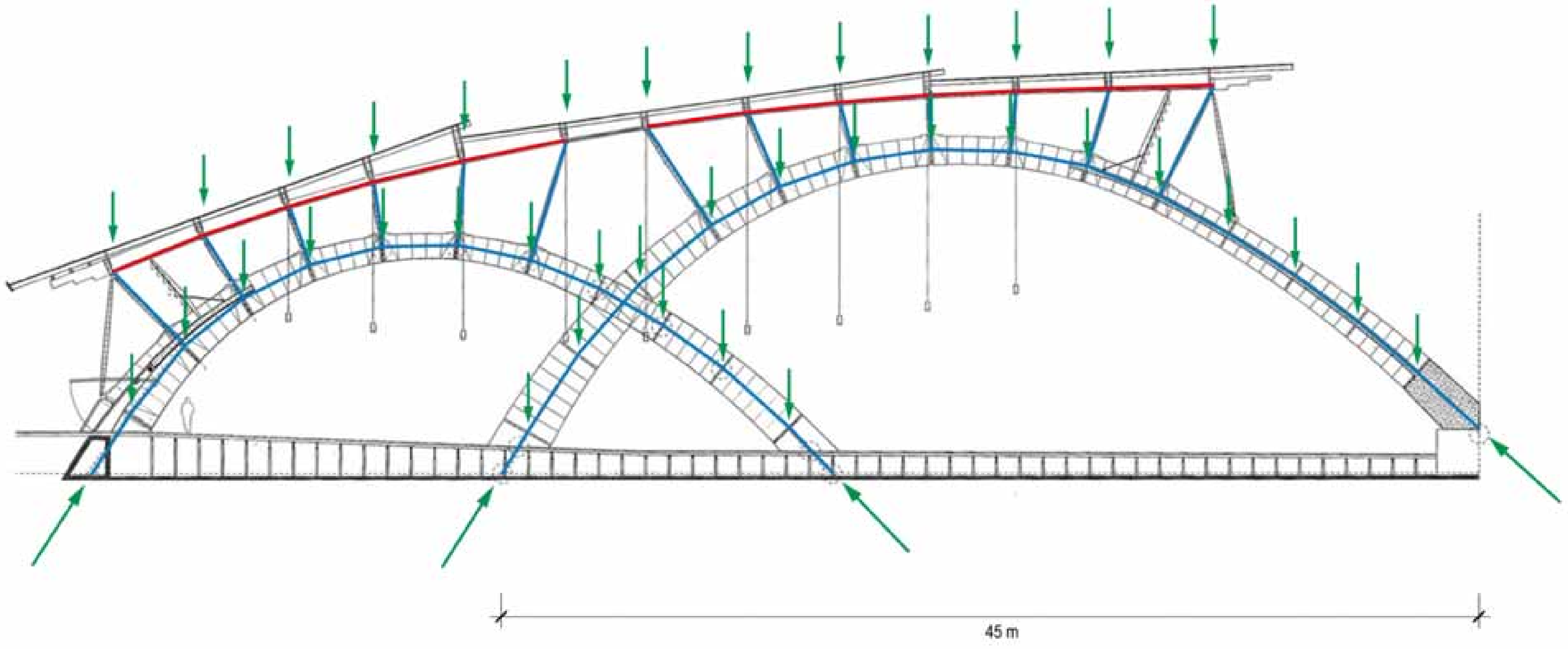
Section

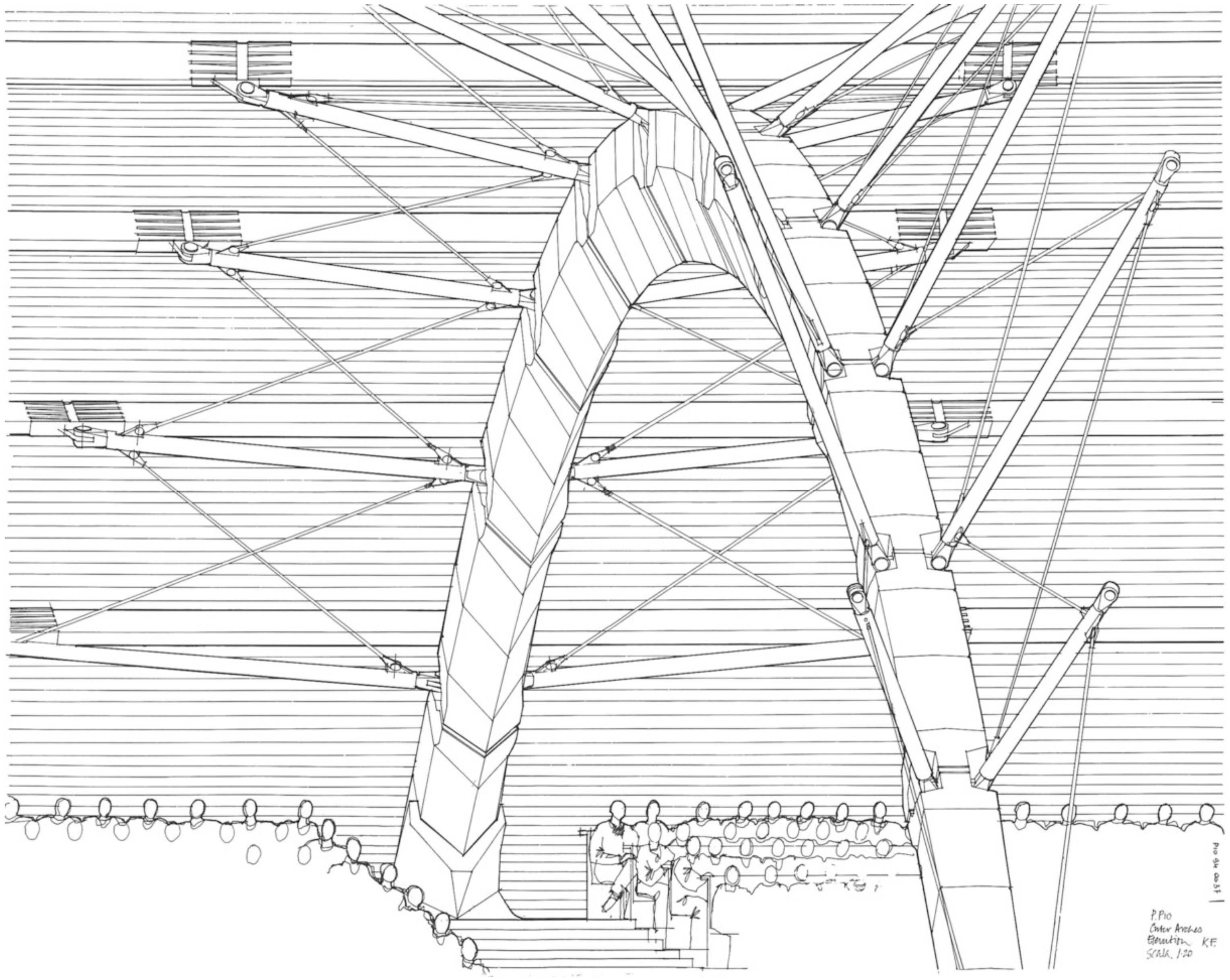


Statisches Gleichgewicht
Static equilibrium



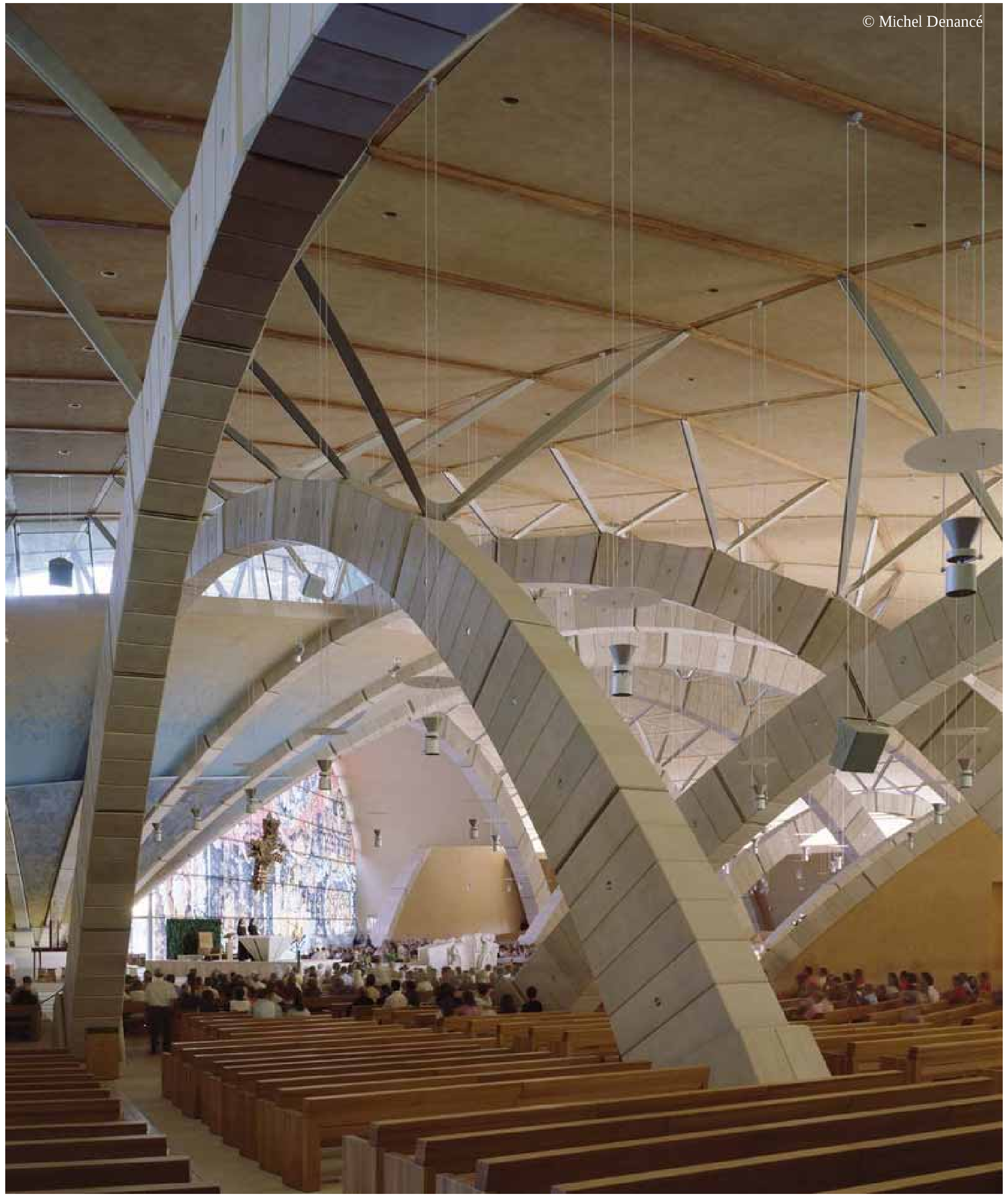
Statisches Gleichgewicht

Static equilibrium



Entwurfsskizzen für die Steinbögen

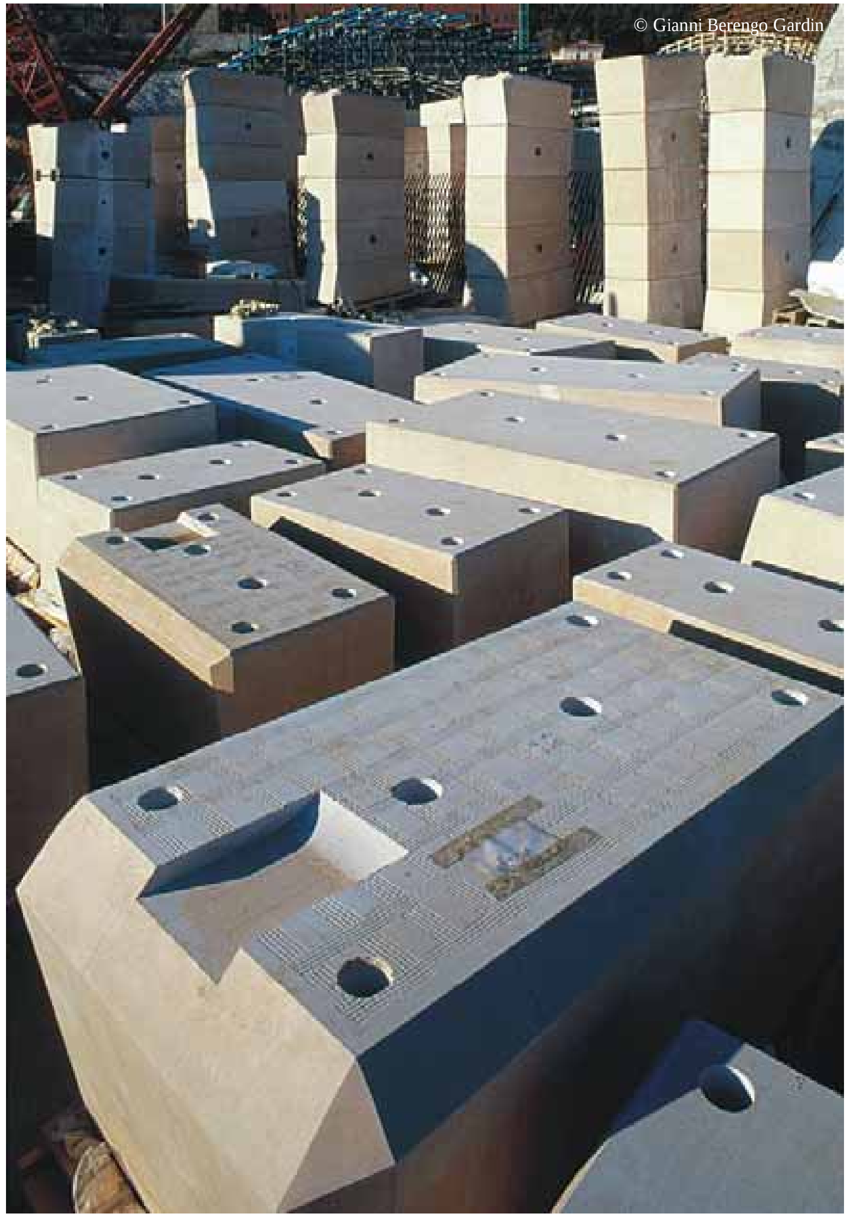
Design sketches of the stone arches



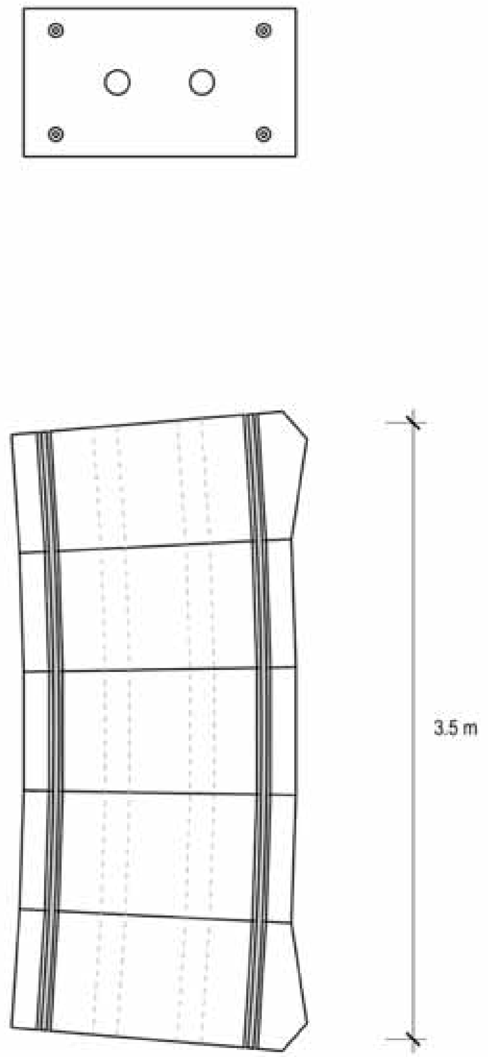
Vorgespannte Steinbögen

Prestressed stone arches

Blöcke aus Apricena-Stein
Blocks of Apricena stone

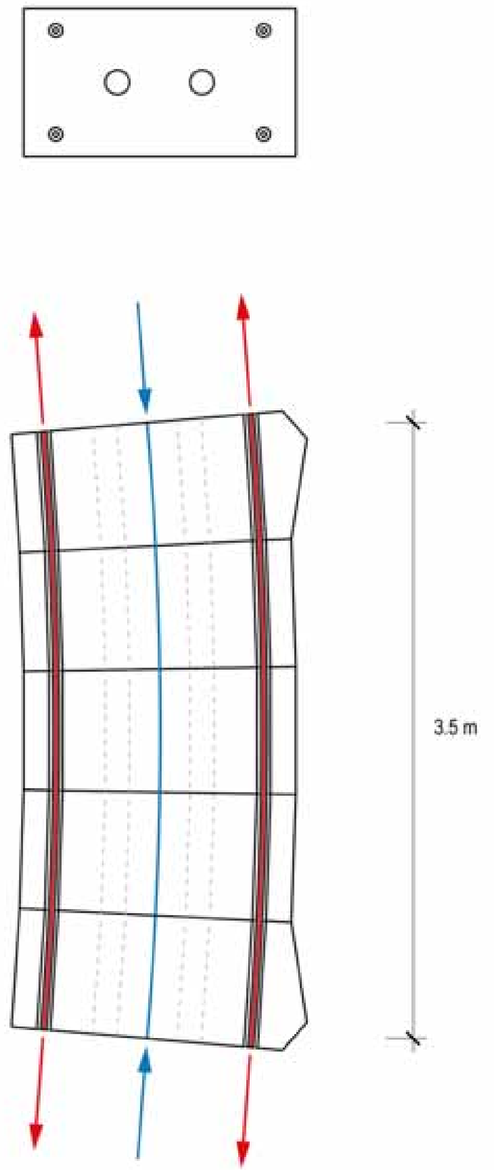


Blöcke aus Apricena-Marmorstein
Blocks of Apricena stone



Vorspannung eines "Maxi-Blocks", der aus mehreren "Mini-Blöcken" besteht

Prestressing of a "maxi-block" made of several "mini-blocks"



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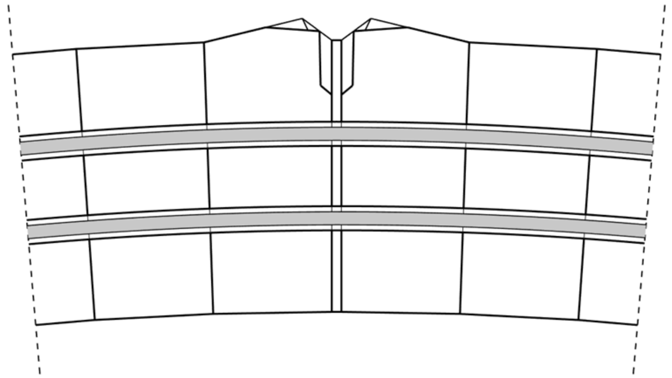

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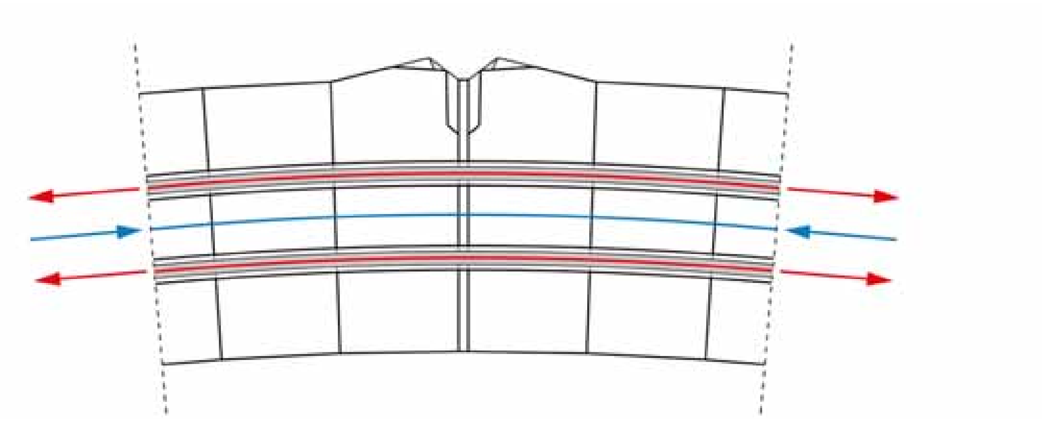

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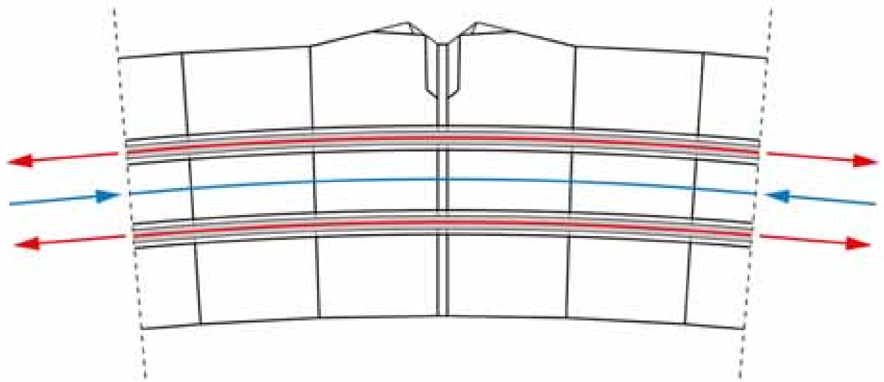
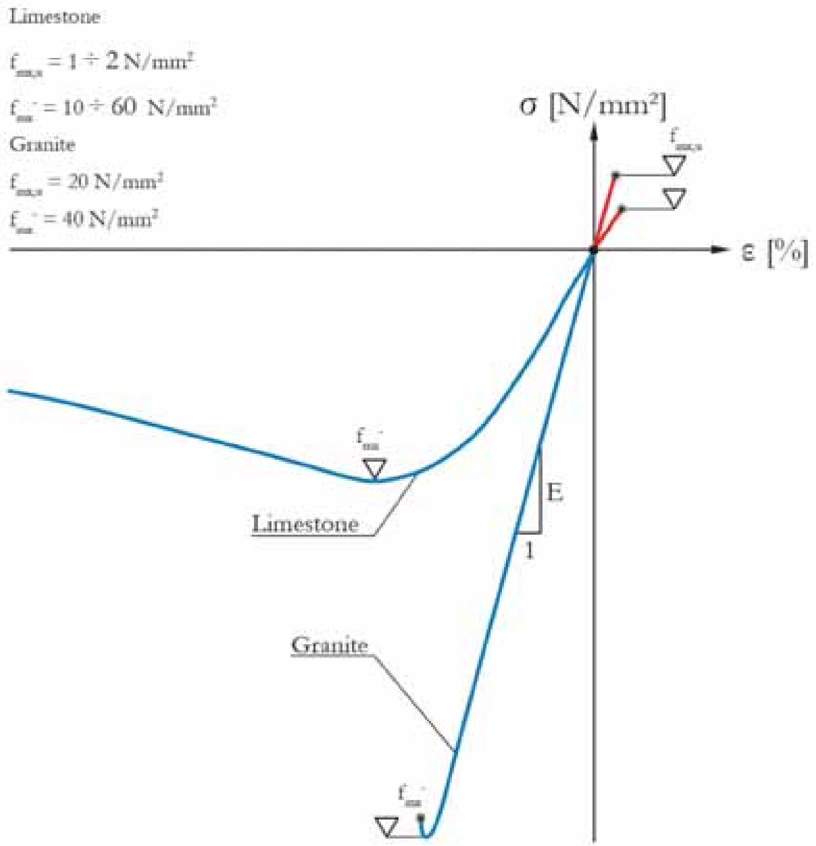


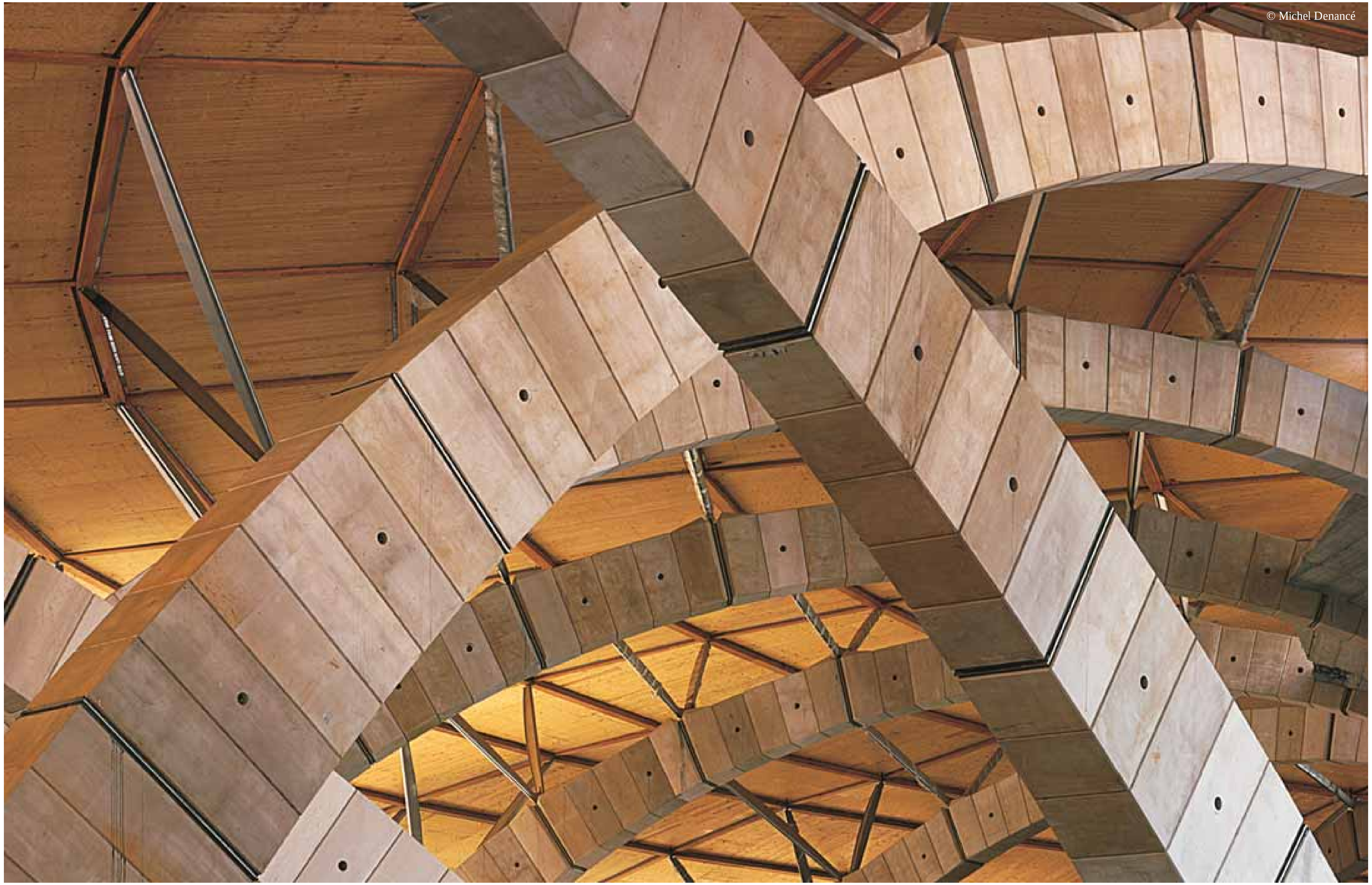
Vorspannung eines "Maxi-Blocks", der aus mehreren "Mini-Blöcken" besteht

Prestressing of a "maxi-block" made of several "mini-blocks"



Mauerwerk (Kalkstein und Granit), Spannungs-Dehnungs-Diagramm

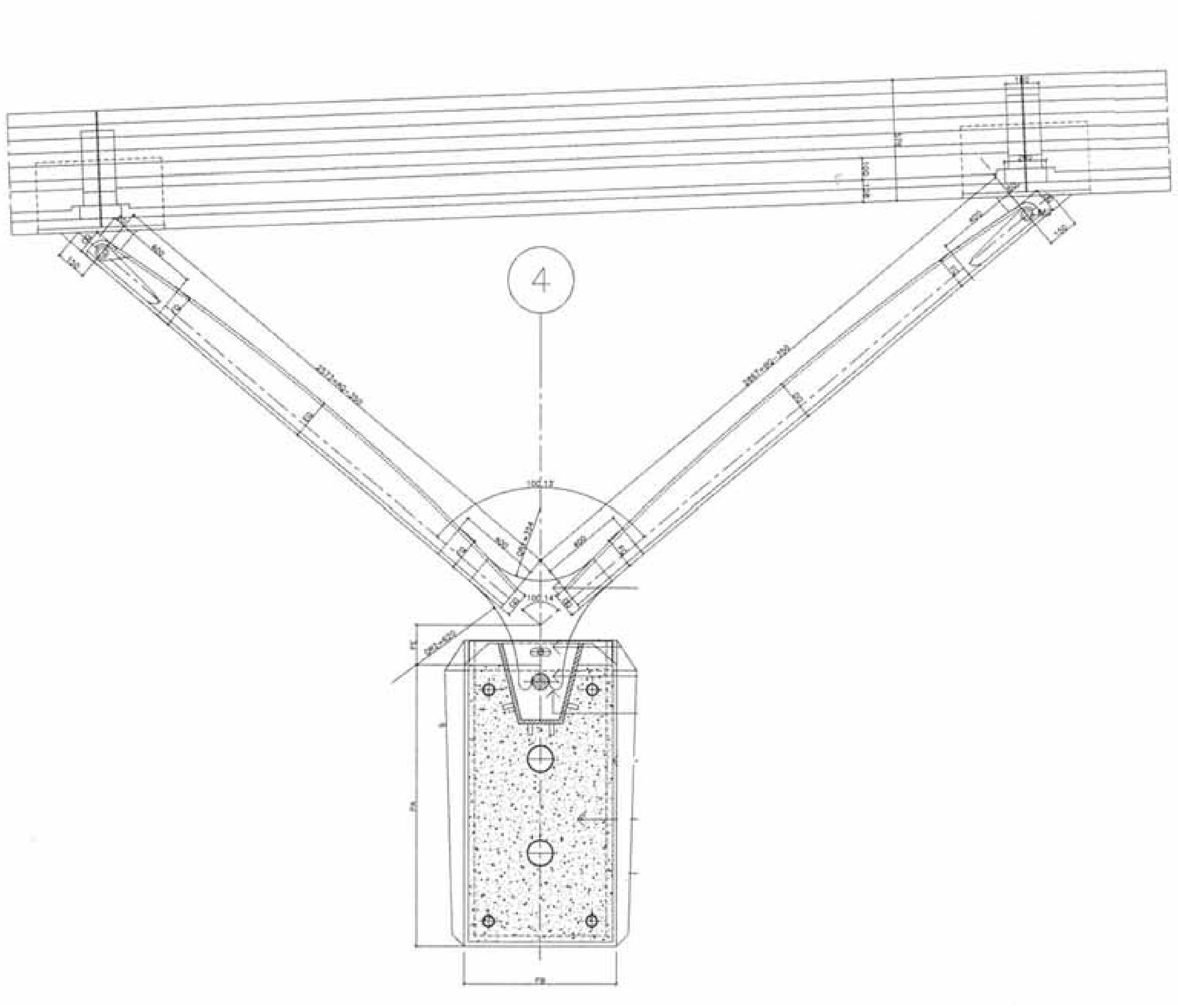
Masonry (limestone and granite), stress-strain diagram



Konstruktionsdetails der Steinbögen
Construction details of the stone arches

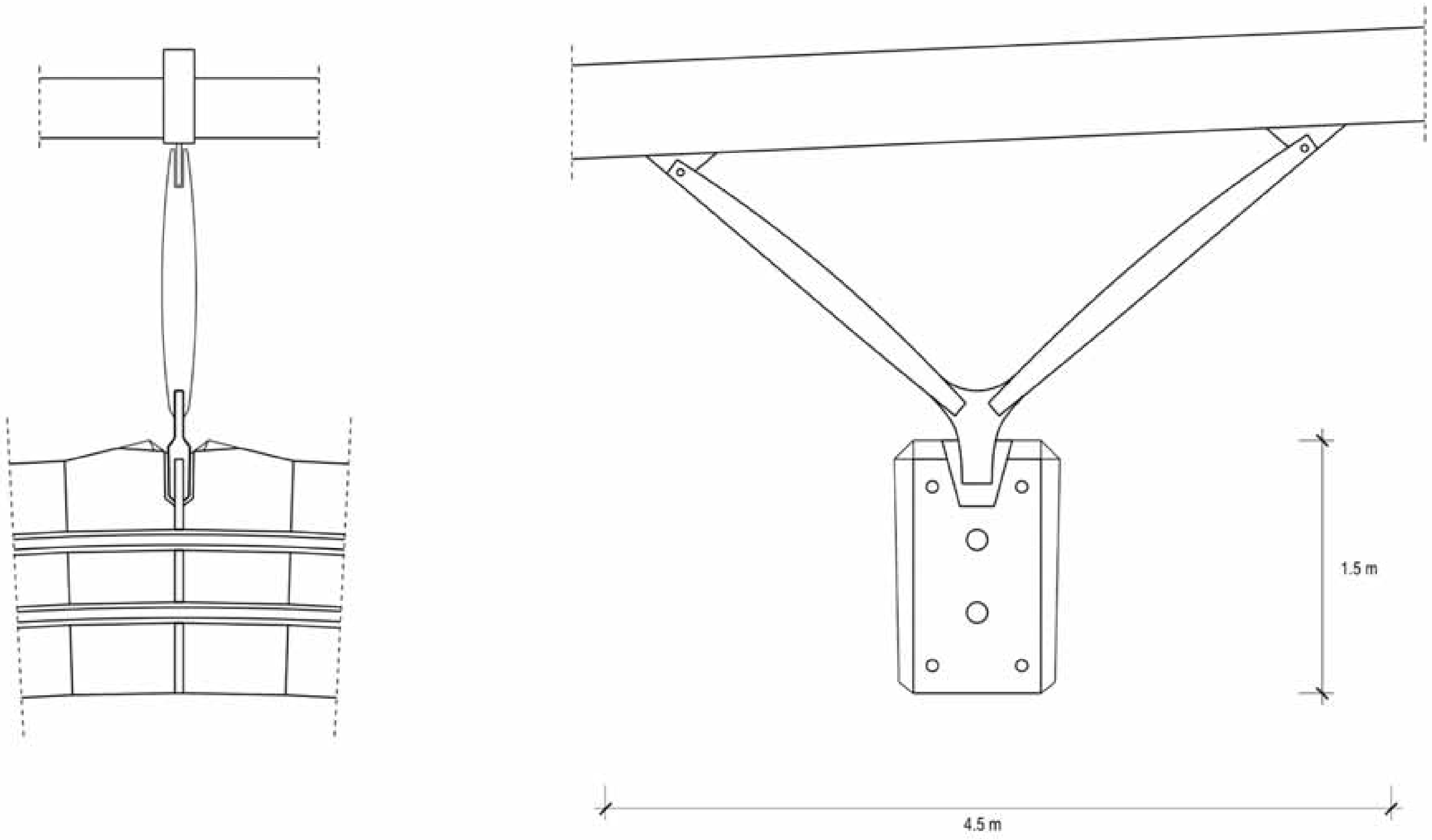
Konstruktionsdetails der Steinbögen

Construction details of the stone arches



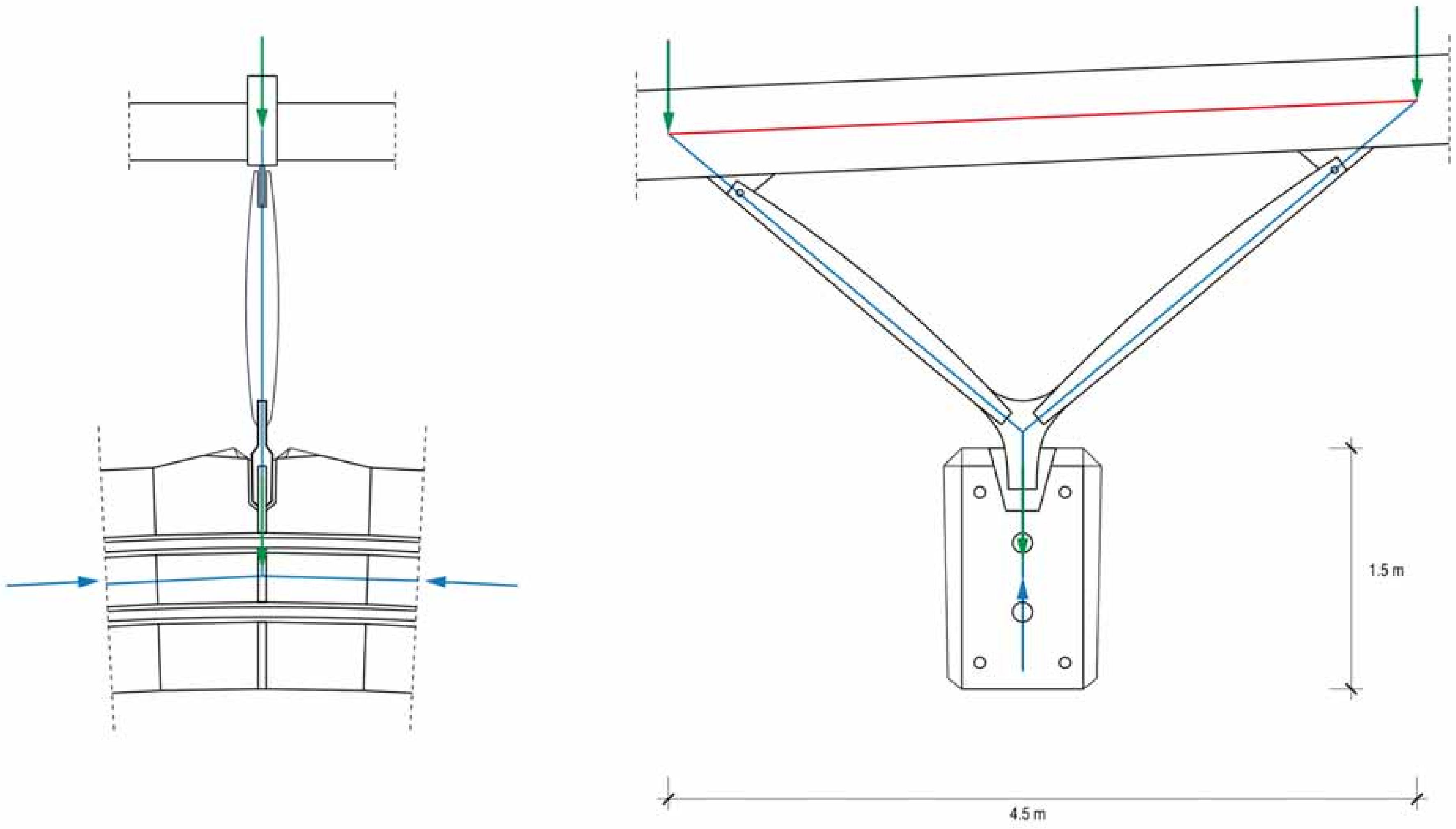
Konstruktionsdetails der Steinbögen

Construction details of the stone arches



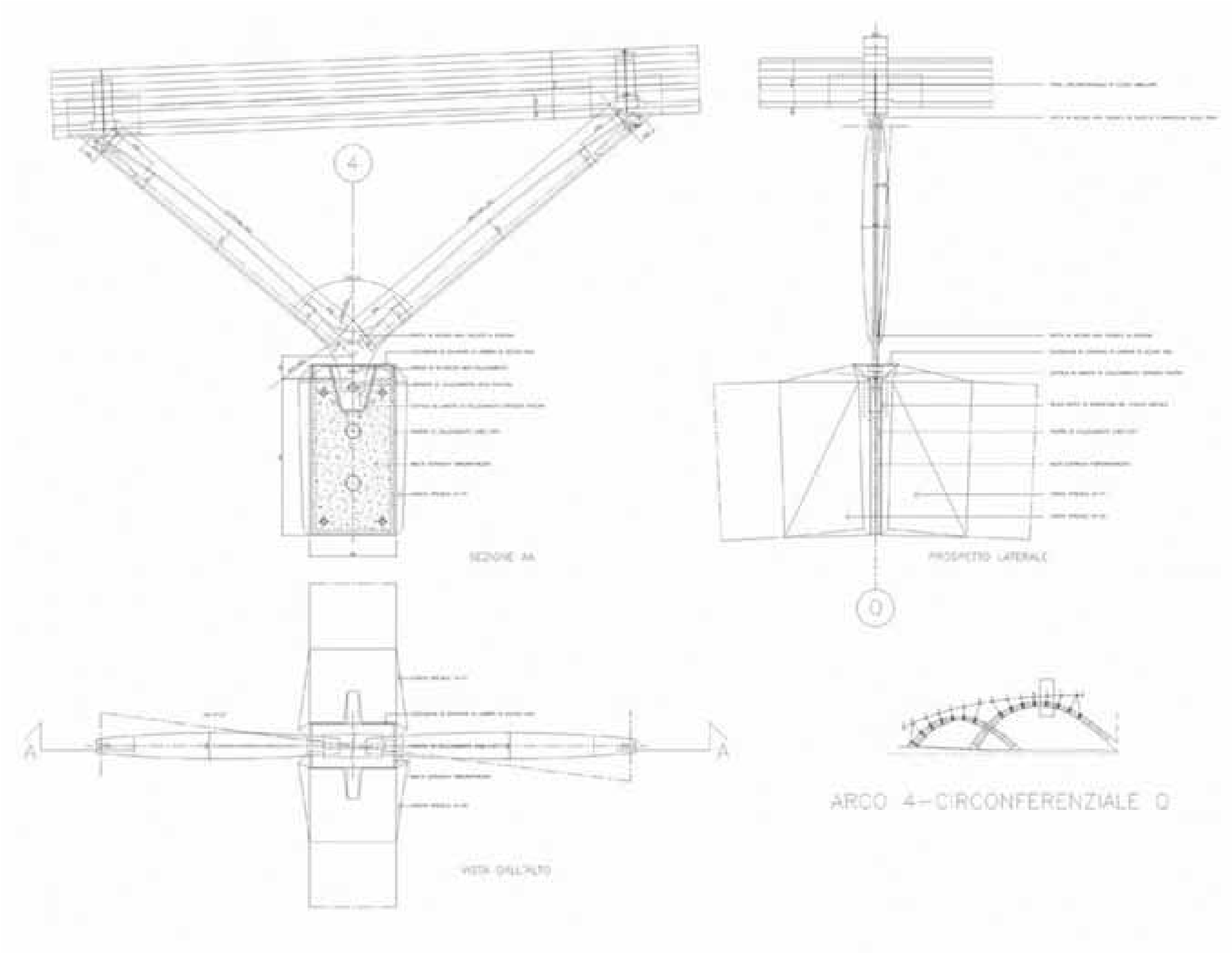
Konstruktionsdetails der Steinbögen

Construction details of the stone arches



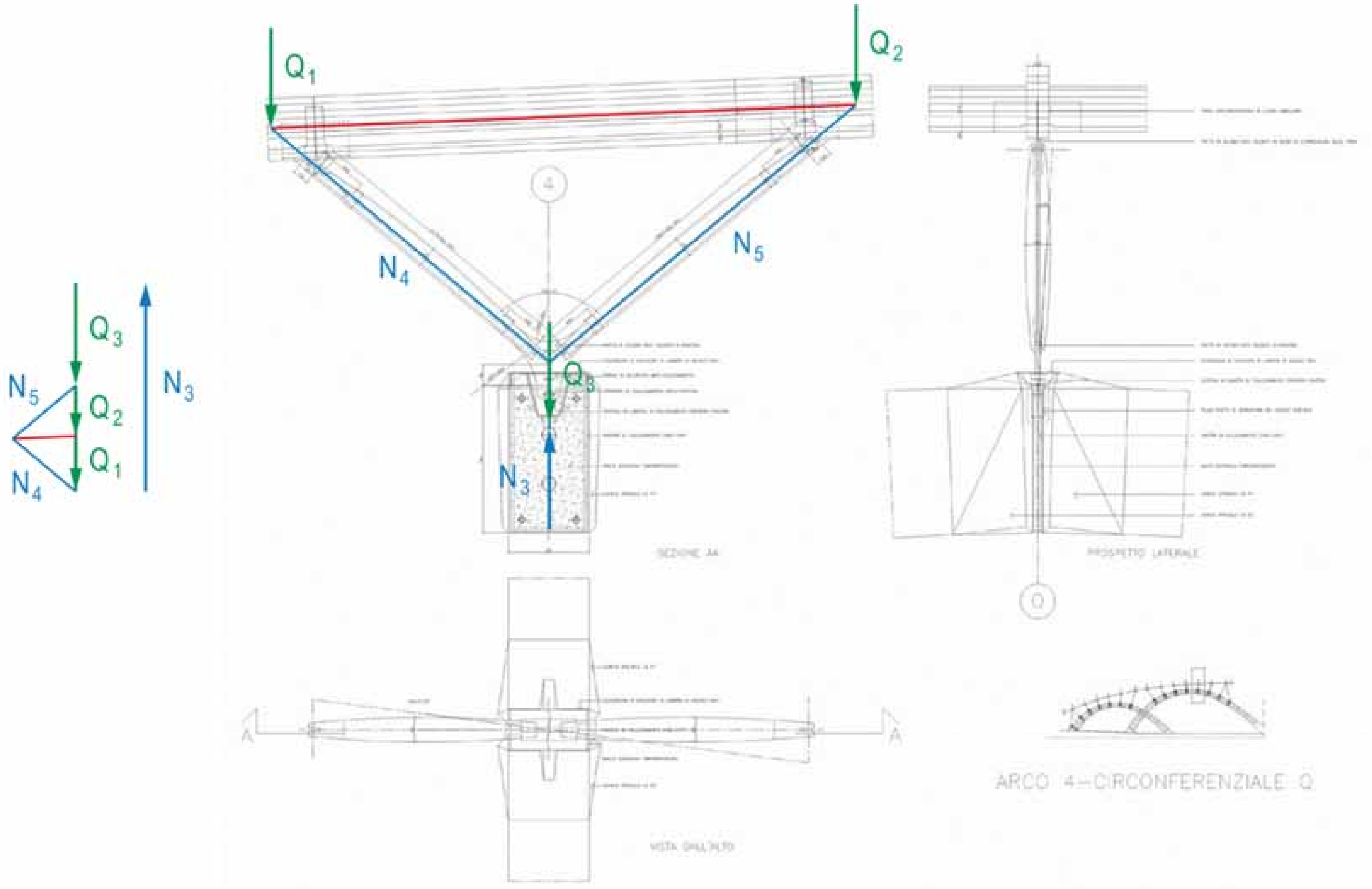
Konstruktionsdetails der Steinbögen

Construction details of the stone arches



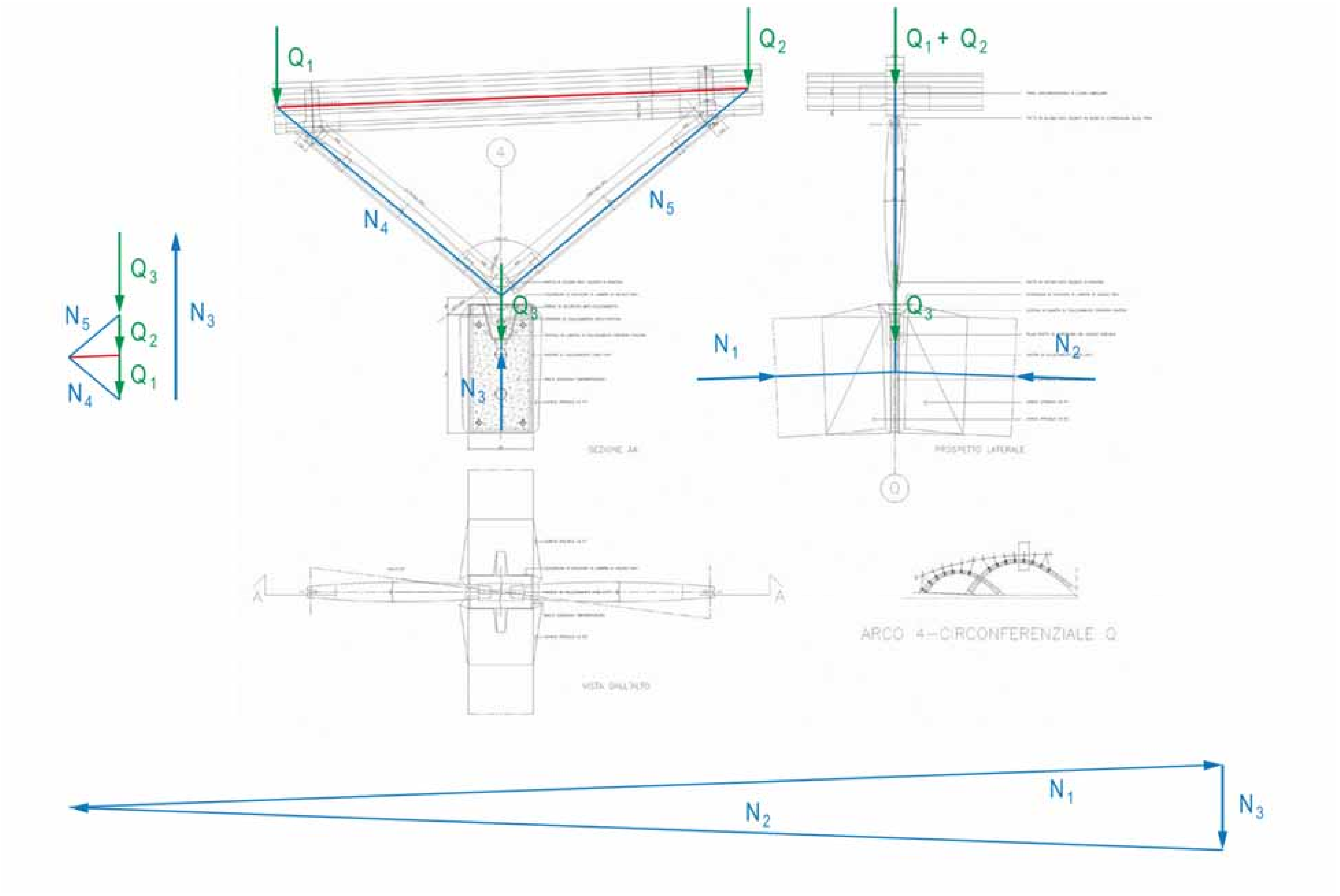
Konstruktionsdetails der Steinbögen

Construction details of the stone arches

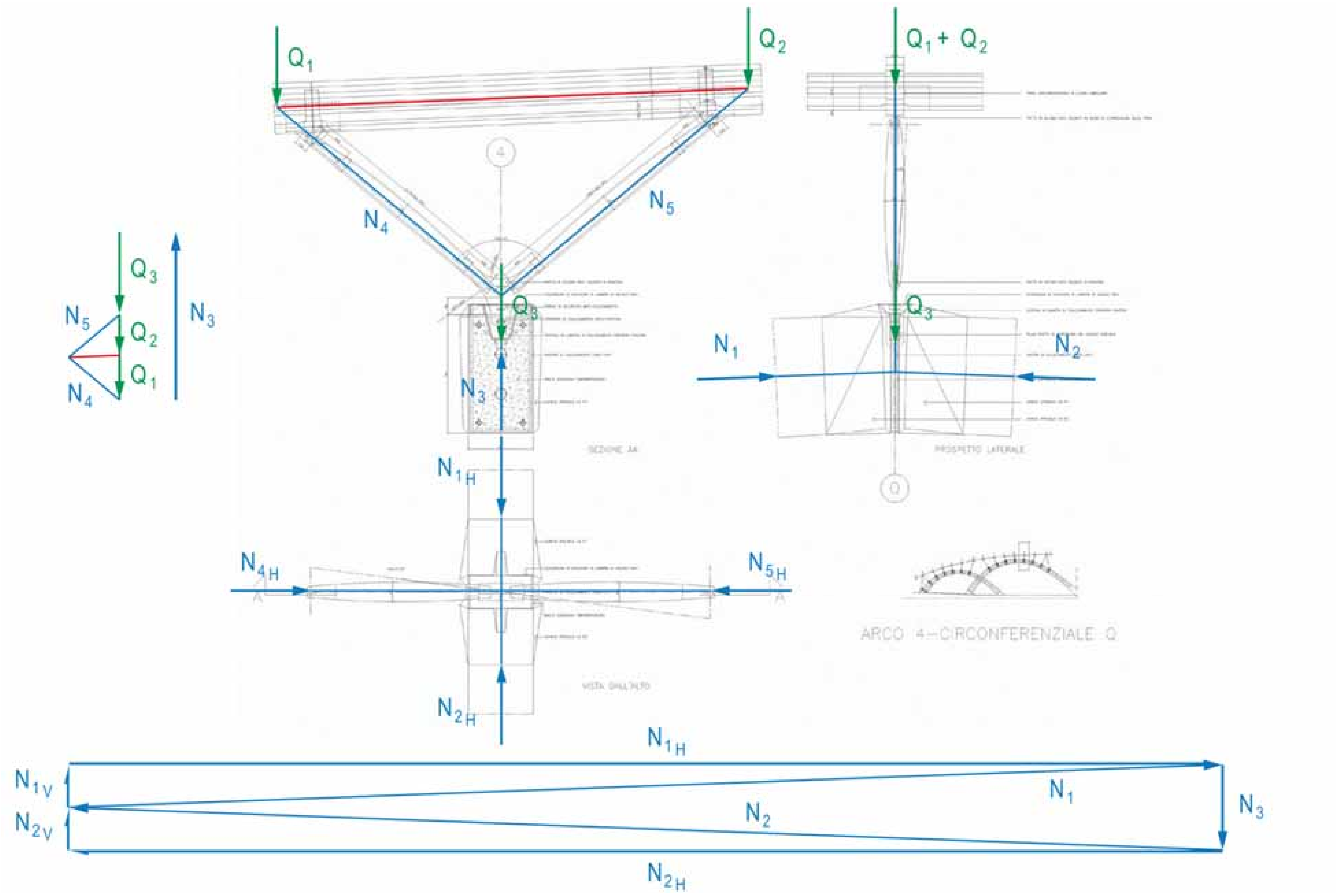


Konstruktionsdetails der Steinbögen

Construction details of the stone arches



Konstruktionsdetails der Steinbögen
Construction details of the stone arches



Konstruktionsdetails der Steinbögen
Construction details of the stone arches

Dach und Steinbögen
Roof and stone arches

Sean Collier Memorial

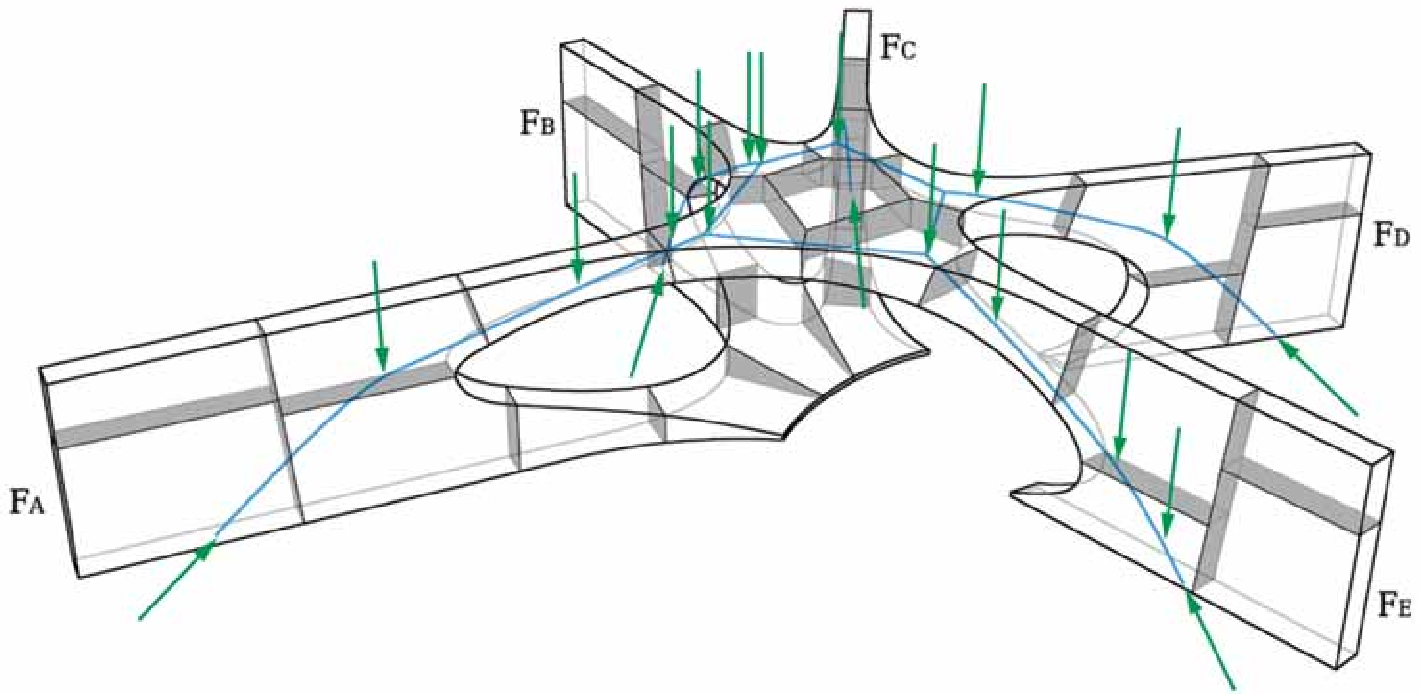
Cambridge (USA), 2015

Architects: Höweler + Yoon

Engineers: Ochsendorf, DeJong & Block, Knippers Helbig Advanced Engineering

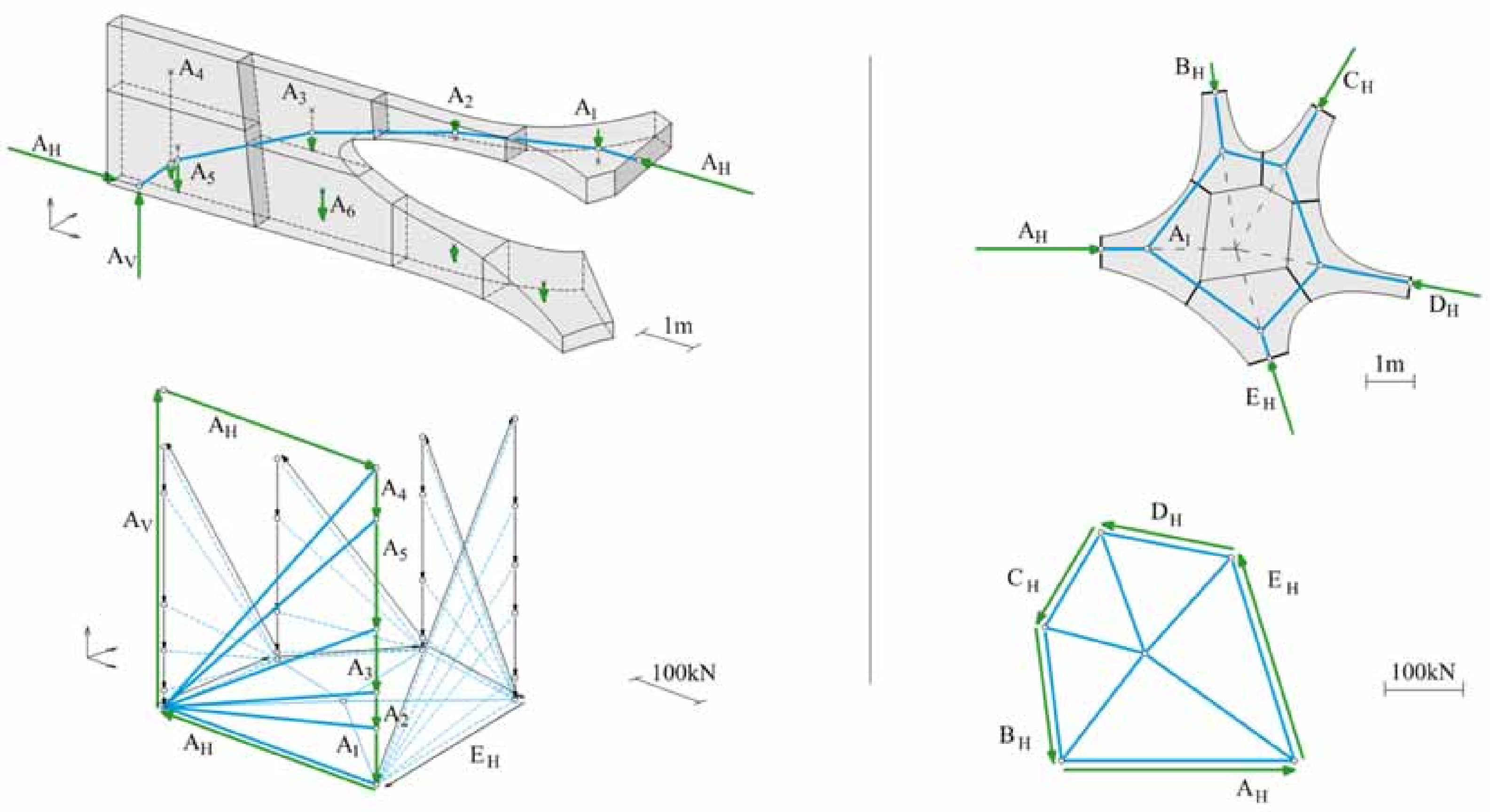
Luftaufnahme
Aerial view

Fußgängeransicht
Pedestrian view



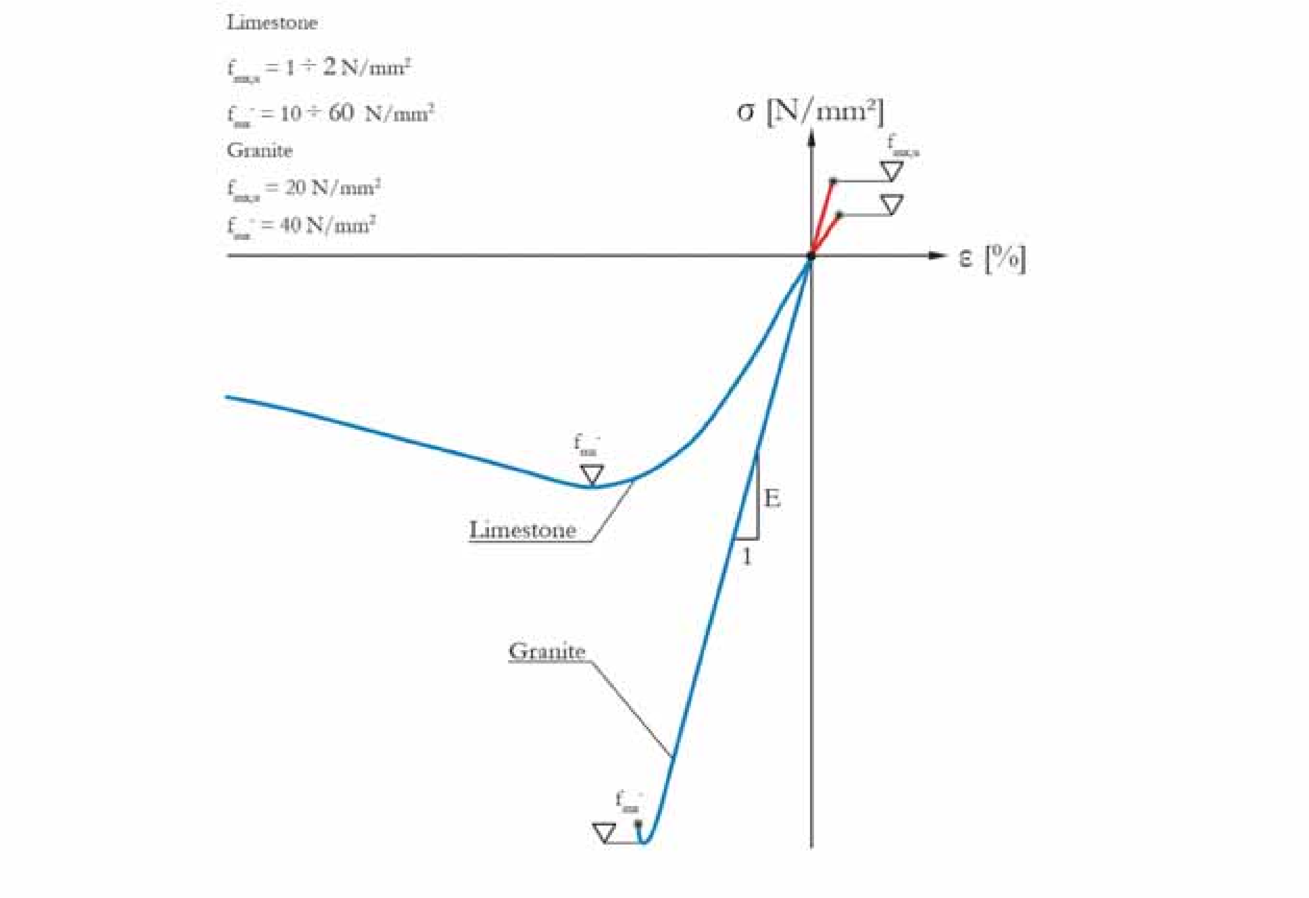
Globales statisches Gleichgewicht

Global static equilibrium



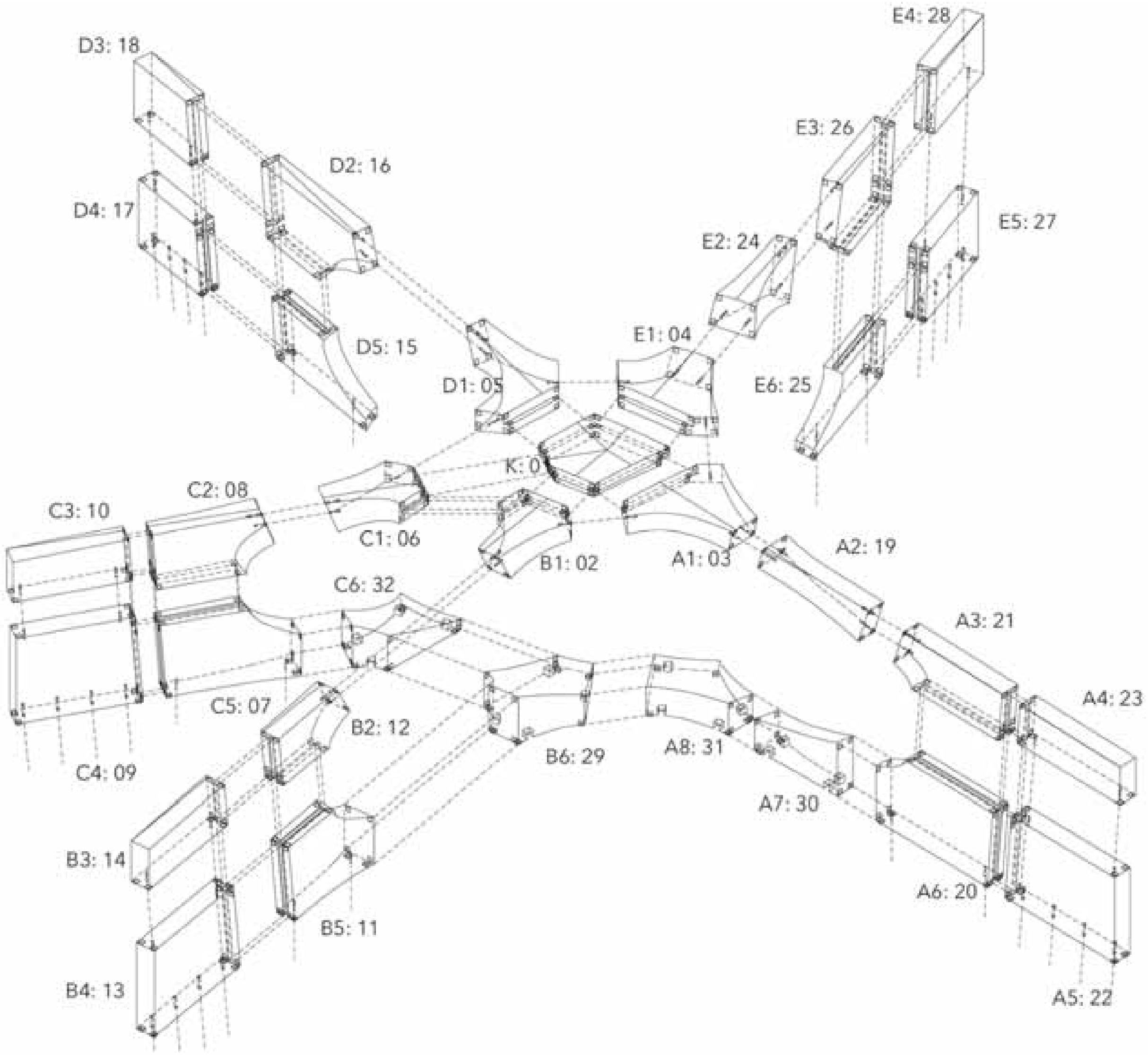
Statisches Gleichgewicht der einen Wand und des Schlusssteins

Static equilibrium of one wall and of the keystone



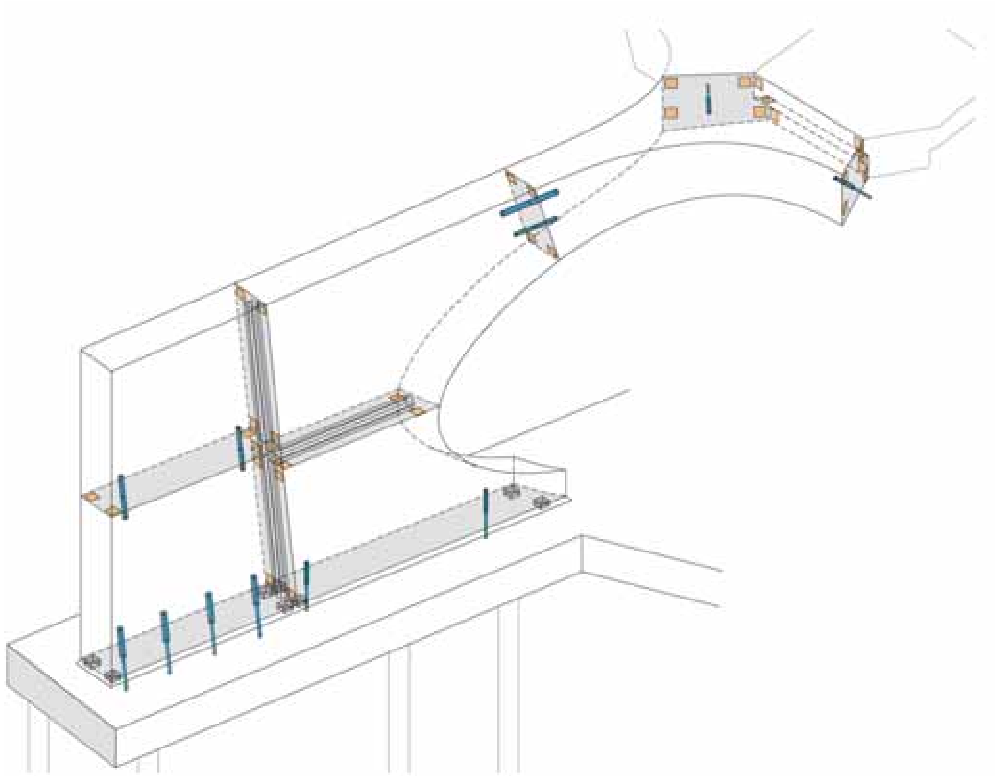
Mauerwerk (Kalkstein und Granit), Spannungs-Dehnungs-Diagramm

Masonry (limestone and granite), stress-strain diagram



Zusammenbau

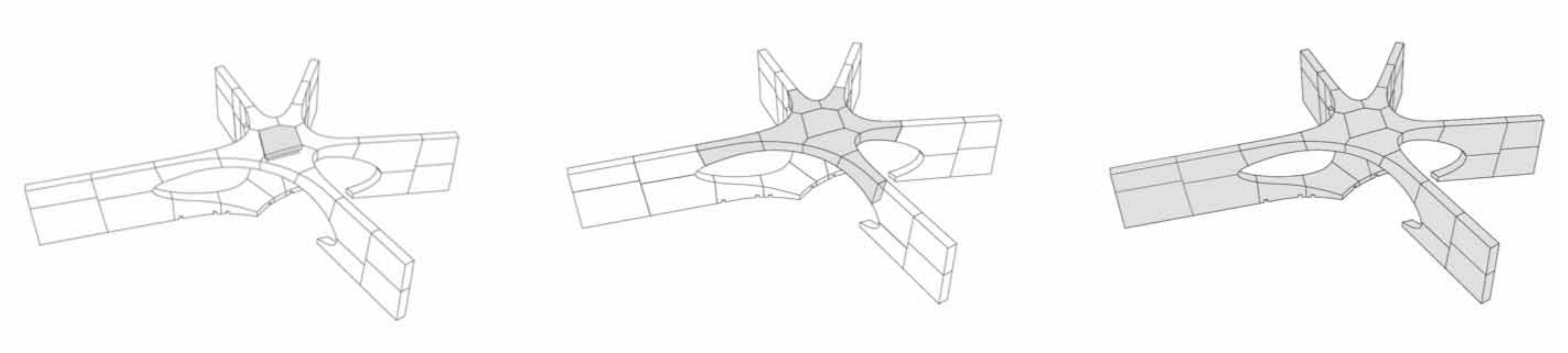
Assembly



Verbindungen zwischen Blöcken
Connections between blocks

Digitales Schneiden der Blöcke

Digital cutting of the blocks




© Höweler + Yoon Architecture


© Iwan Baan


© Höweler + Yoon Architecture


© Höweler + Yoon Architecture

Montageprozess
Assembly sequence

Luftaufnahme
Aerial view

Fußgängeransicht

Pedestrian view

Konstruktionsdetails
Construction details

Seiltragwerke
Cable structures

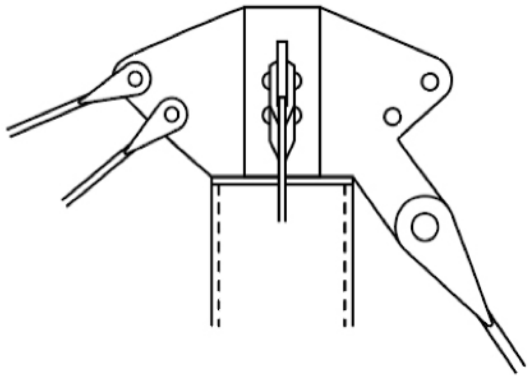
Bogenkonstruktionen
Arch structures

>> Bogenseilkonstruktionen
Arch-cable structures

Fachwerkstrukturen
Trusses

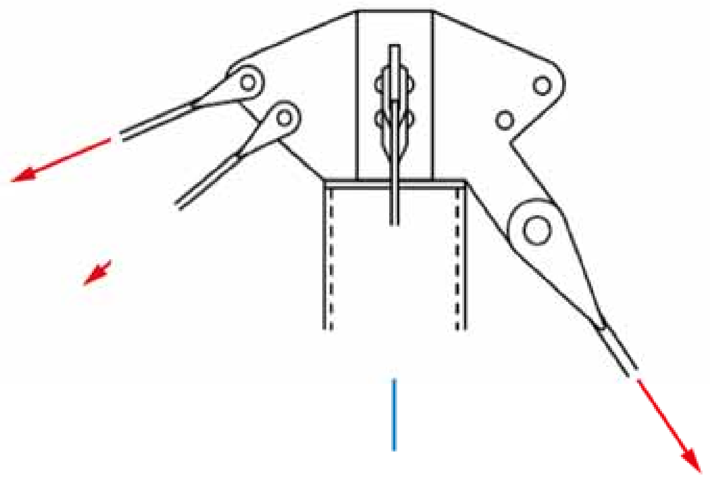
Balken
Beams

Rahmen
Frames



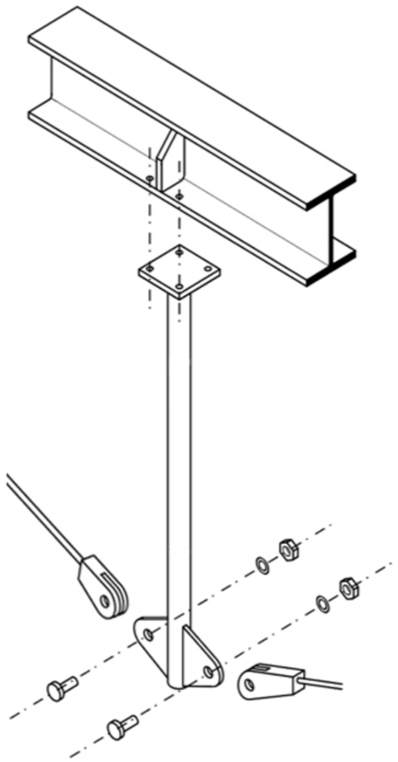
Streben und Seile im Stahlbau (oben: Patscenter, 1985, R. Rogers, unten: Fleetguard, 1981, R. Rogers)

Struts and cables in steel construction (top: Patscenter, 1985, R. Rogers, bottom: Fleetguard, 1981, R. Rogers)



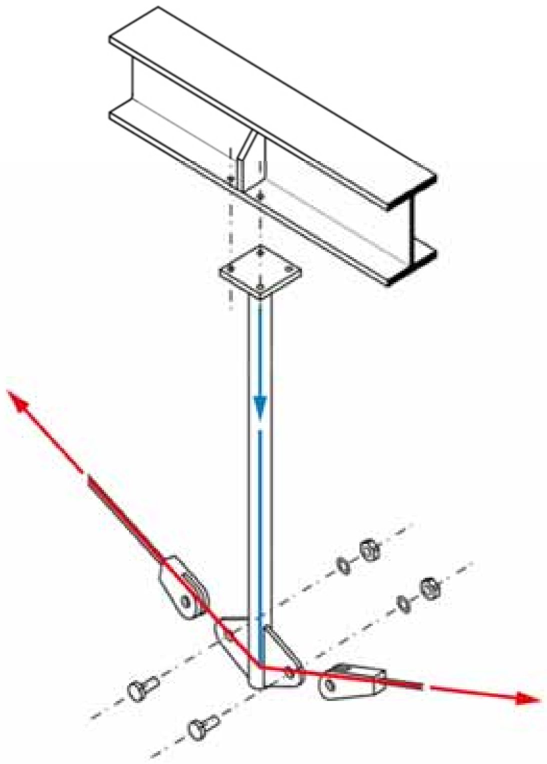
Streben und Seile im Stahlbau (oben: Patscenter, 1985, R. Rogers, unten: Fleetguard, 1981, R. Rogers)

Struts and cables in steel construction (top: Patscenter, 1985, R. Rogers, bottom: Fleetguard, 1981, R. Rogers)

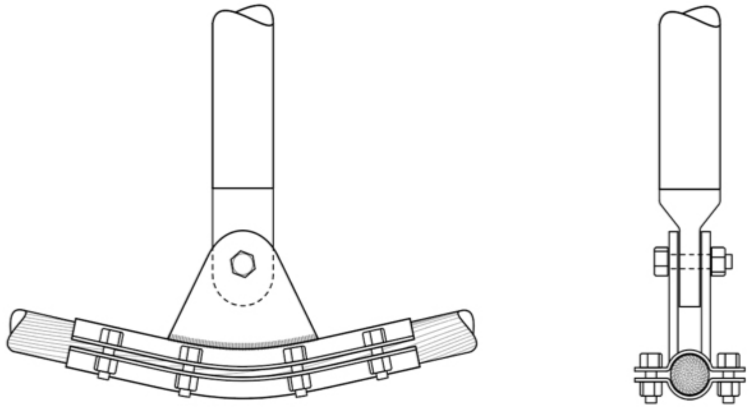


Verstrebungen und Seile in Stahlbauweise

Struts and cables in steel construction

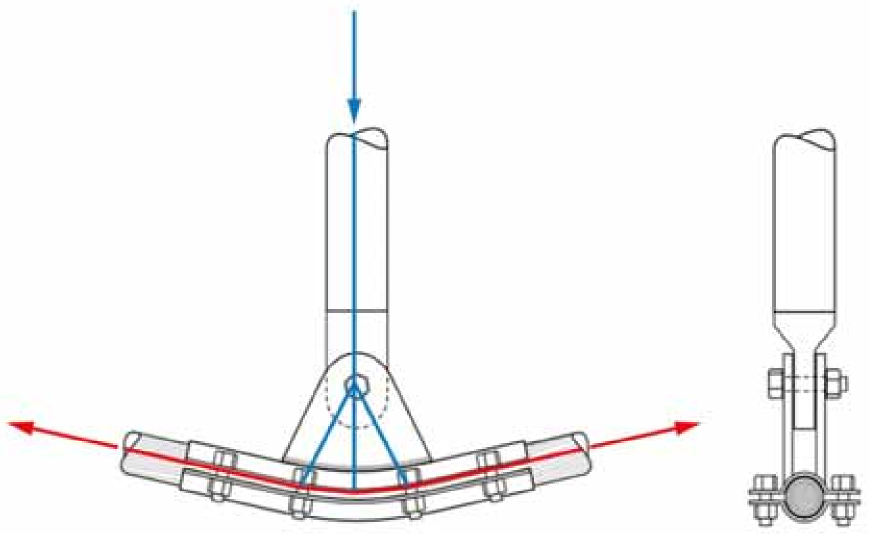


Verstrebungen und Seile in Stahlbauweise
Struts and cables in steel construction



Verstrebungen und Seile in Stahlbauweise

Struts and cables in steel construction



Verstrebungen und Seile in Stahlbauweise

Struts and cables in steel construction

Office for Waste Management

Munich, 1999

Architect: Ackermann und Partner

Engineer: Schlaich, Bergermann und Partner

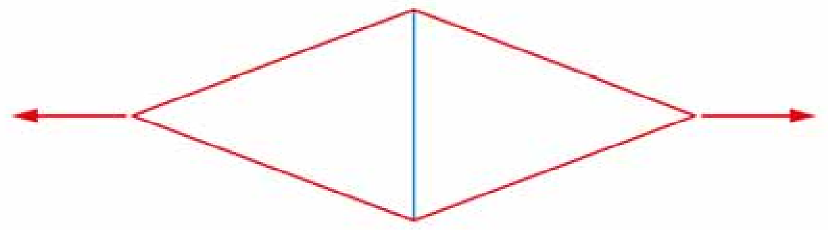
Innenansicht

Interior view

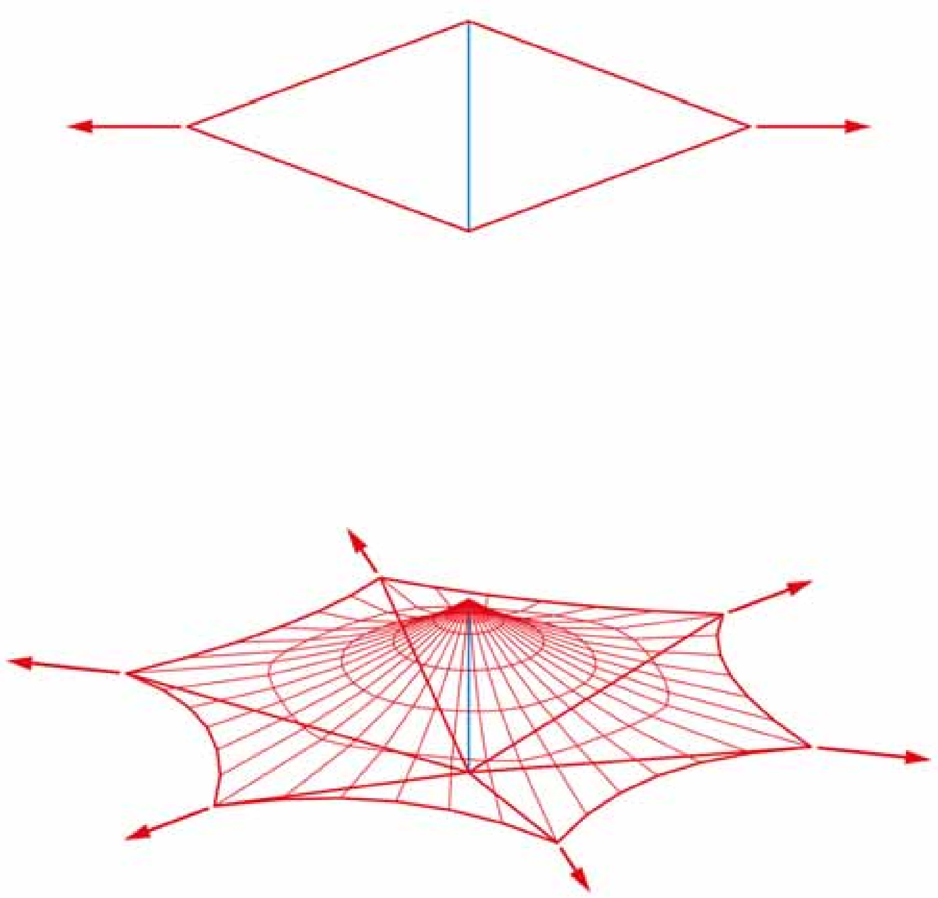
Innenansicht

Interior view

Leichtbau-Dach
Lightweight roof

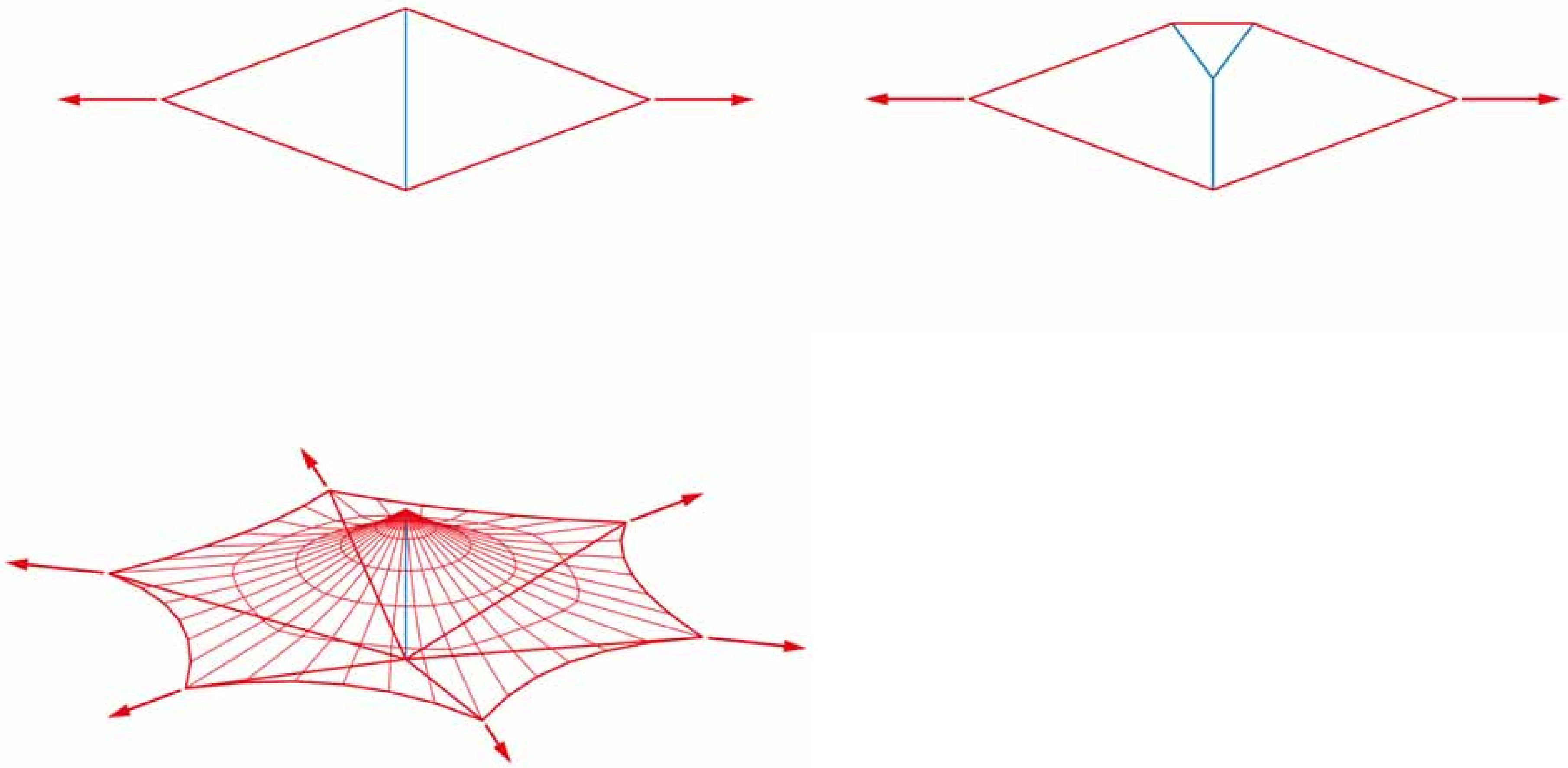


Fliegende Stütze und Spannungen in der Membran
Flying column and stress in the membrane



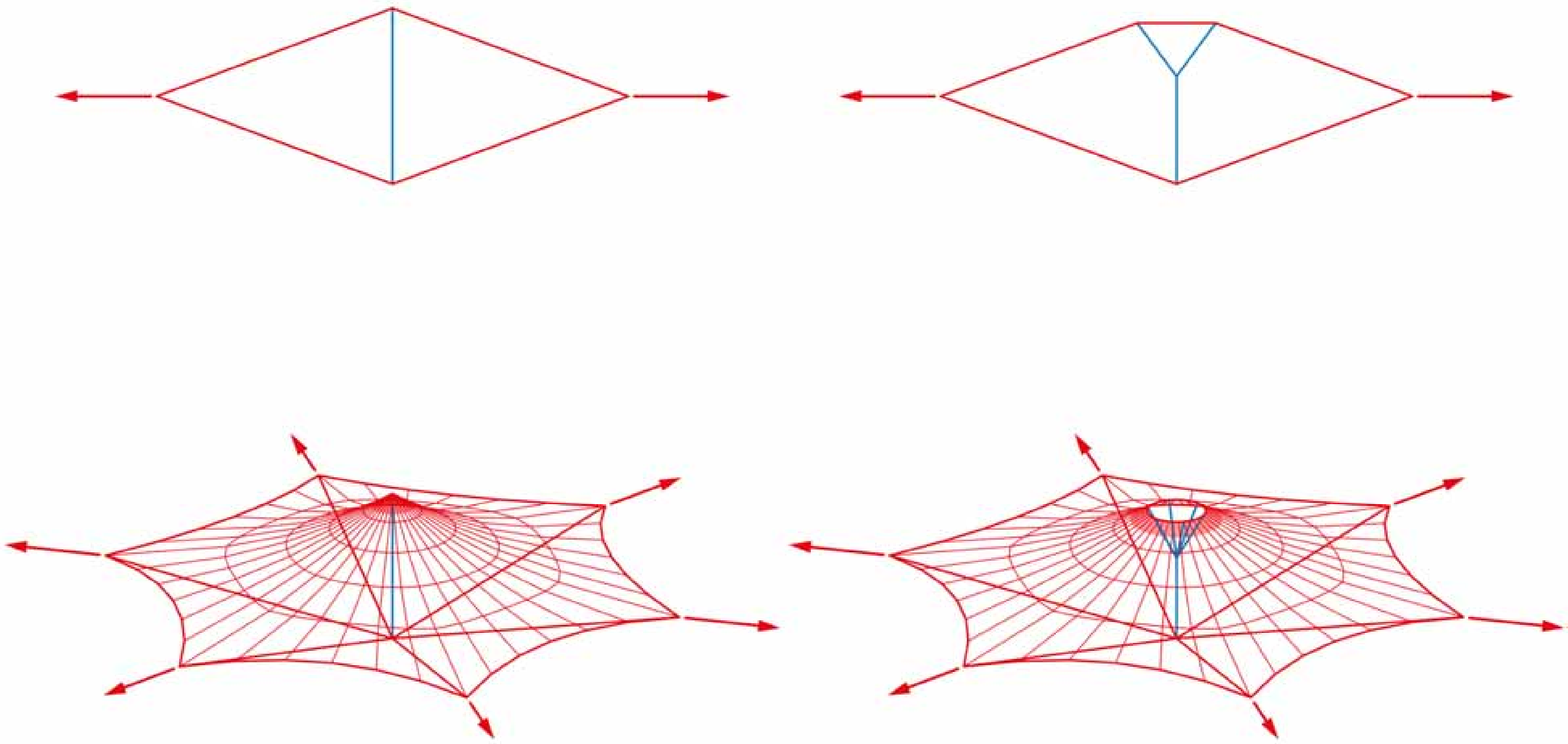
Fliegende Stütze und Spannungen in der Membran

Flying column and stress in the membrane

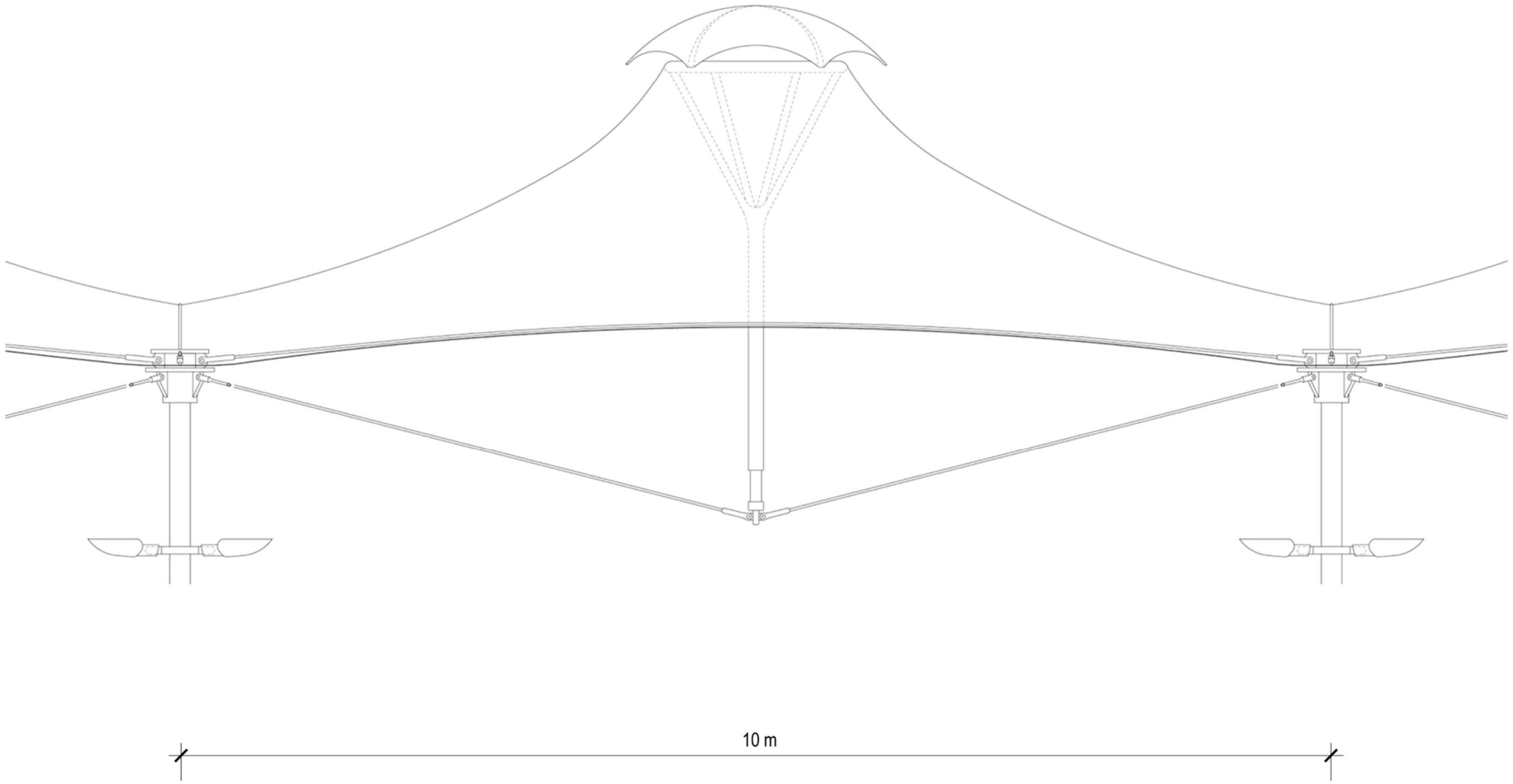


Fliegende Stütze und Spannungen in der Membran

Flying column and stress in the membrane

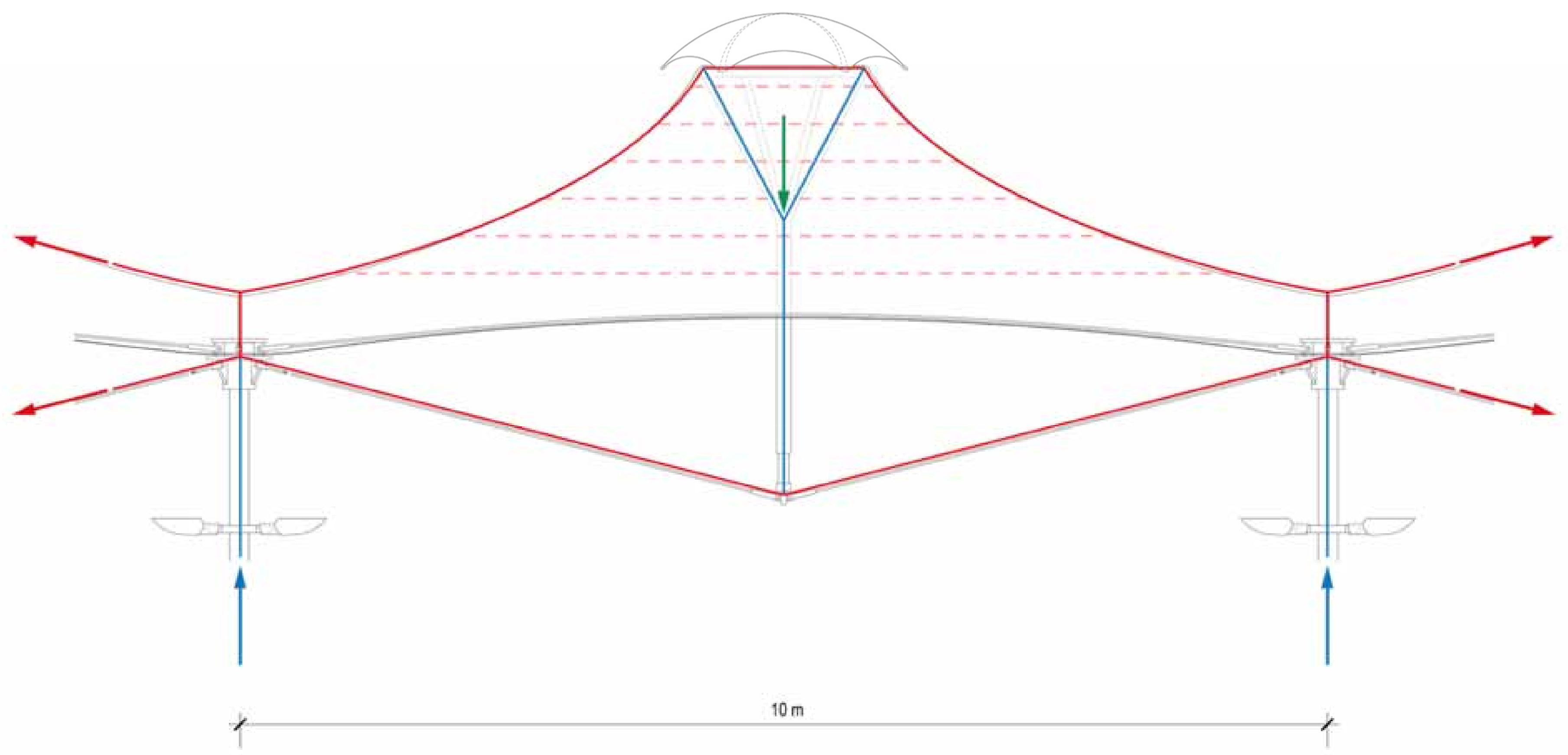


Fliegende Stütze und Spannungen in der Membran
Flying column and stress in the membrane

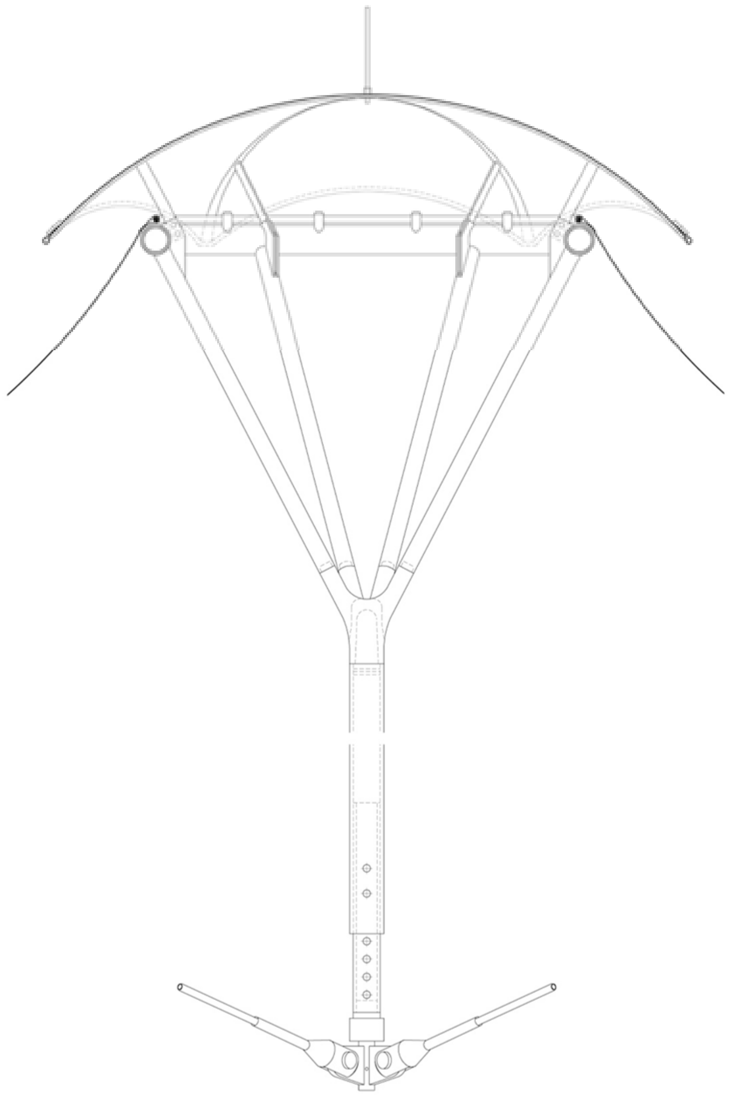


Schnitt durch das Dach

Section of the roof



Statisches Gleichgewicht
Static equilibrium

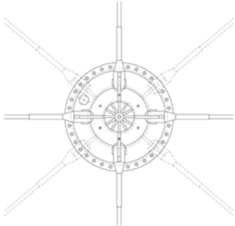


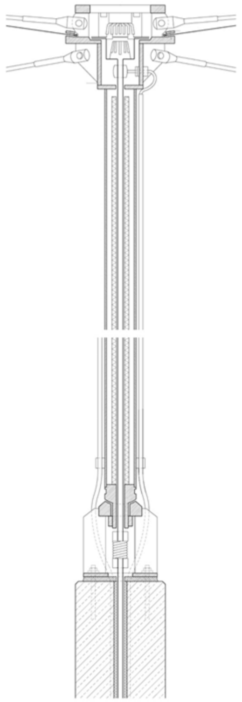
Detail der fliegenden Stütze
Detail of the flying column

Konstruktionsdetails
Construction details

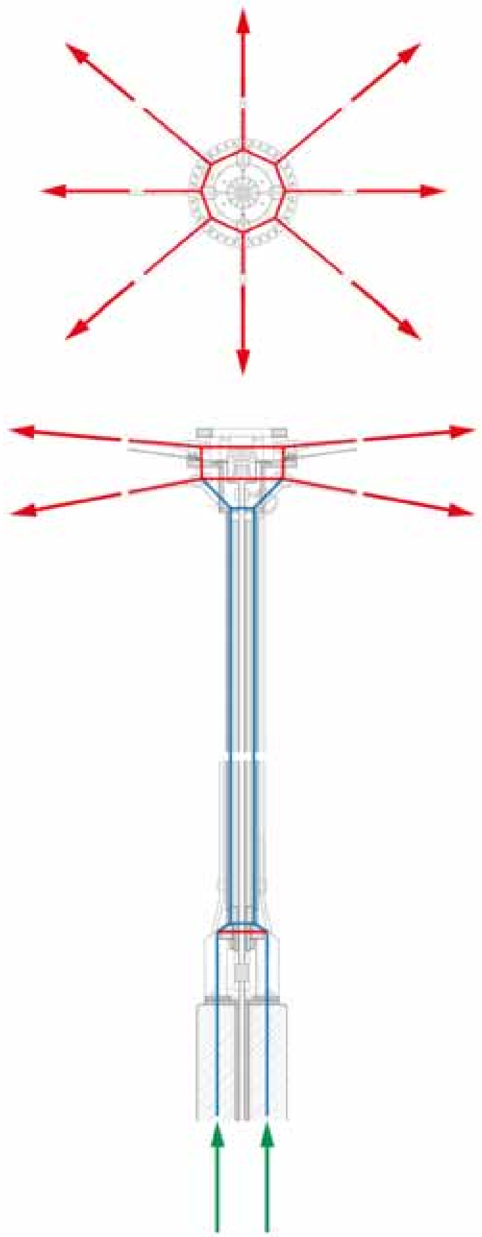
Konstruktionsdetails

Construction details



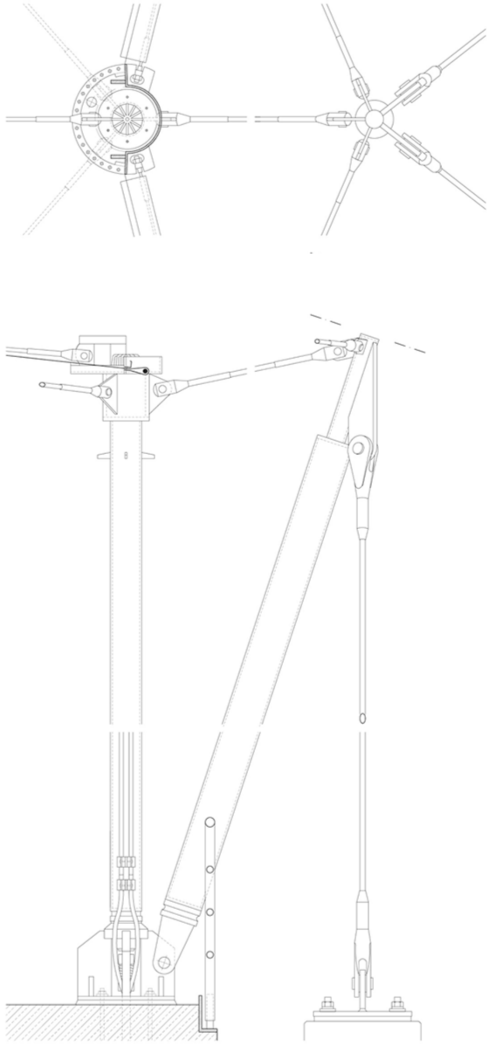


Konstruktionsdetails
Construction details

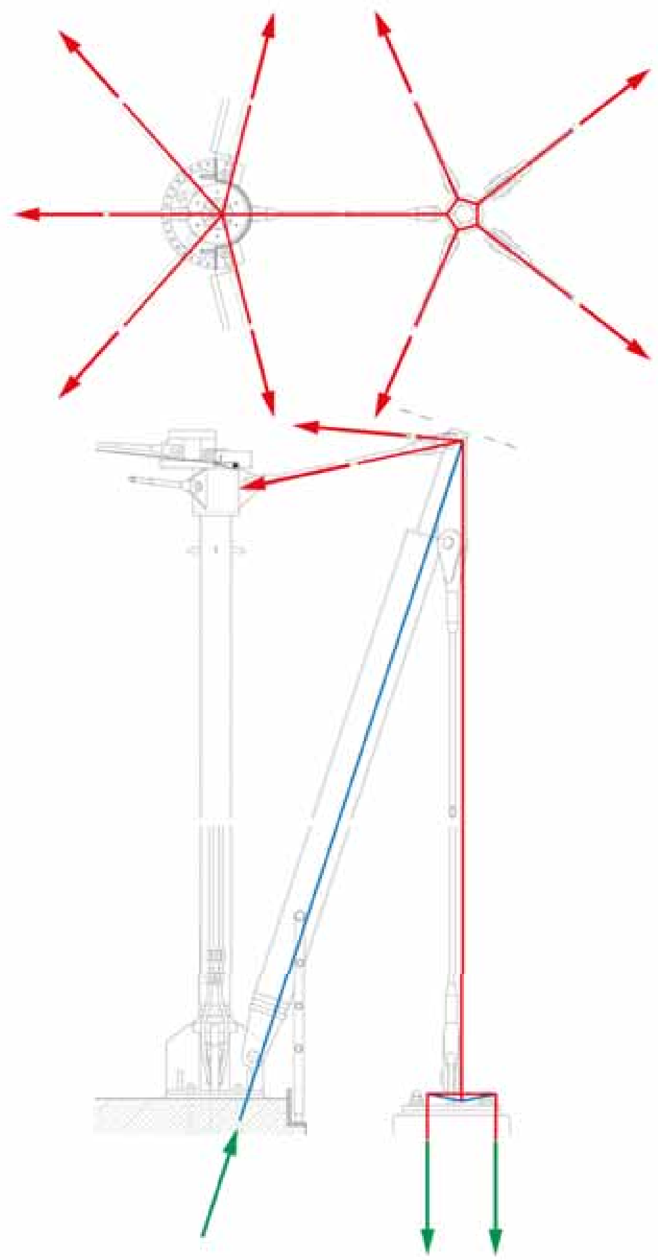


Konstruktionsdetails

Construction details



Konstruktionsdetails
Construction details



Konstruktionsdetails

Construction details

Renault Distribution Centre

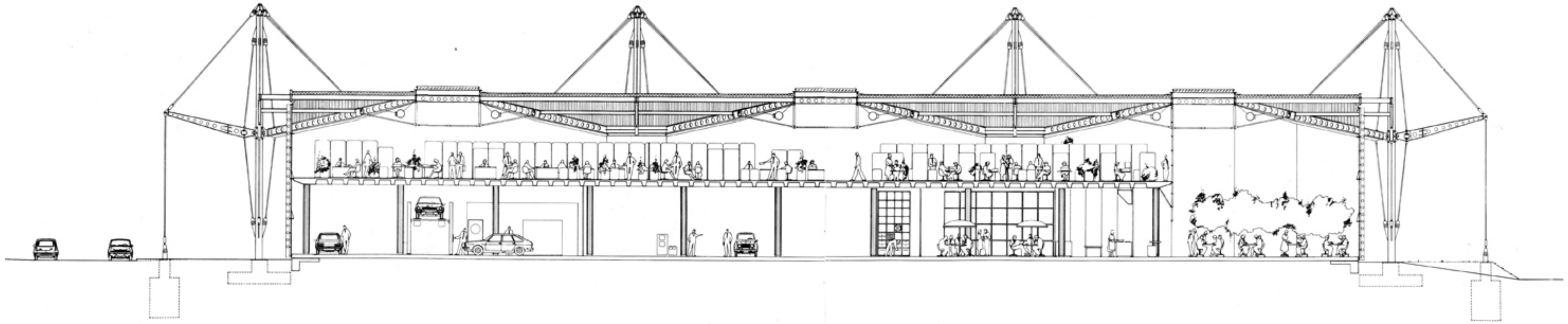
Swindon, 1982

Architect: Norman Foster

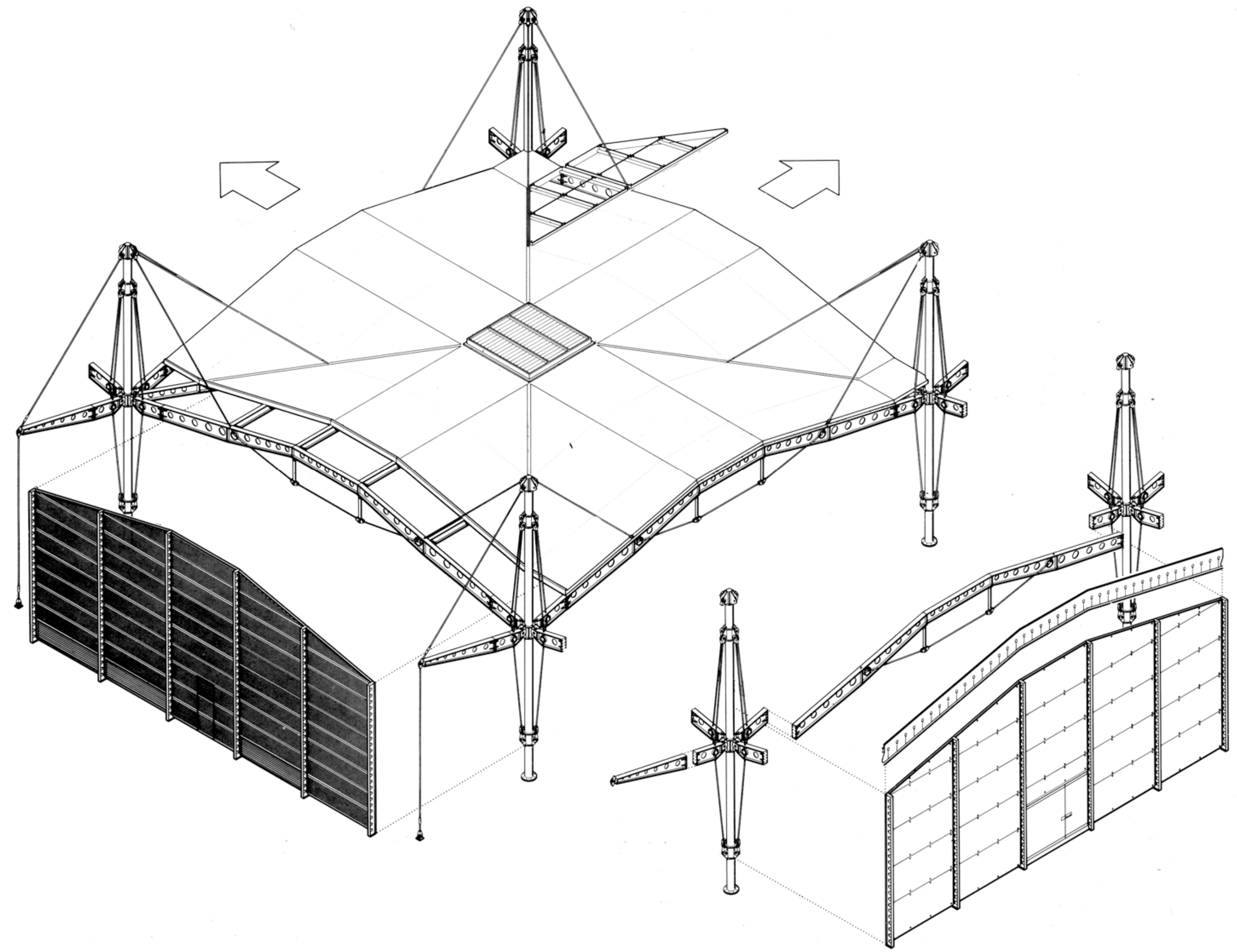
Engineer: Ove Arup

Gesamtansicht des Gebäudes

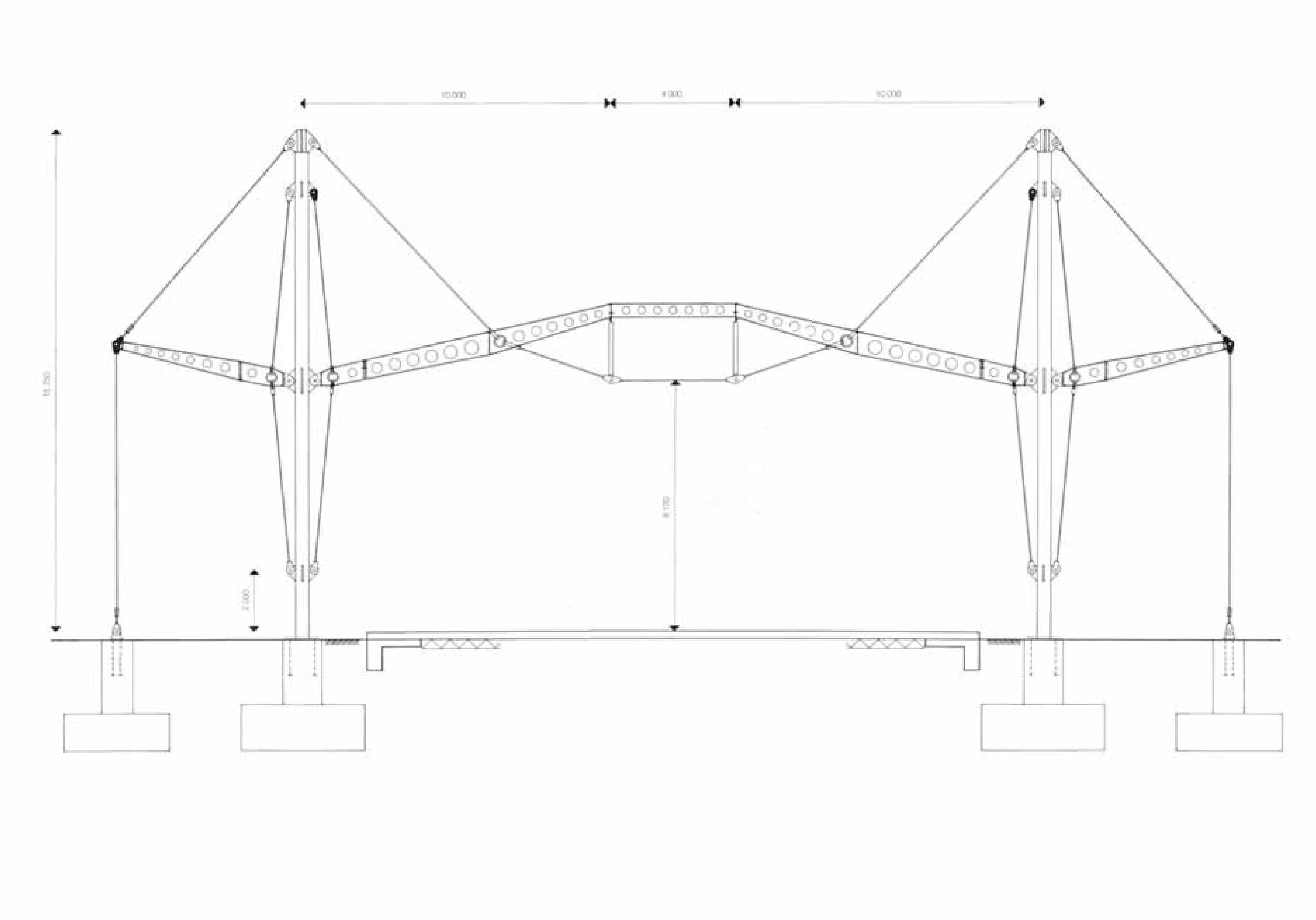
General view of the building



Schnitt
Section

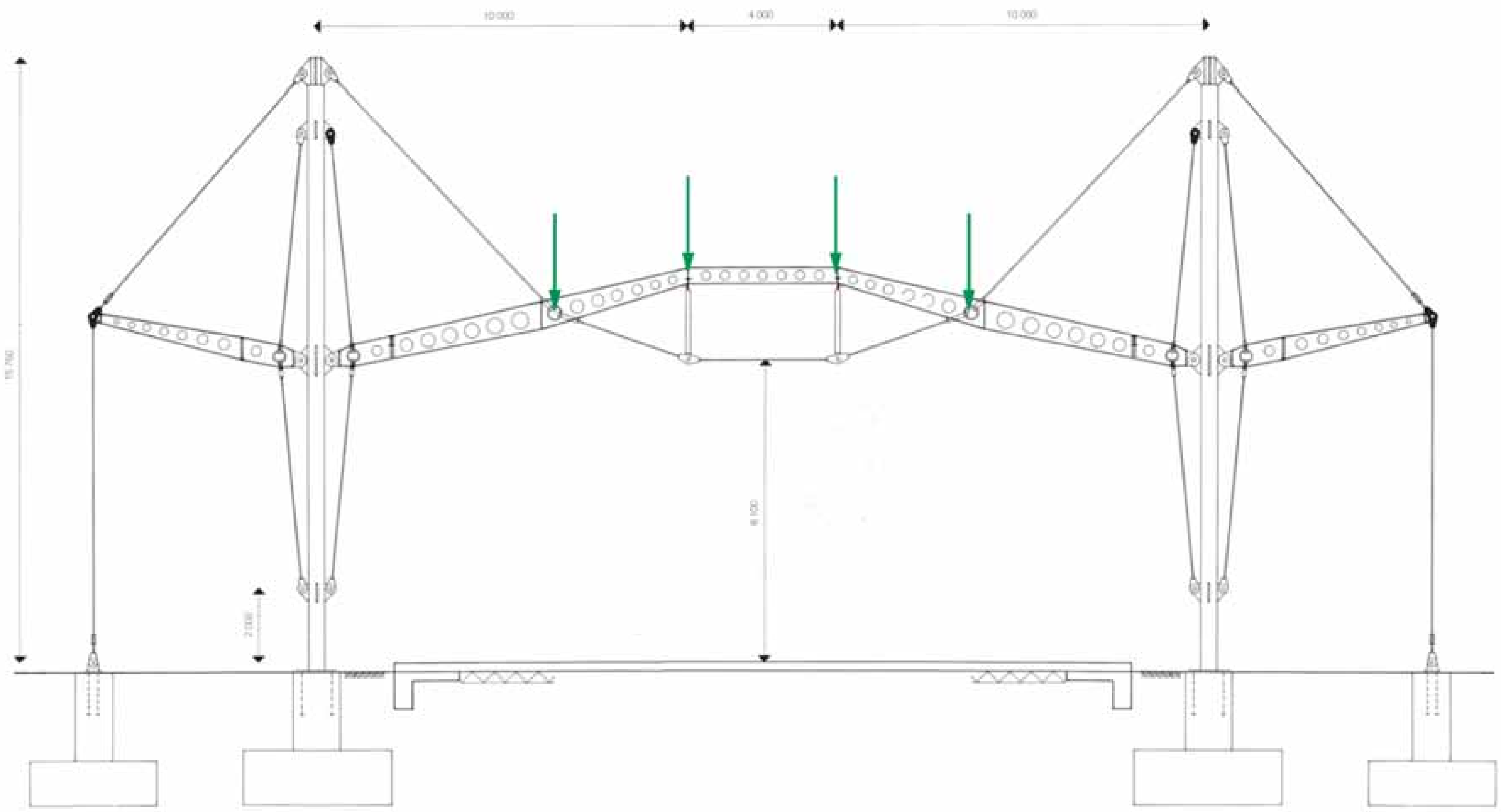


Axonometrische Ansicht eines Gebäudemoduls
Axonometric view of a building module



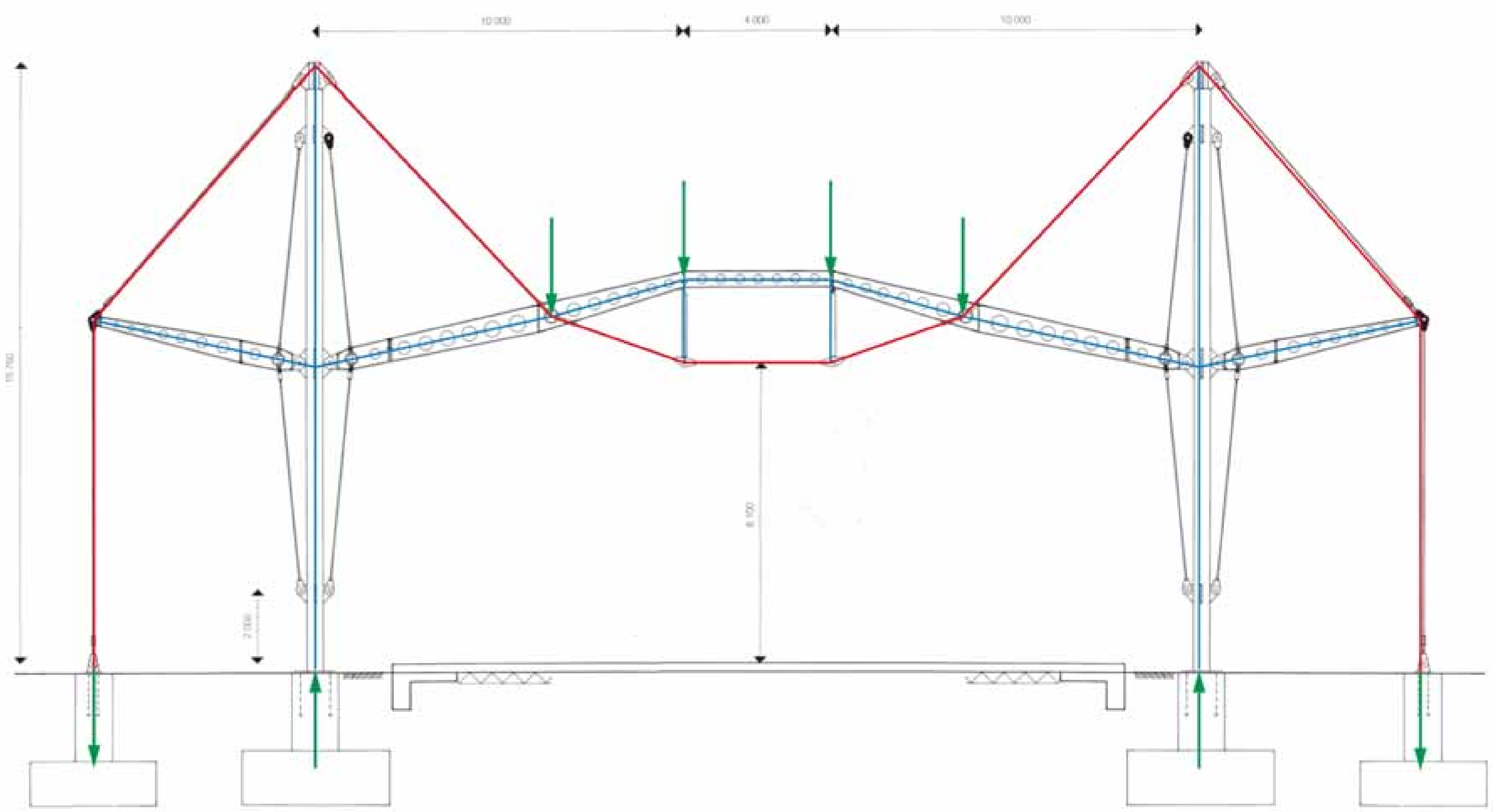
Schnitt eines Moduls

Section of a module



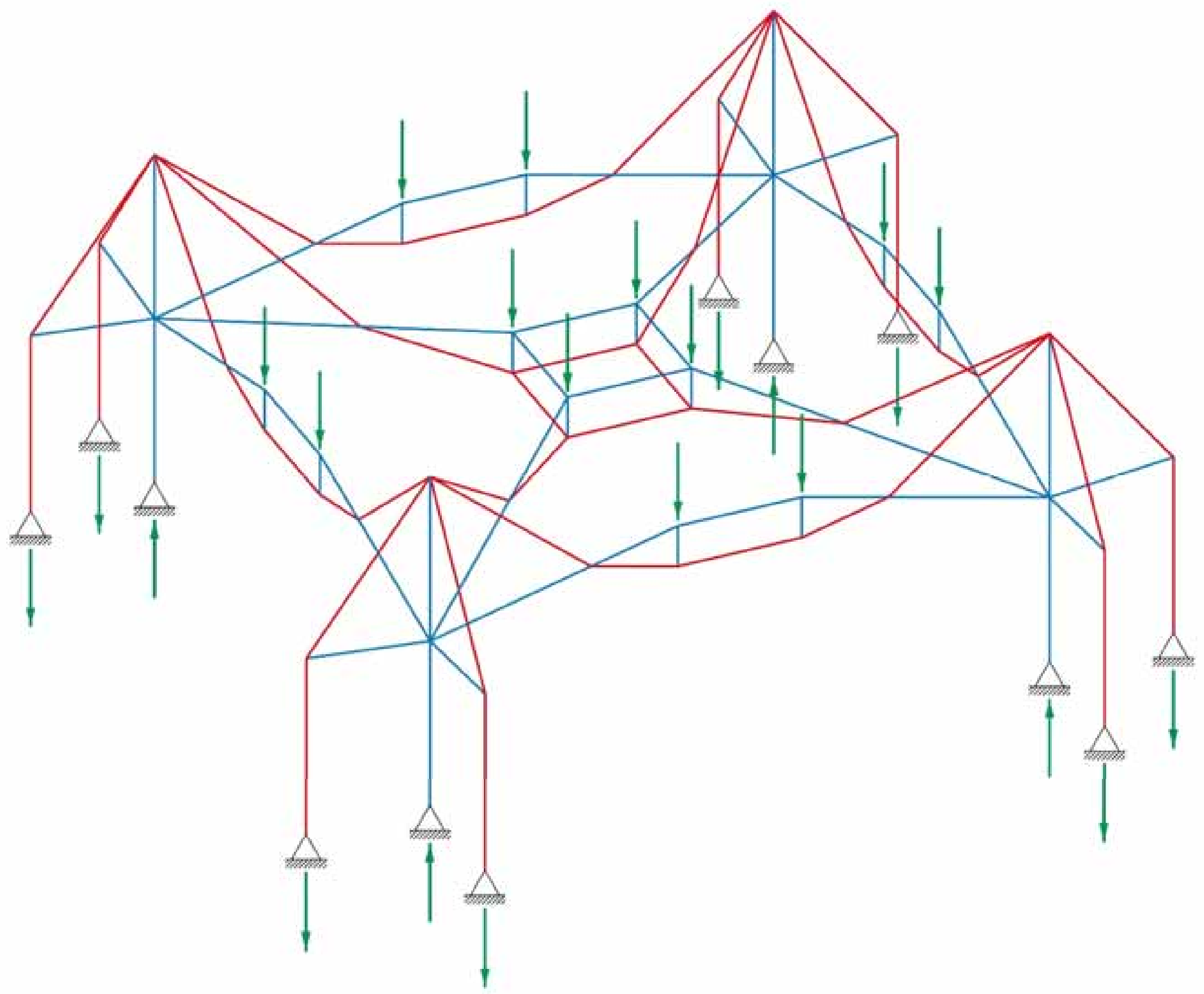
Statisches Gleichgewicht eines Moduls

Static equilibrium of a module



Statisches Gleichgewicht eines Moduls

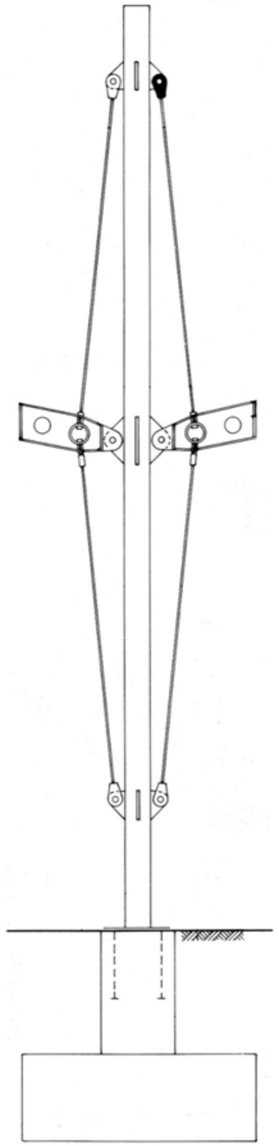
Static equilibrium of a module

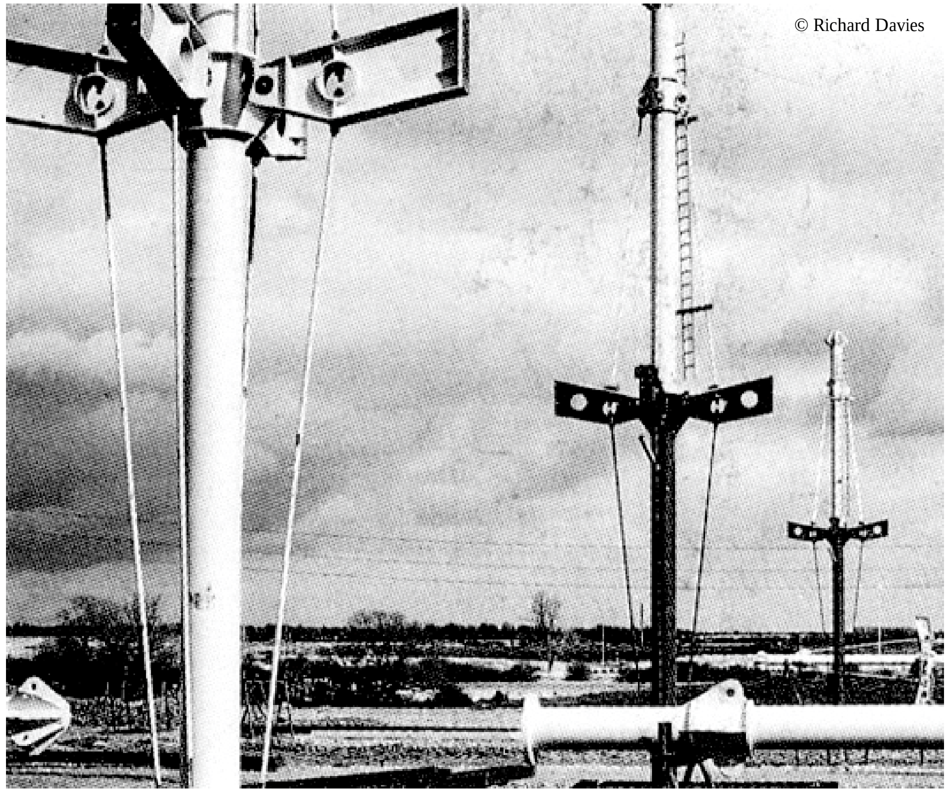


Statisches Gleichgewicht eines Moduls
Static equilibrium of a module

Details der Stahlkonstruktion

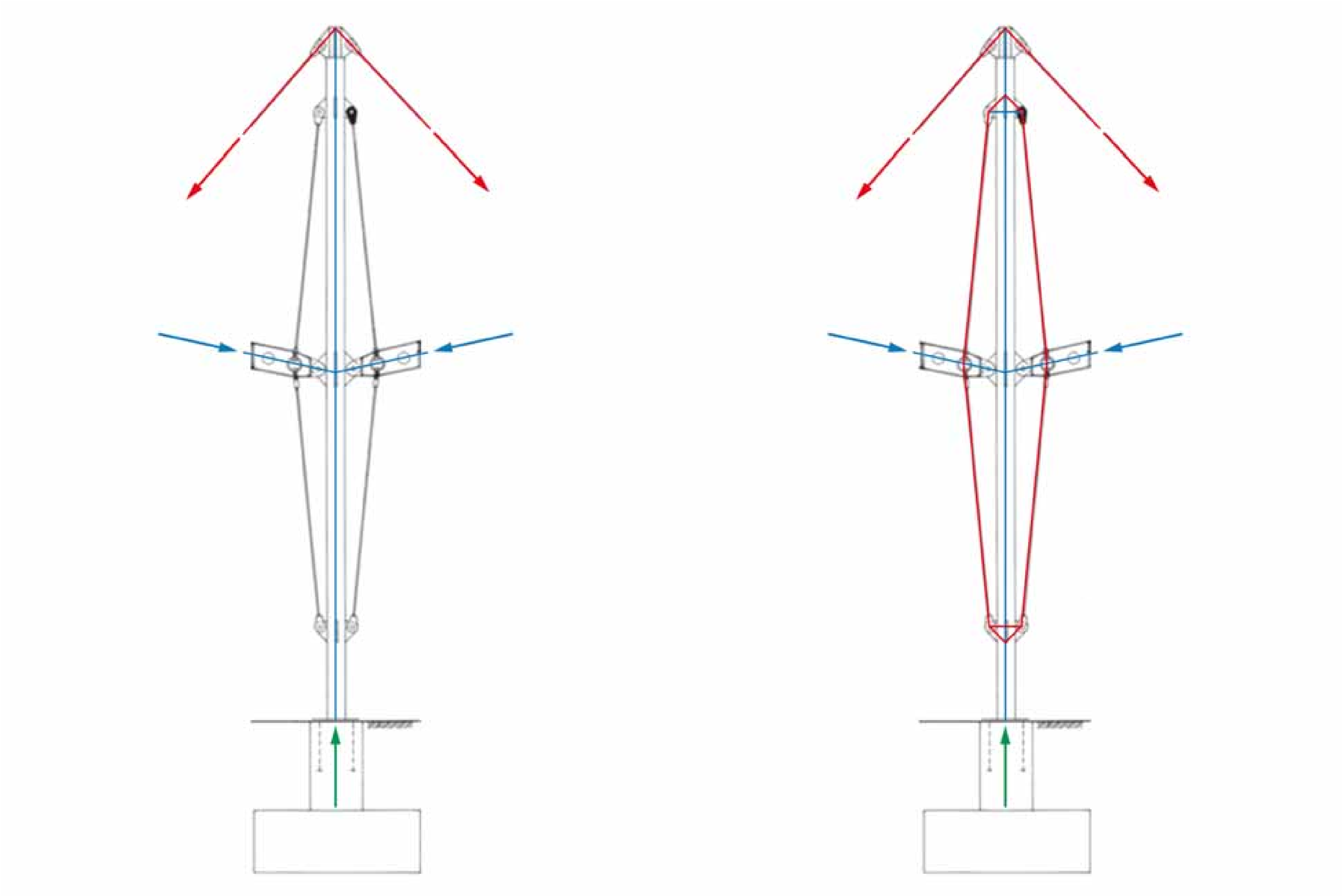
Steel construction details





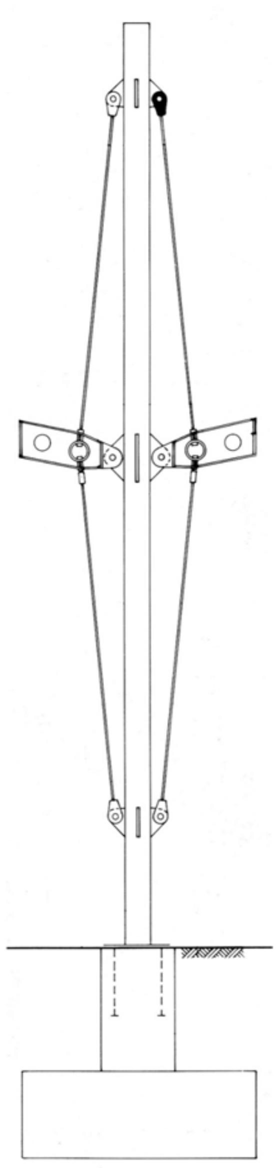
Stützen mit Vorspannung

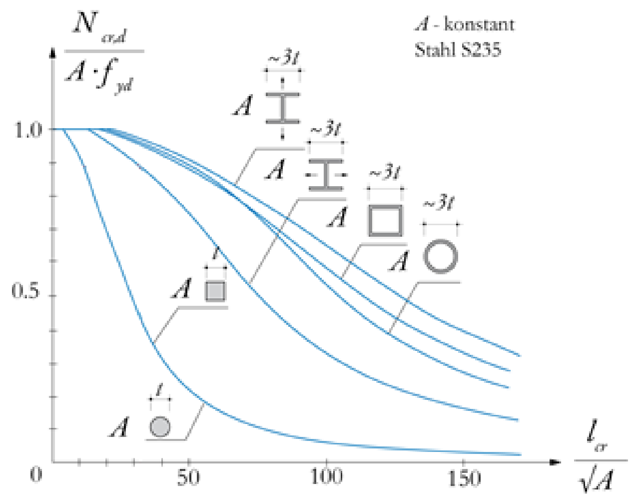
Columns with prestressing

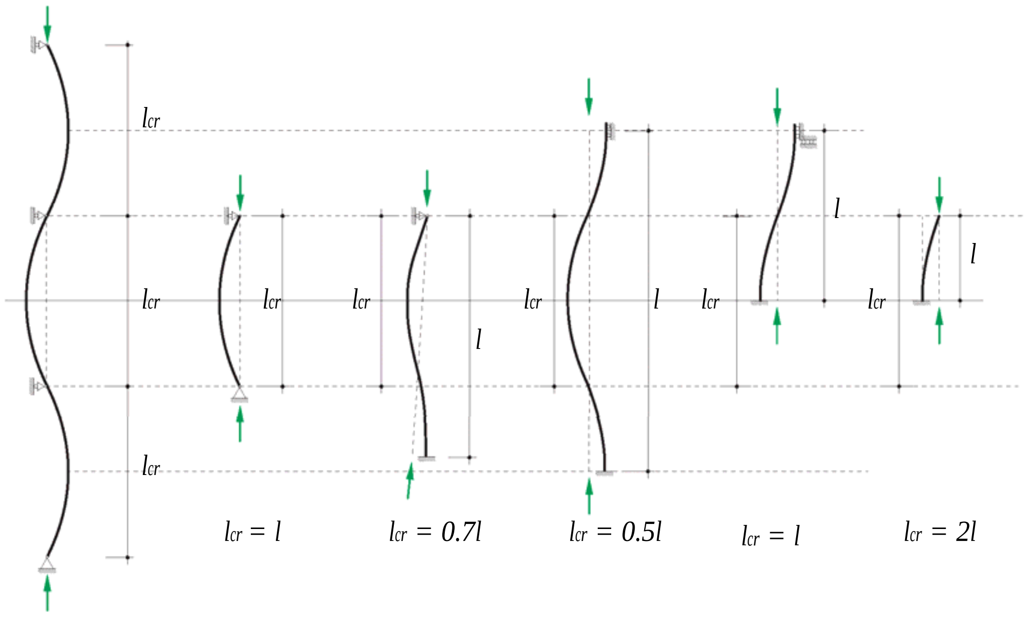


Stützen mit Vorspannung

Columns with prestressing

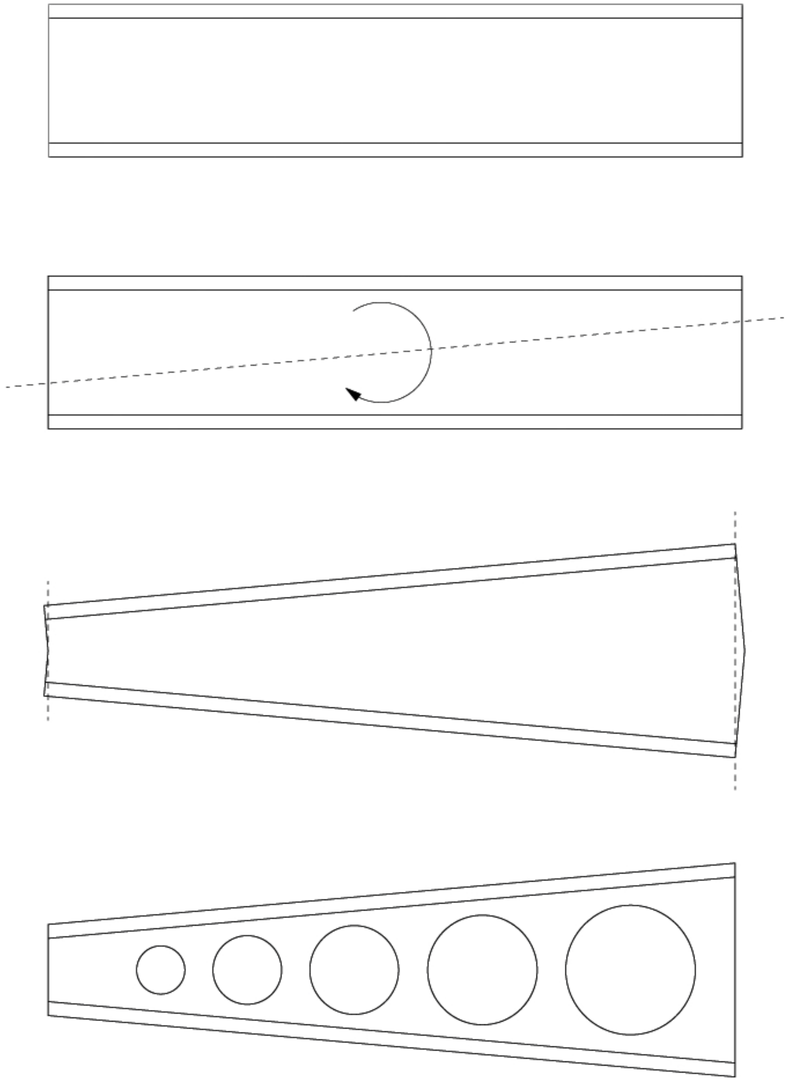






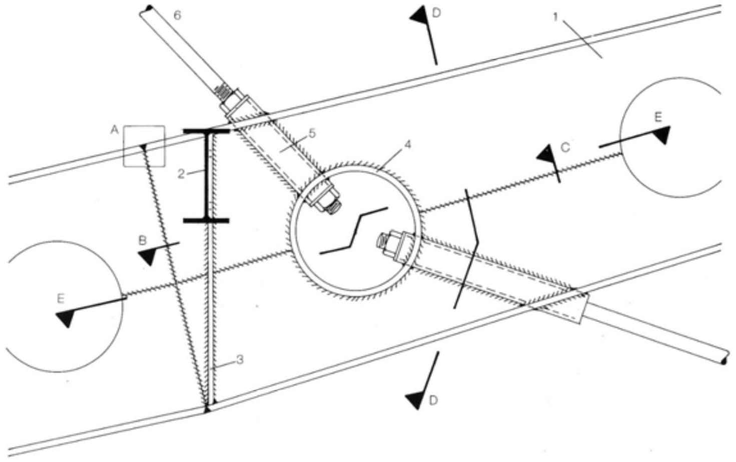
Stützen mit Vorspannung

Columns with prestressing

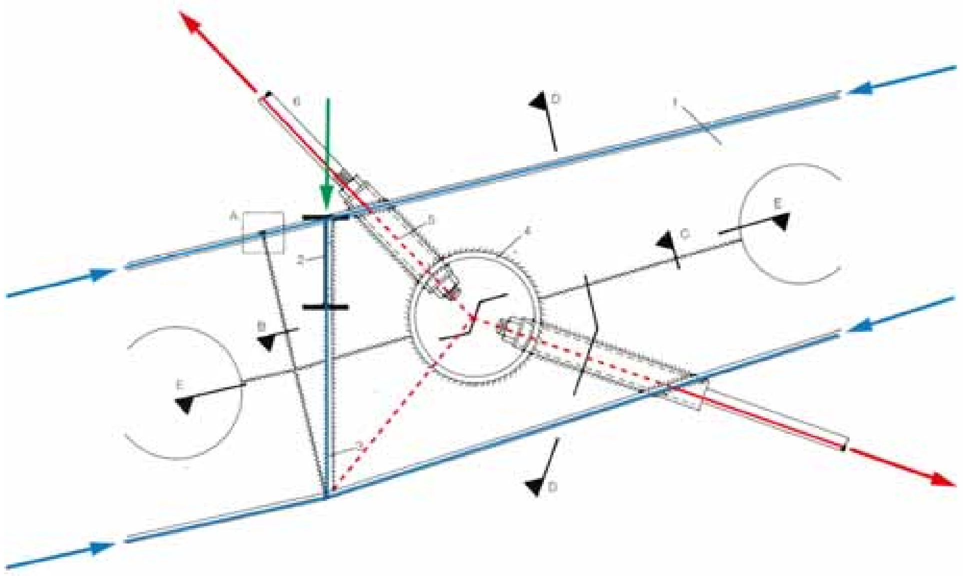


I-Profil-Träger

I-profile beams

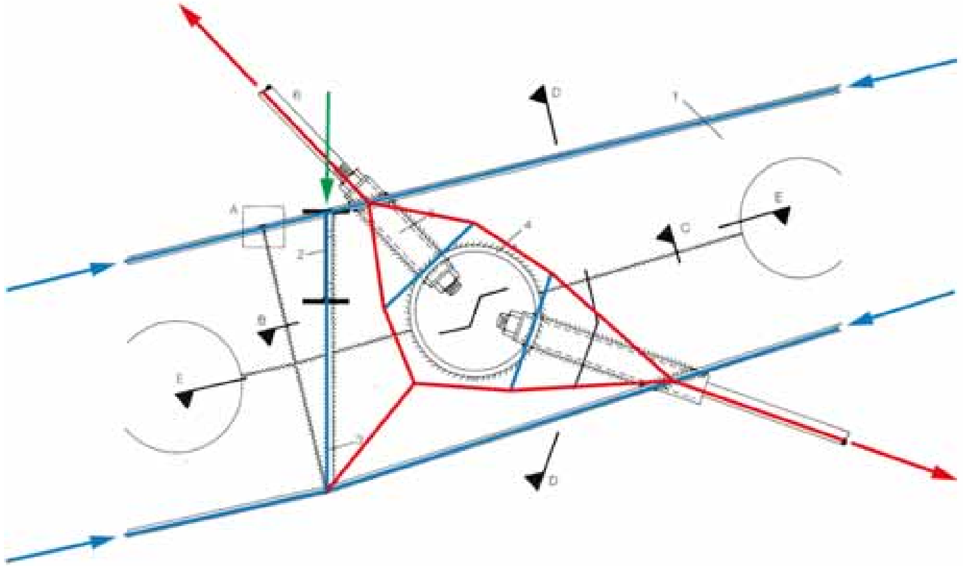


Detail der Balken-Kabel-Verbindungen
Detail of the beams-cables connections



Detail der Balken-Kabel-Verbindungen

Detail of the beams-cables connections



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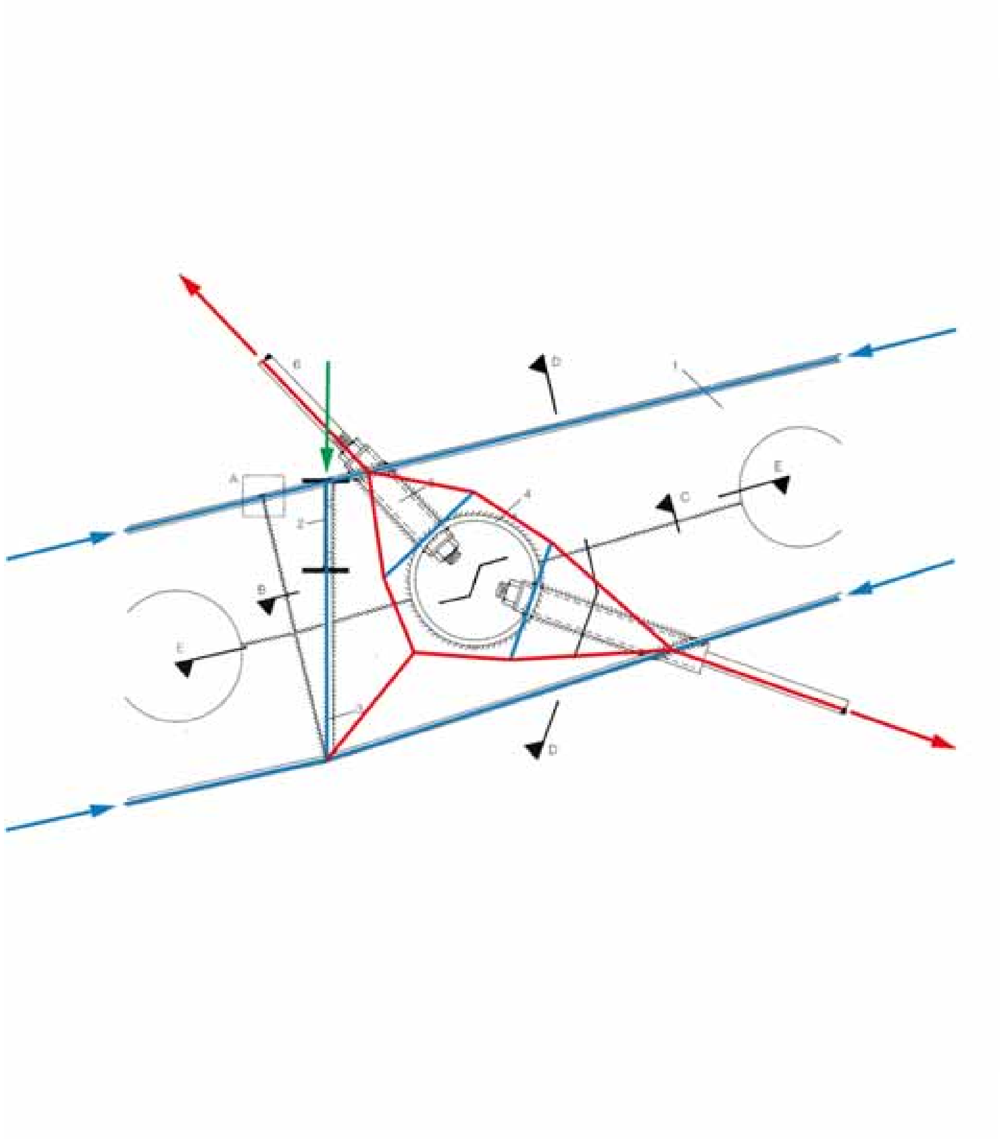

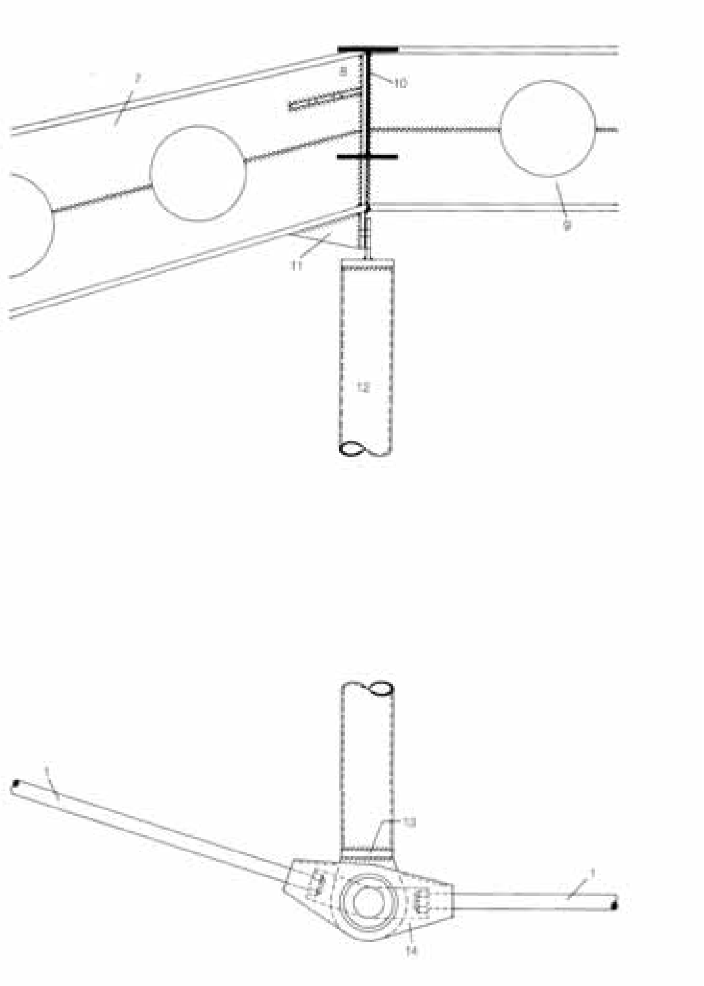

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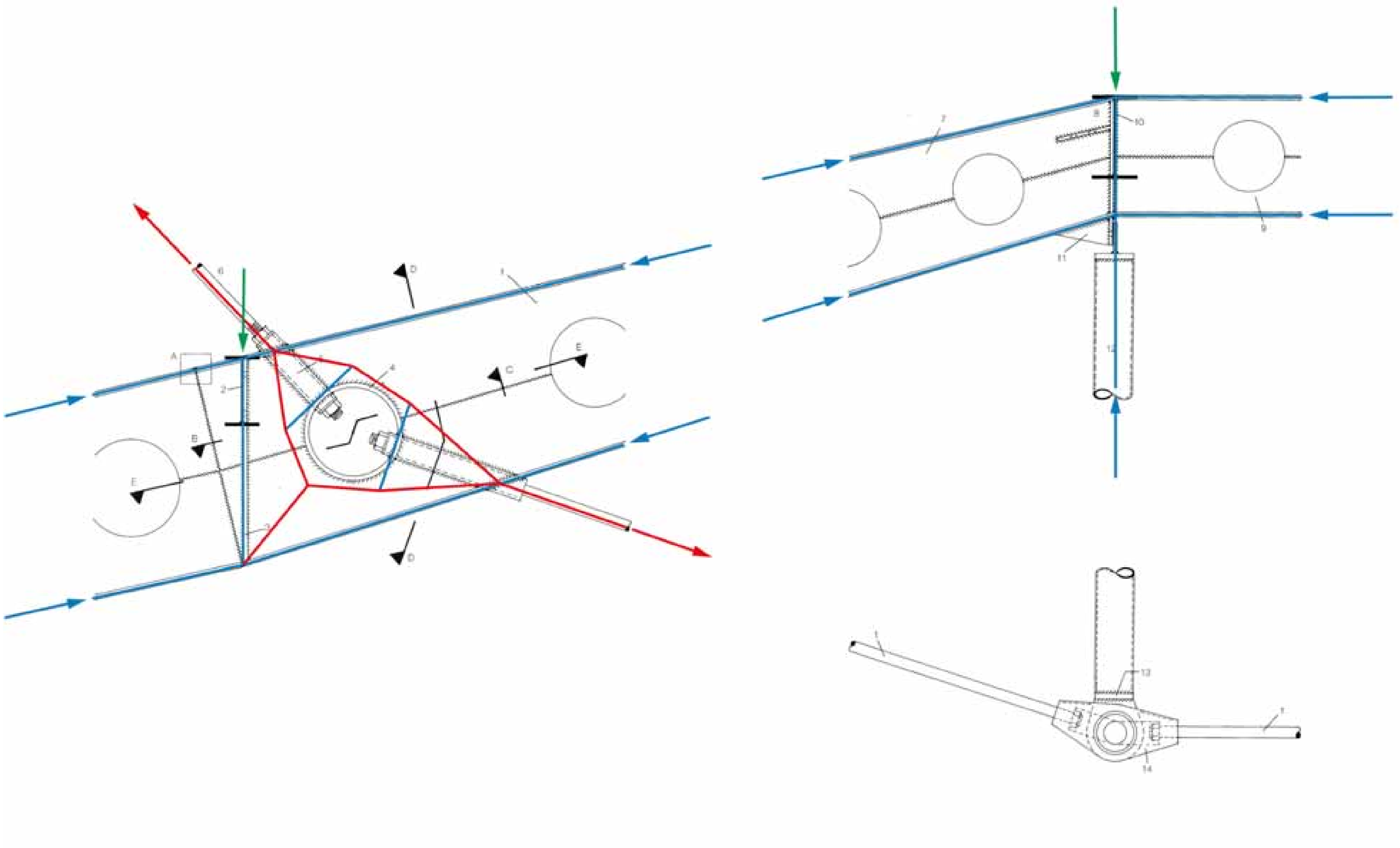
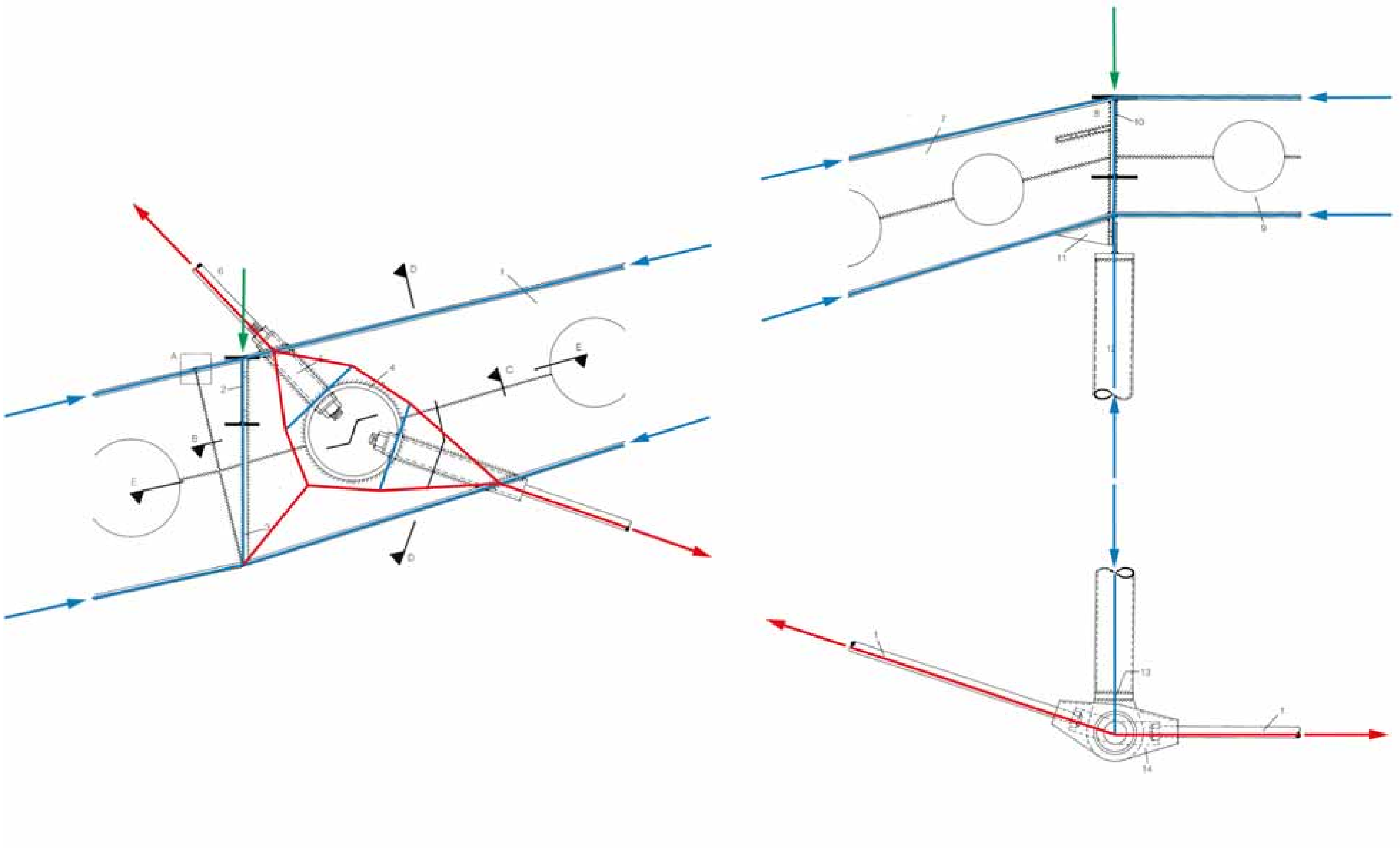
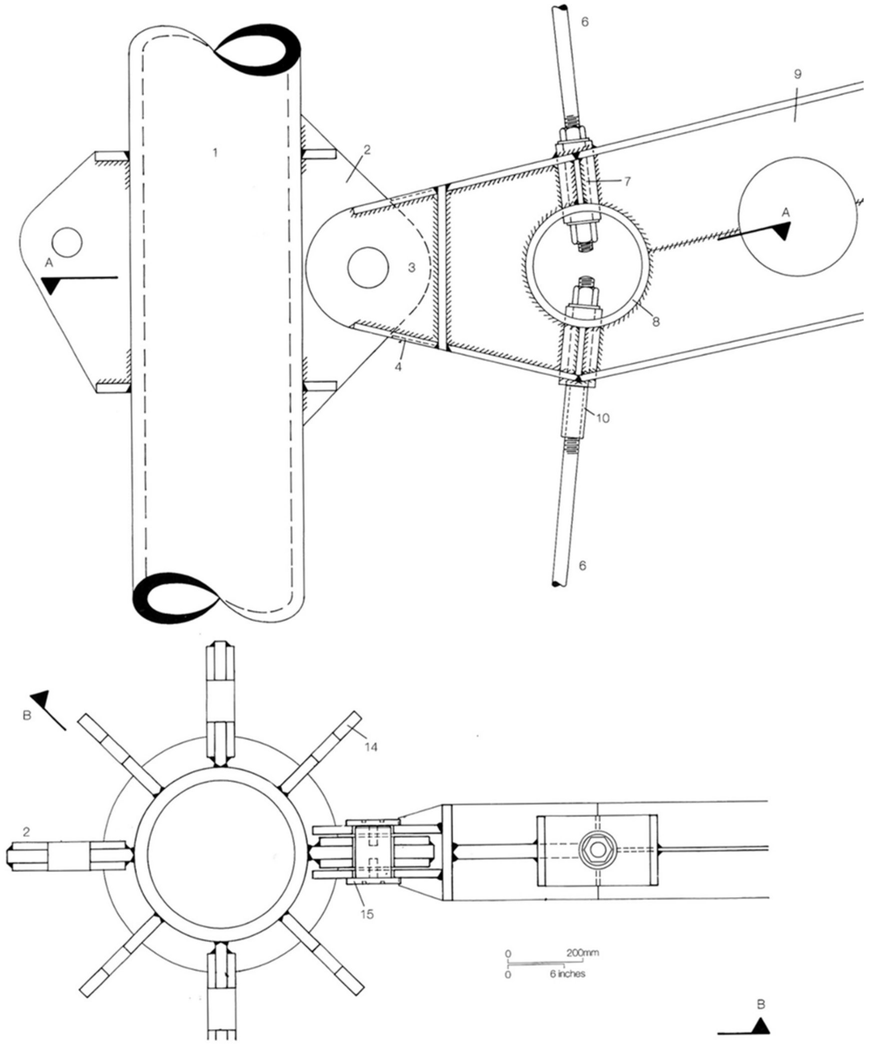


Detail der Balken-Kabel-Verbindungen
Detail of the beams-cables connections



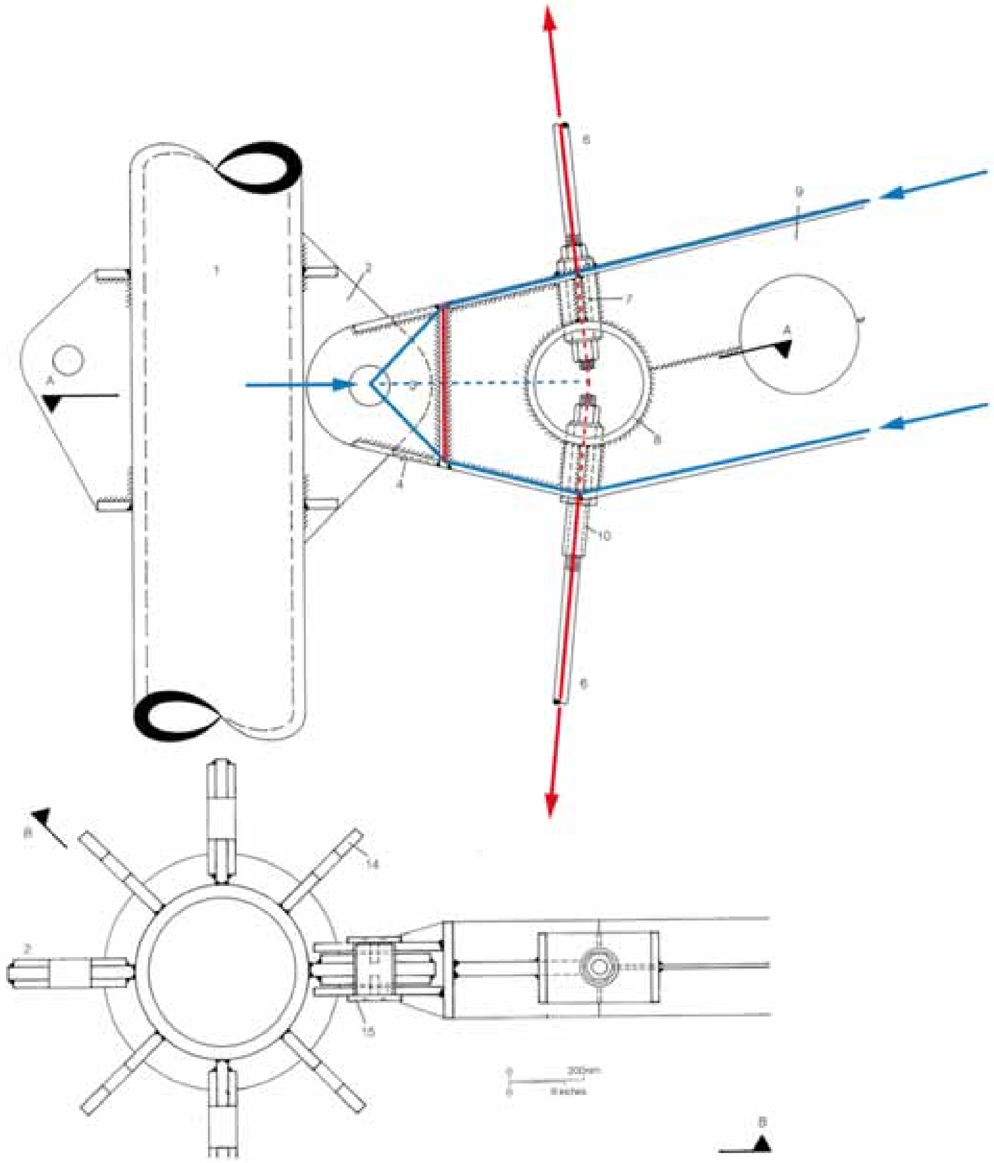
Detail der Balken-Kabel-Verbindungen

Detail of the beams-cables connections



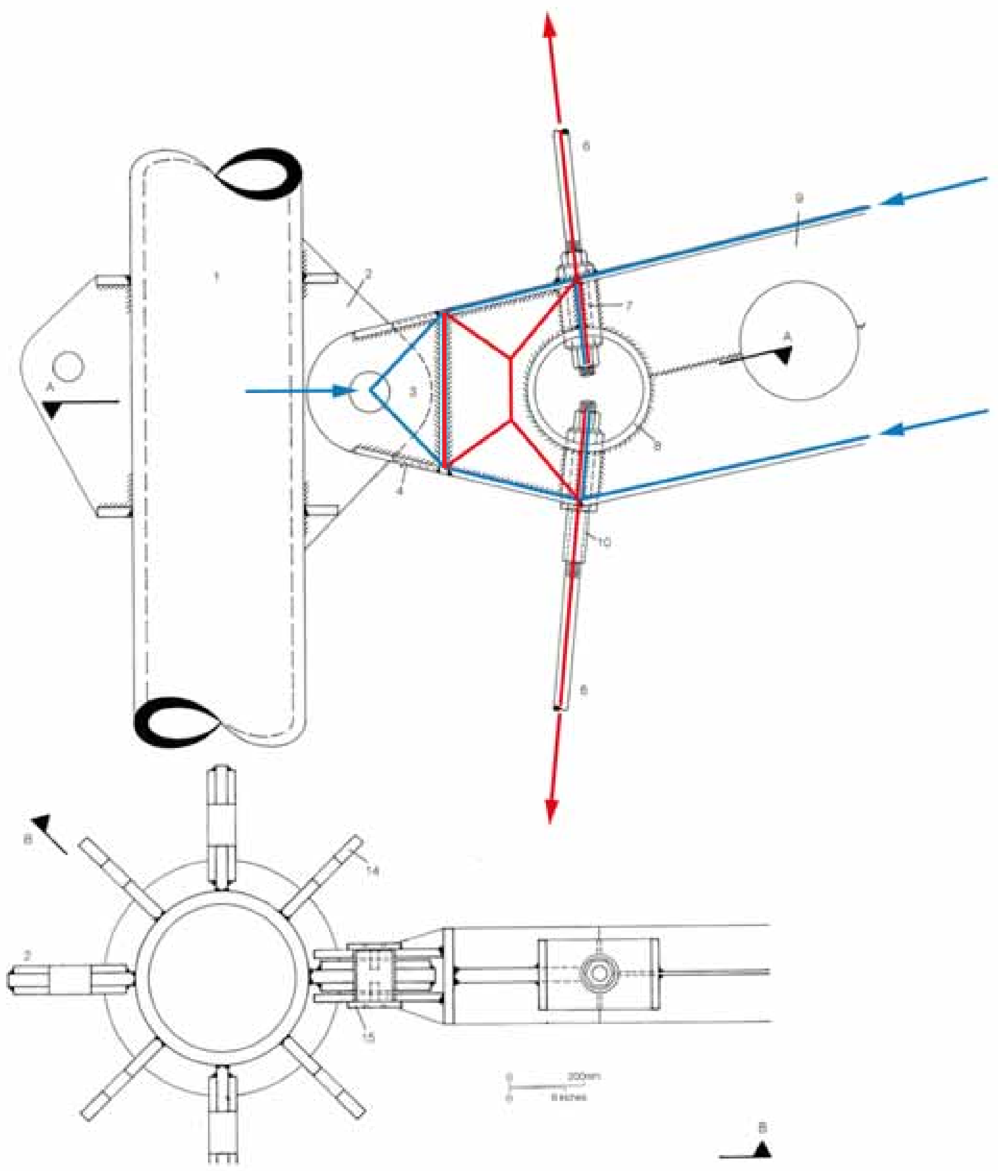
Detail der Balken-Kabel-Verbindungen

Detail of the beams-cables connections



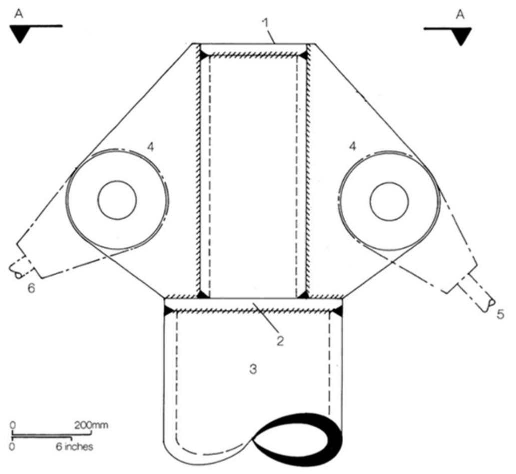
Detail der Balken-Kabel-Verbindungen

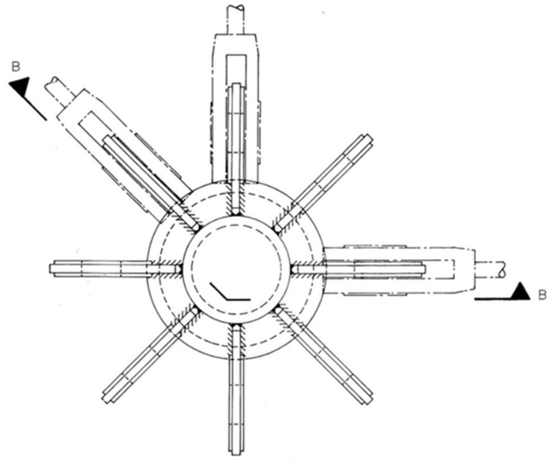
Detail of the beams-cables connections



Detail der Balken-Kabel-Verbindungen

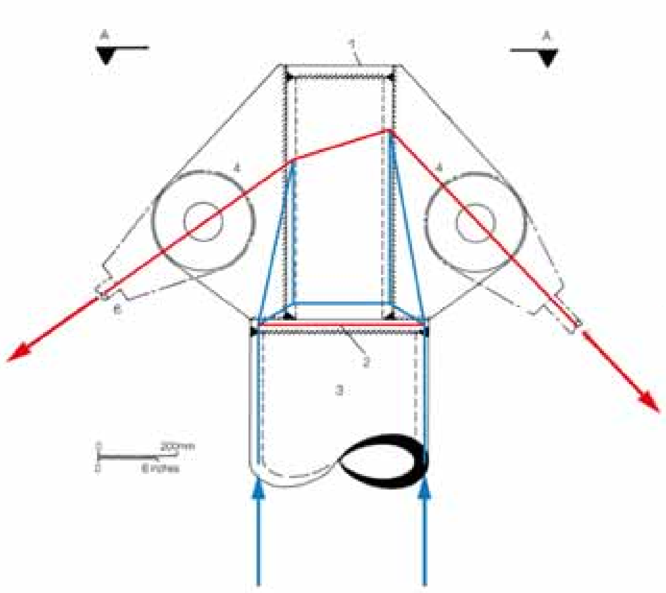
Detail of the beams-cables connections

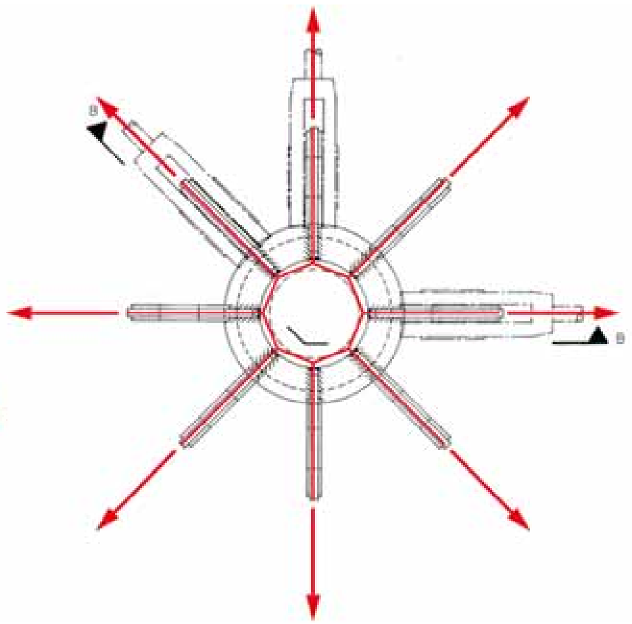




Detail der Balken-Kabel-Verbindungen

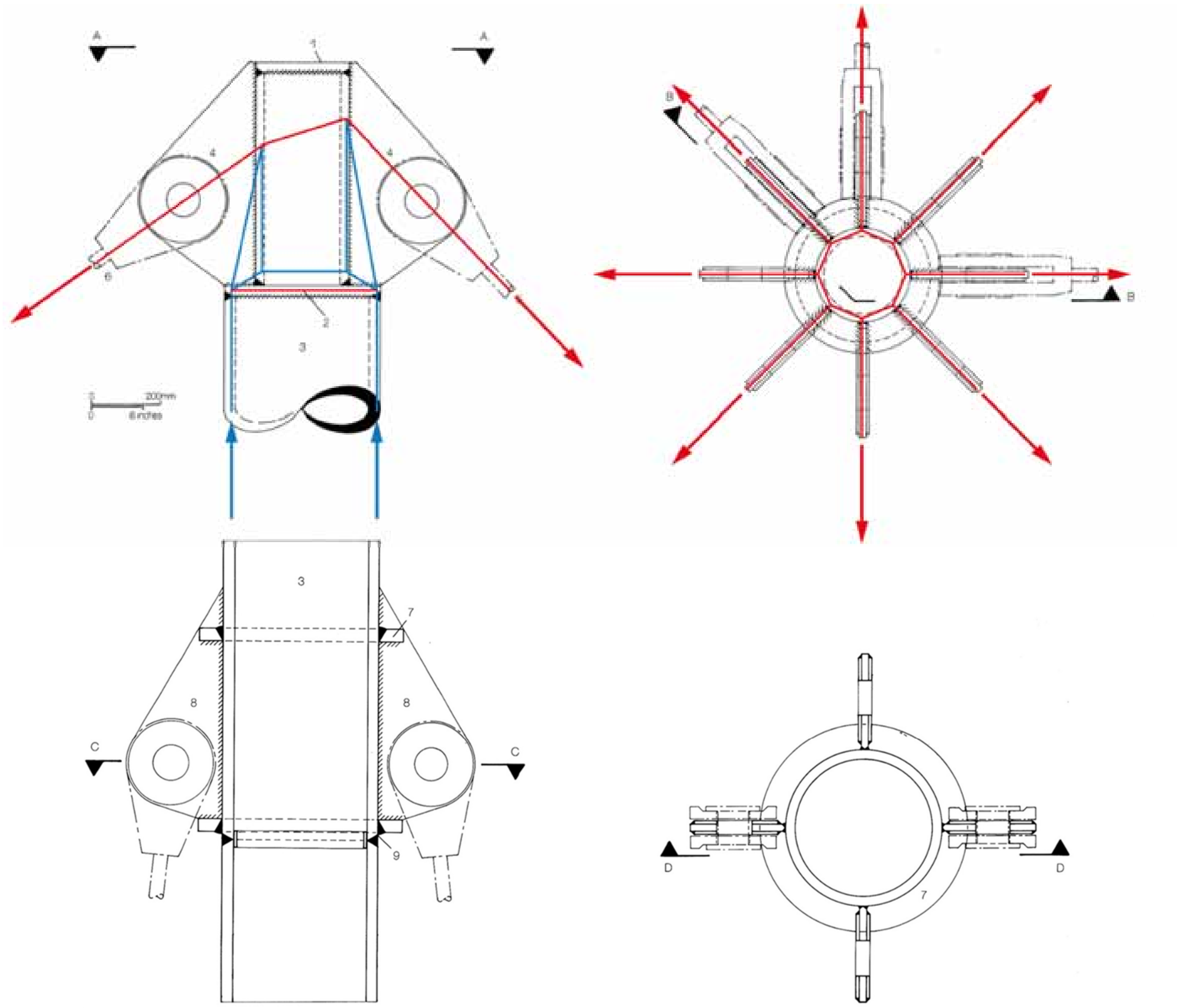
Detail of the beams-cables connections





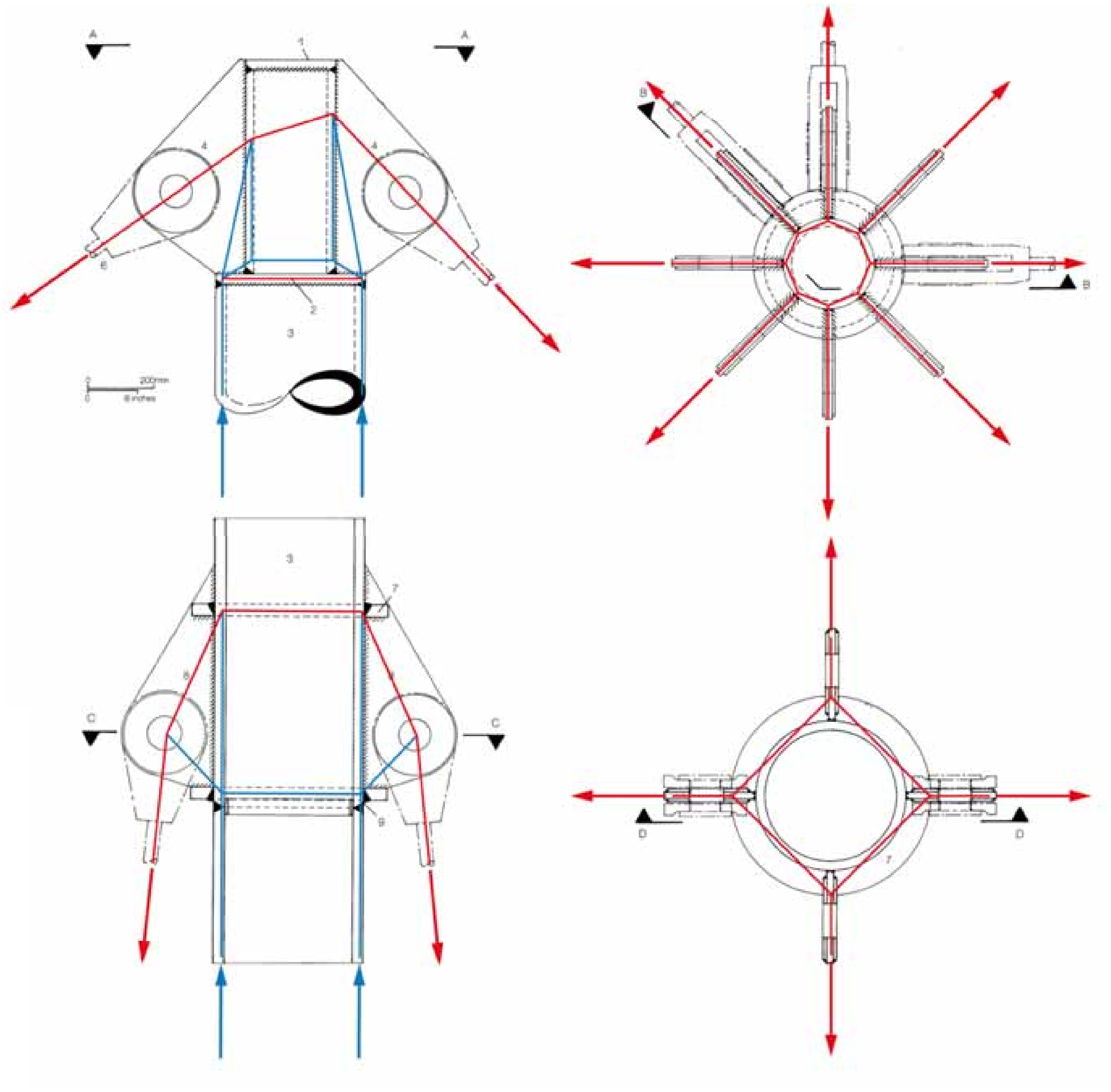
Detail der Balken-Kabel-Verbindungen

Detail of the beams-cables connections



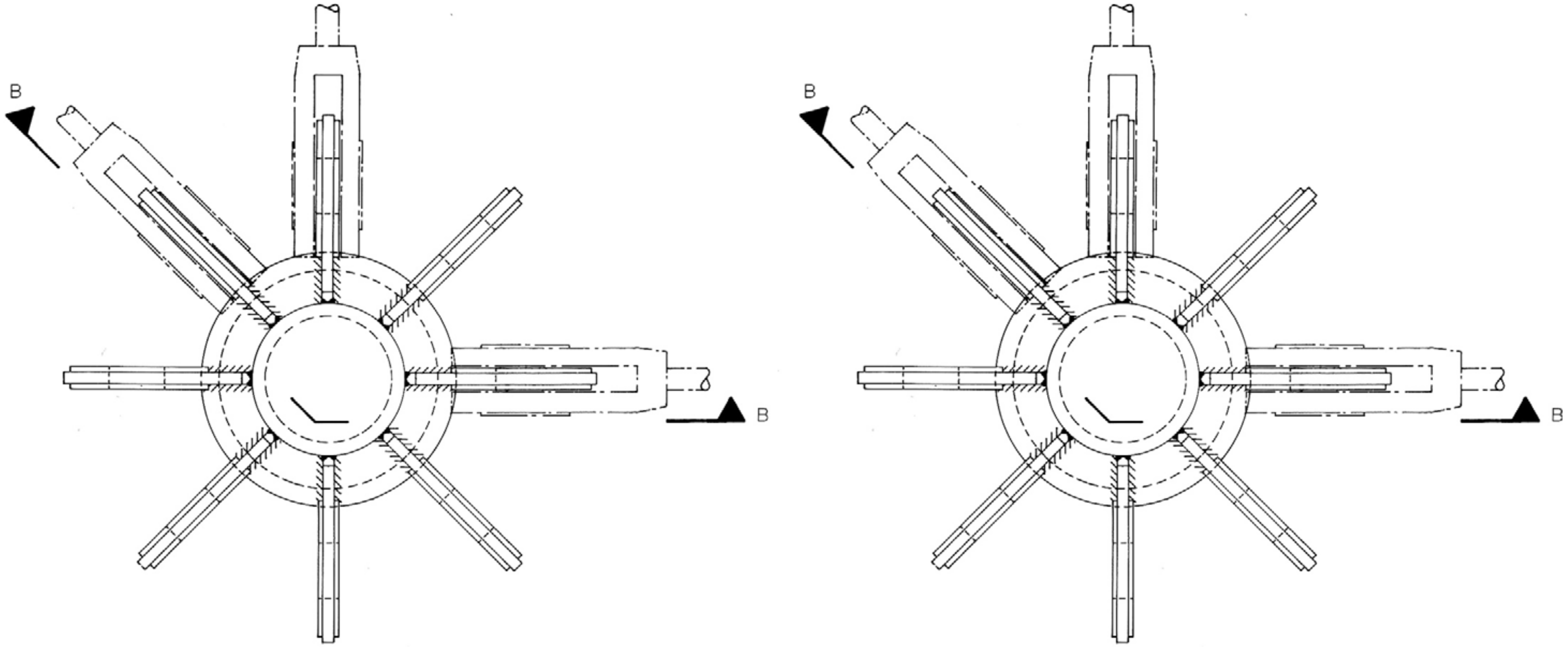
Detail der Balken-Kabel-Verbindungen

Detail of the beams-cables connections



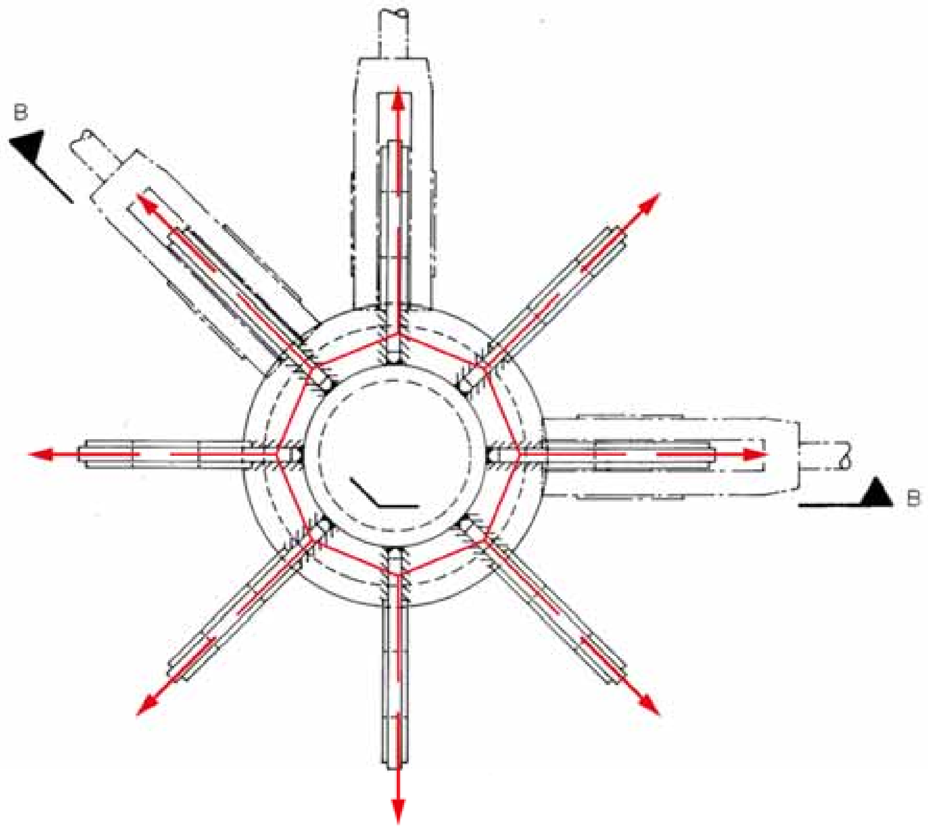
Detail der Balken-Kabel-Verbindungen

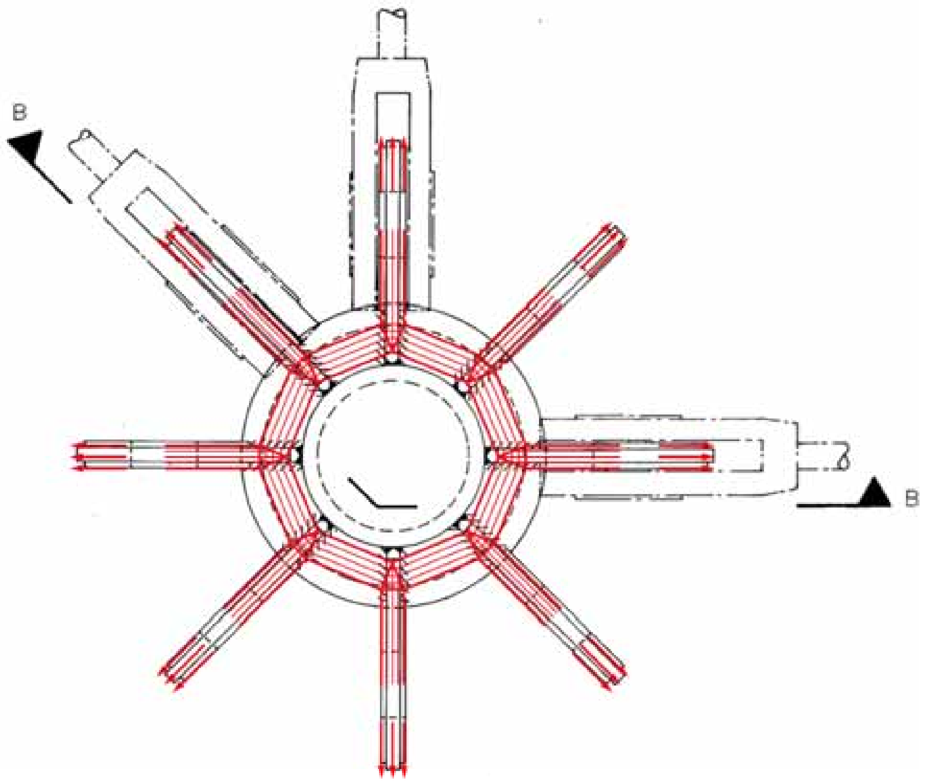
Detail of the beams-cables connections

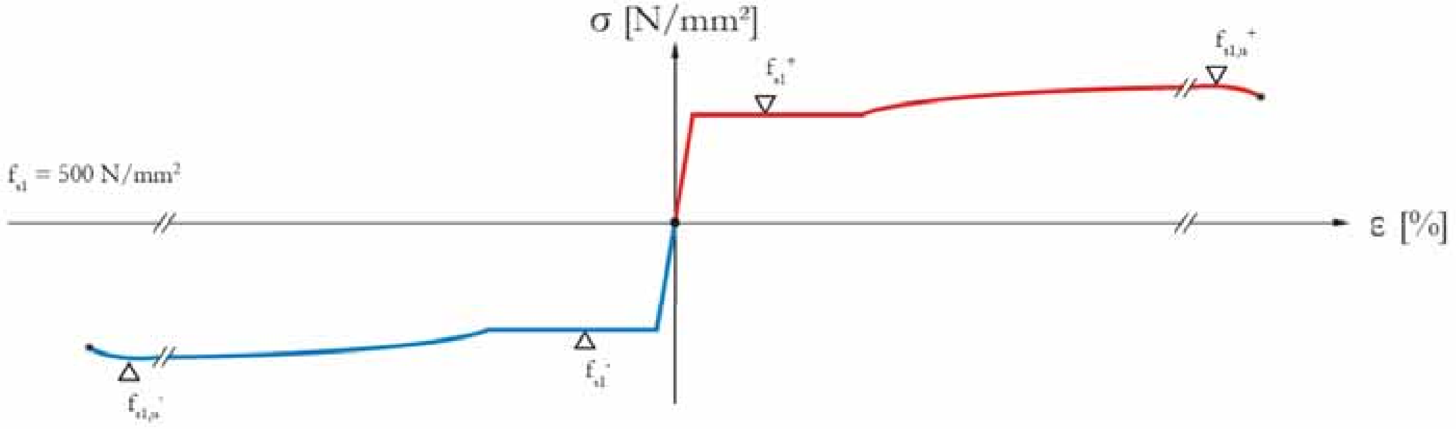


Detail der Balken-Kabel-Verbindungen

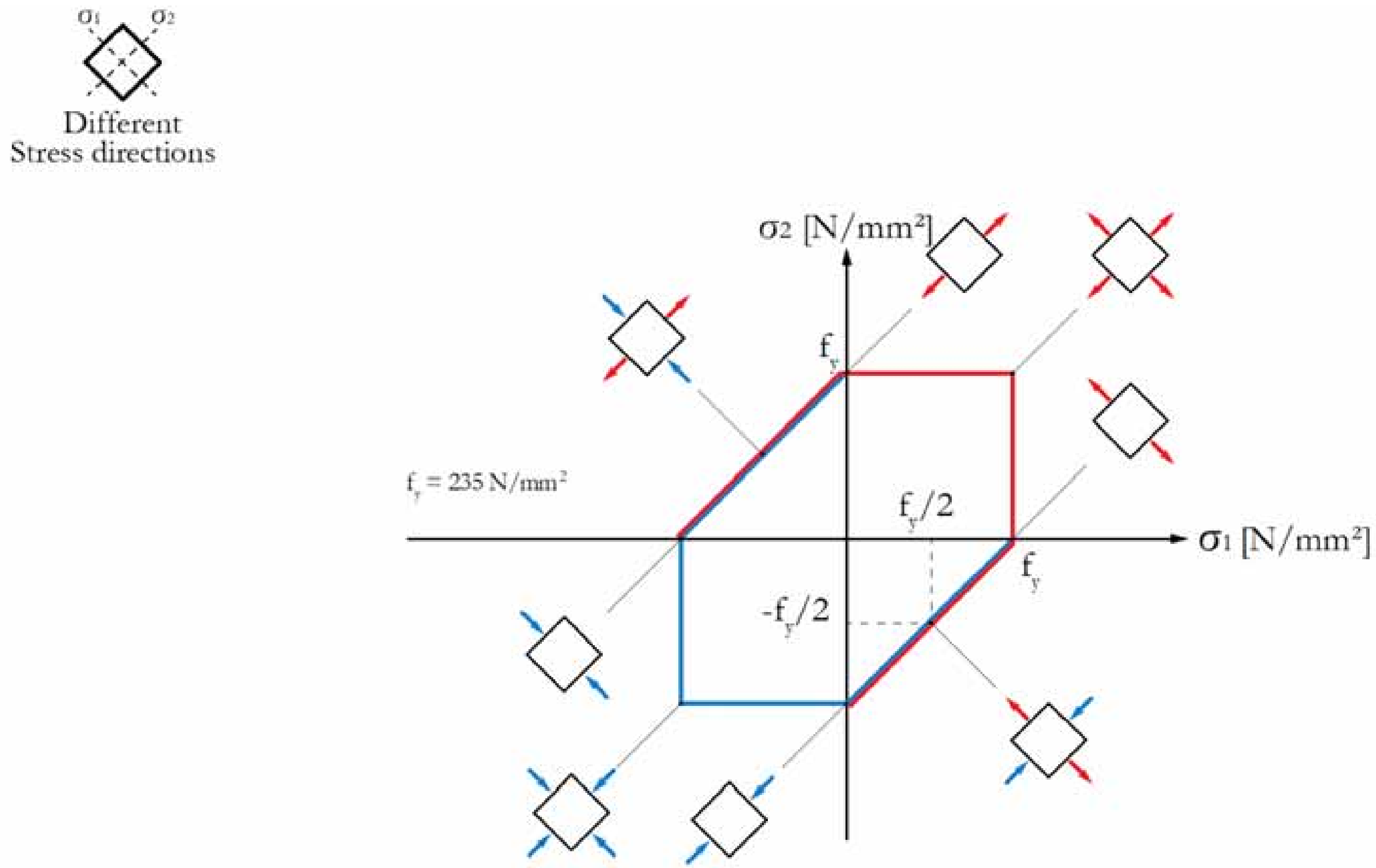
Detail of the beams-cables connections


B
B

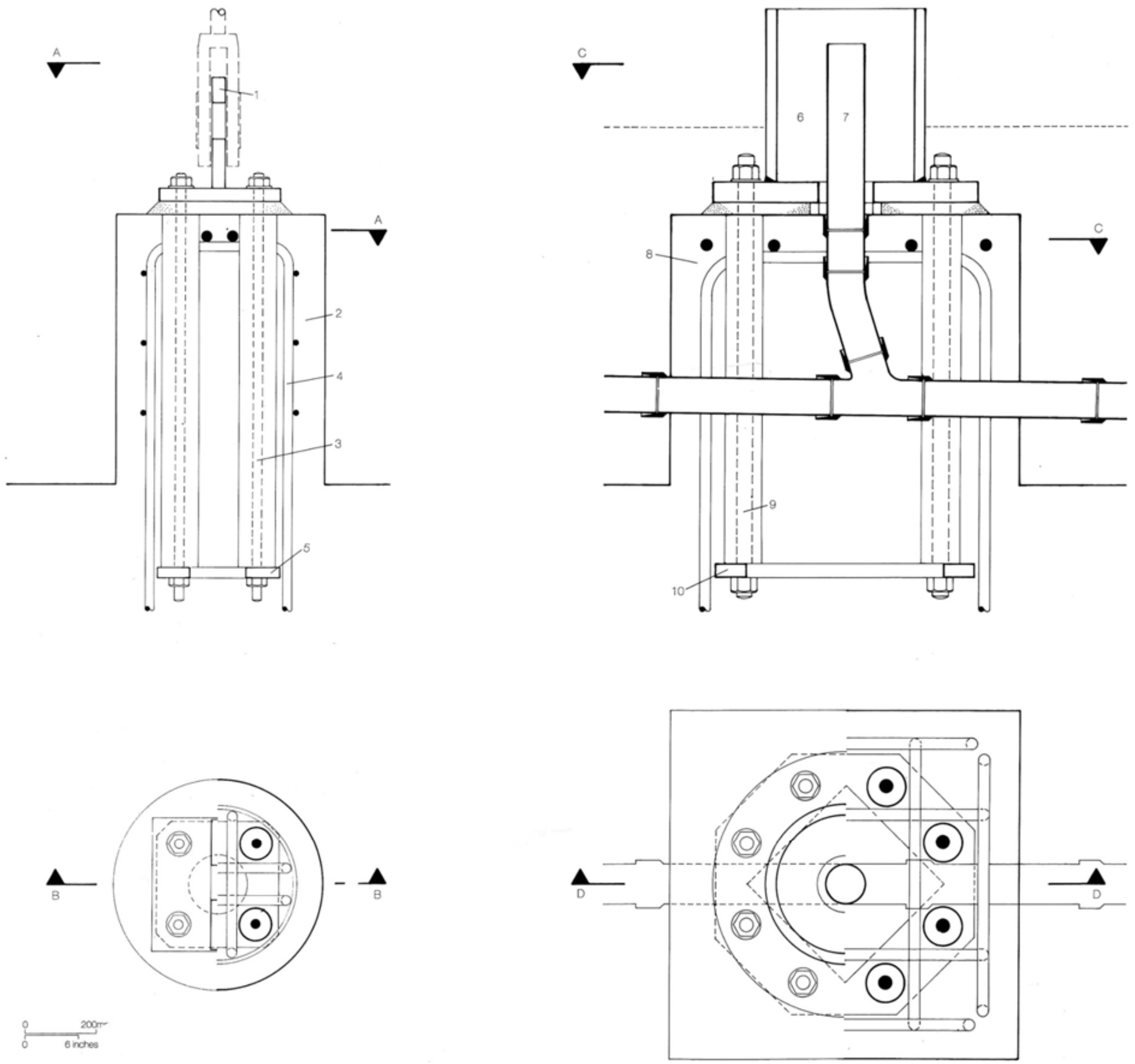

B
B



Stahl, Spannungs-Dehnungs-Diagramm
Steel, stress-strain diagram

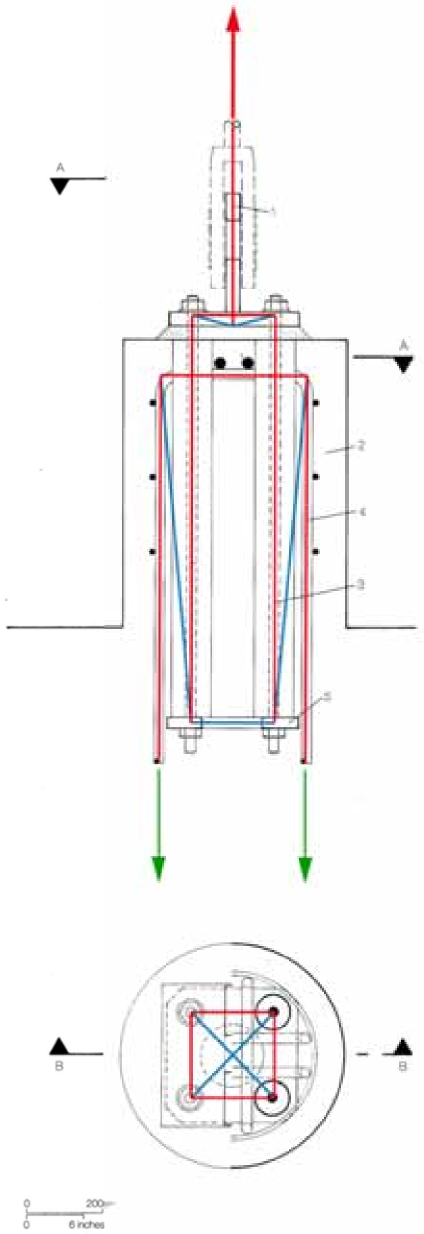


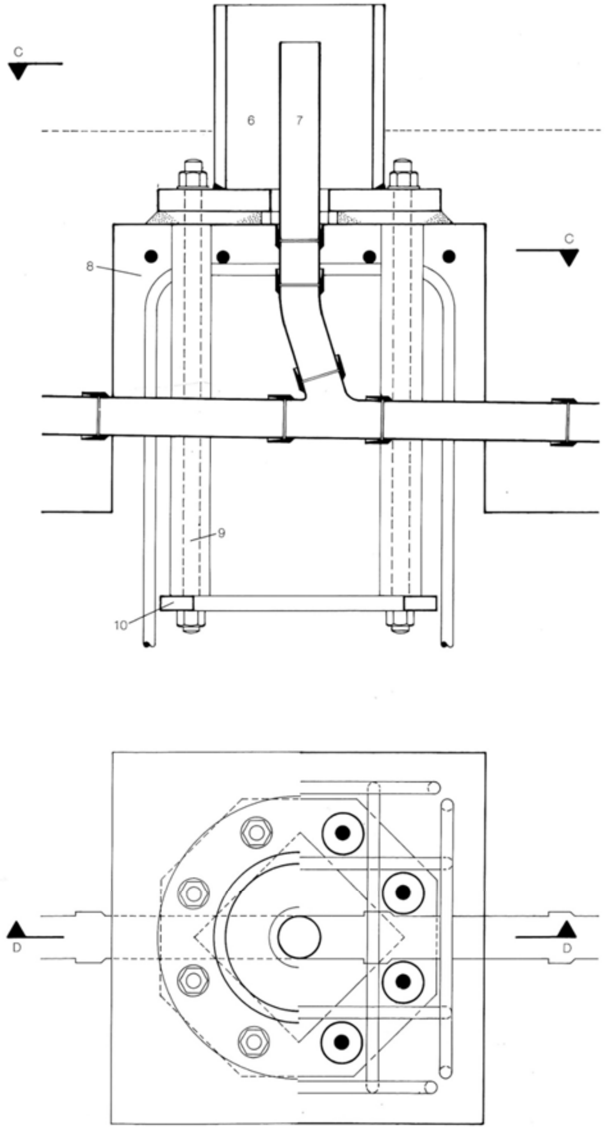
Stahl, Versagenskriterium in 2D
Steel, failure criterion in 2D



Stützendetails

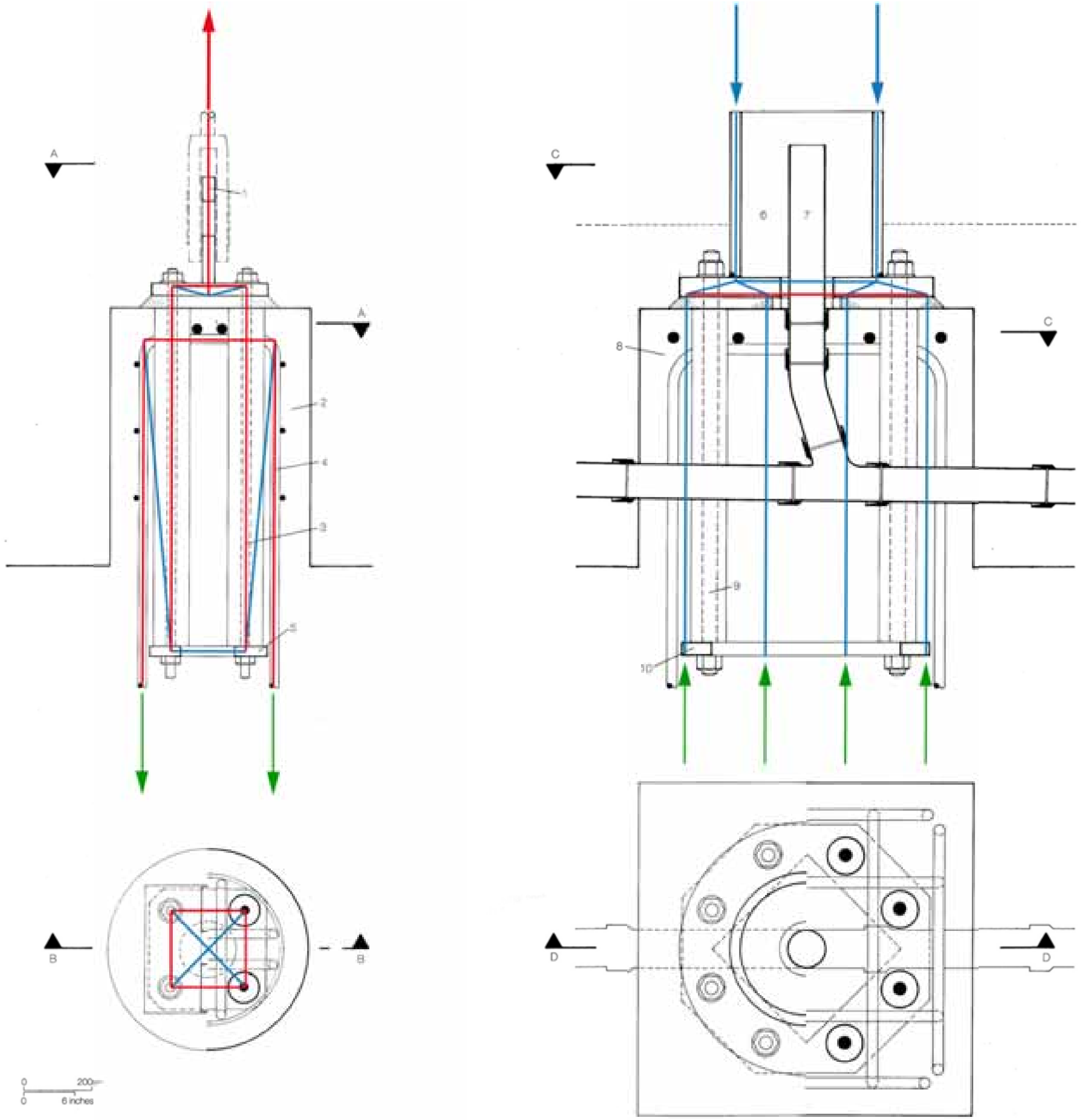
Details of the supports





Stützendetails

Details of the supports



Stützendetails

Details of the supports

Pabellón del Futuro, Expo’92

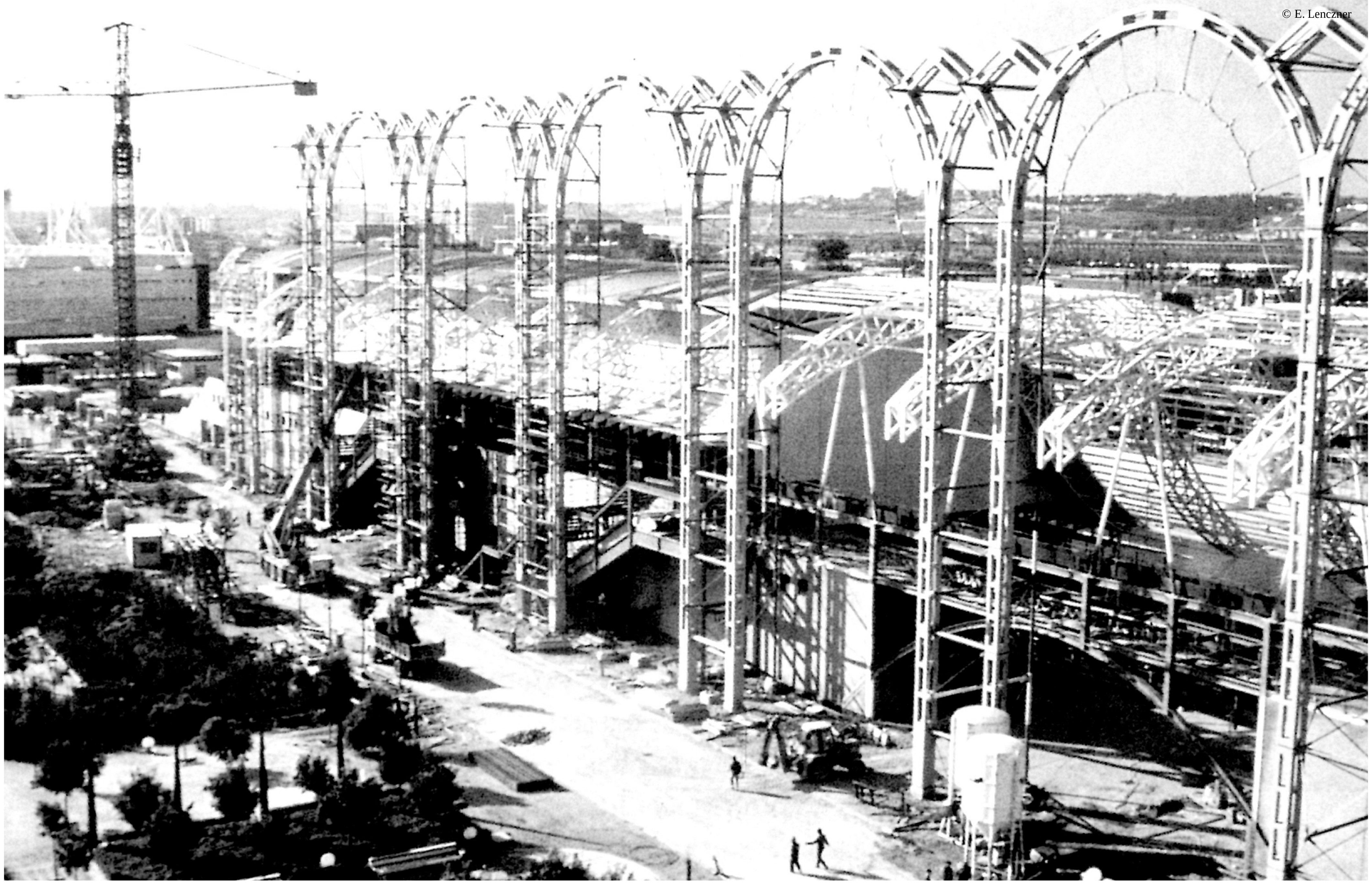
Seville, 1992

Architect: Martorell, Bohigas & Mackay (MBM)

Engineer: Peter Rice (Ove Arup and Partners)

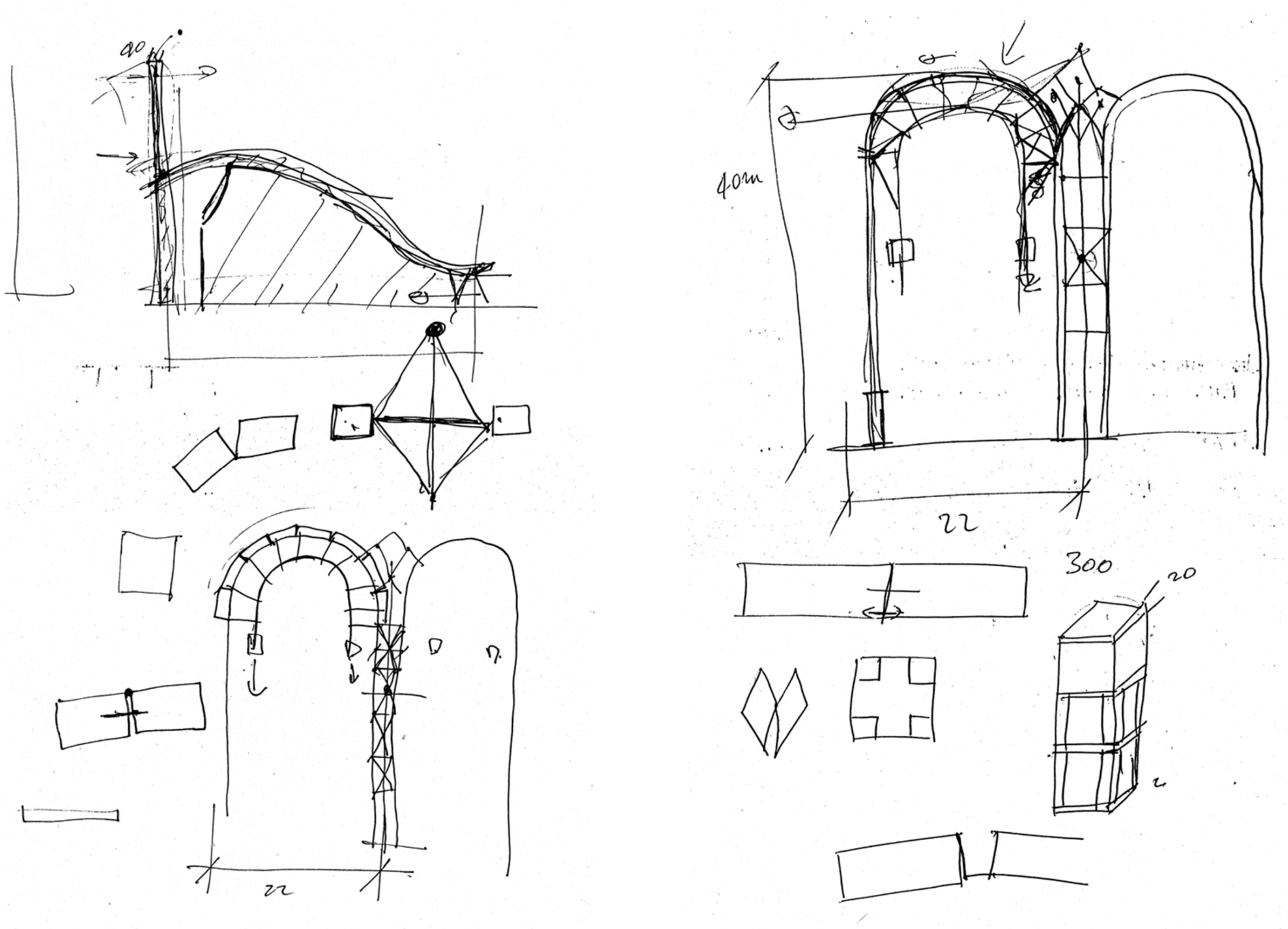
Gesamtansicht des Pavillons von hinten

General view of the Pavilion from rear

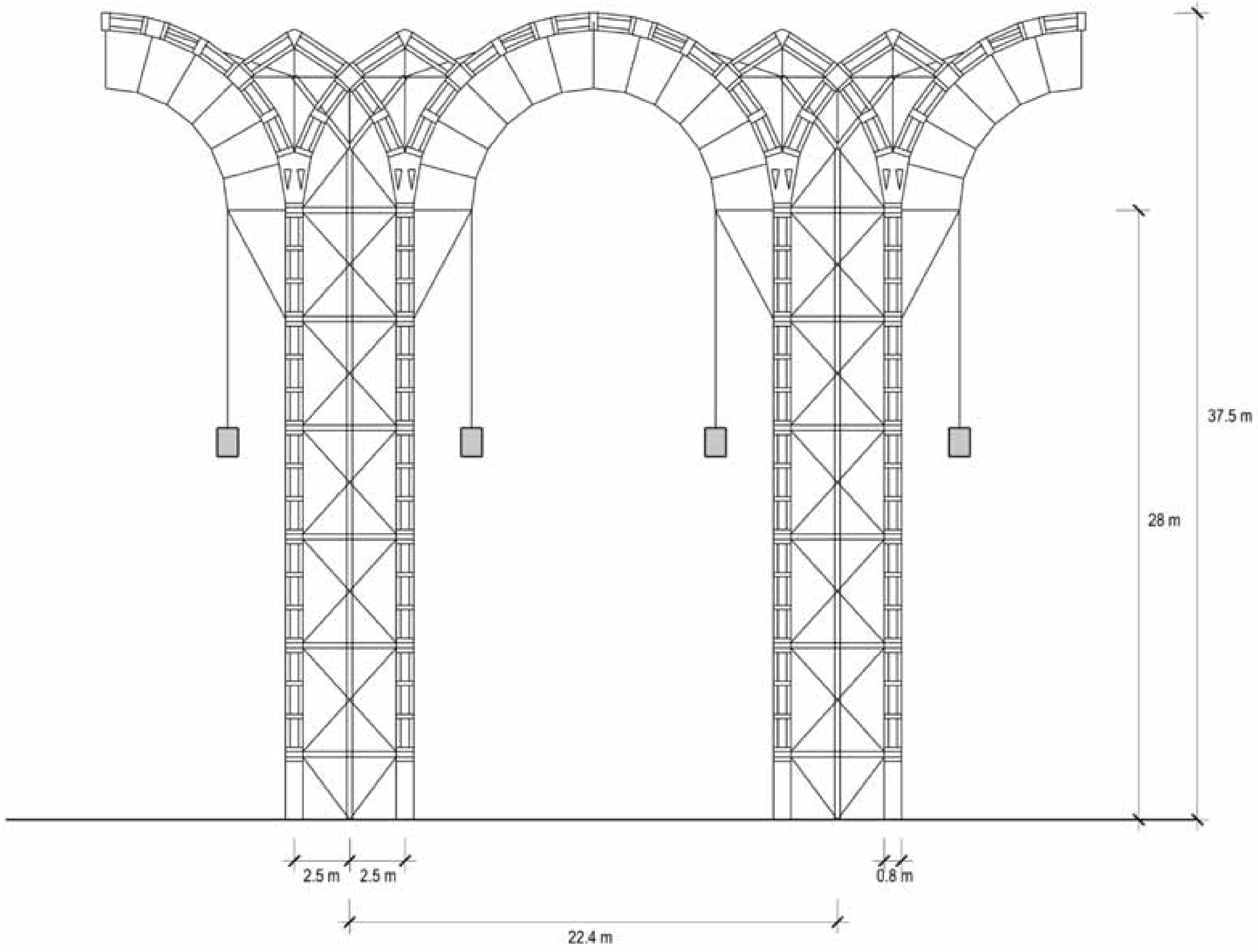


Gesamtansicht der im Bau befindlichen Fassade

General view of the façade under construction

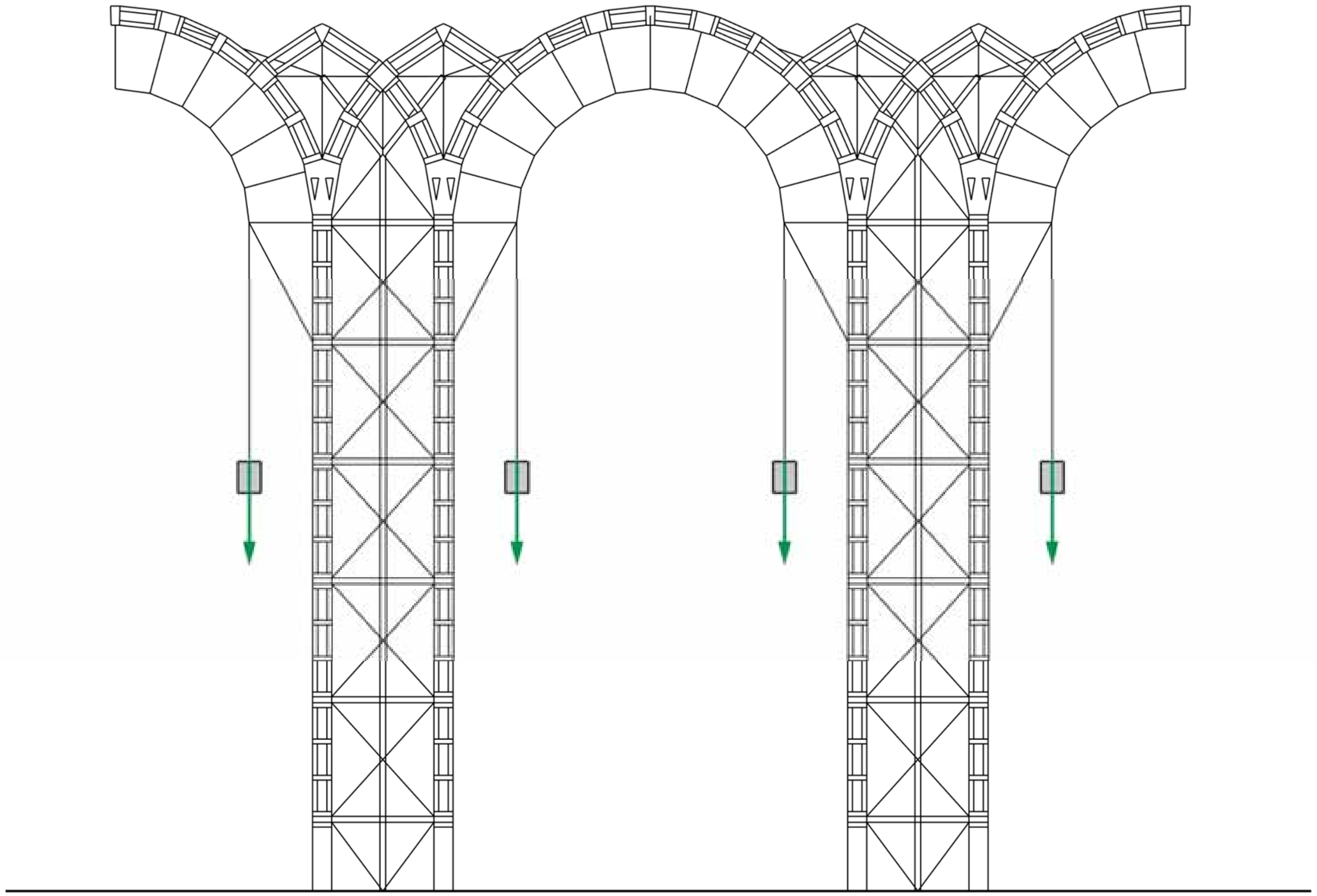


Skizzen von Peter Rice für den Pavillon
Peter Rice's sketches for the pavilion

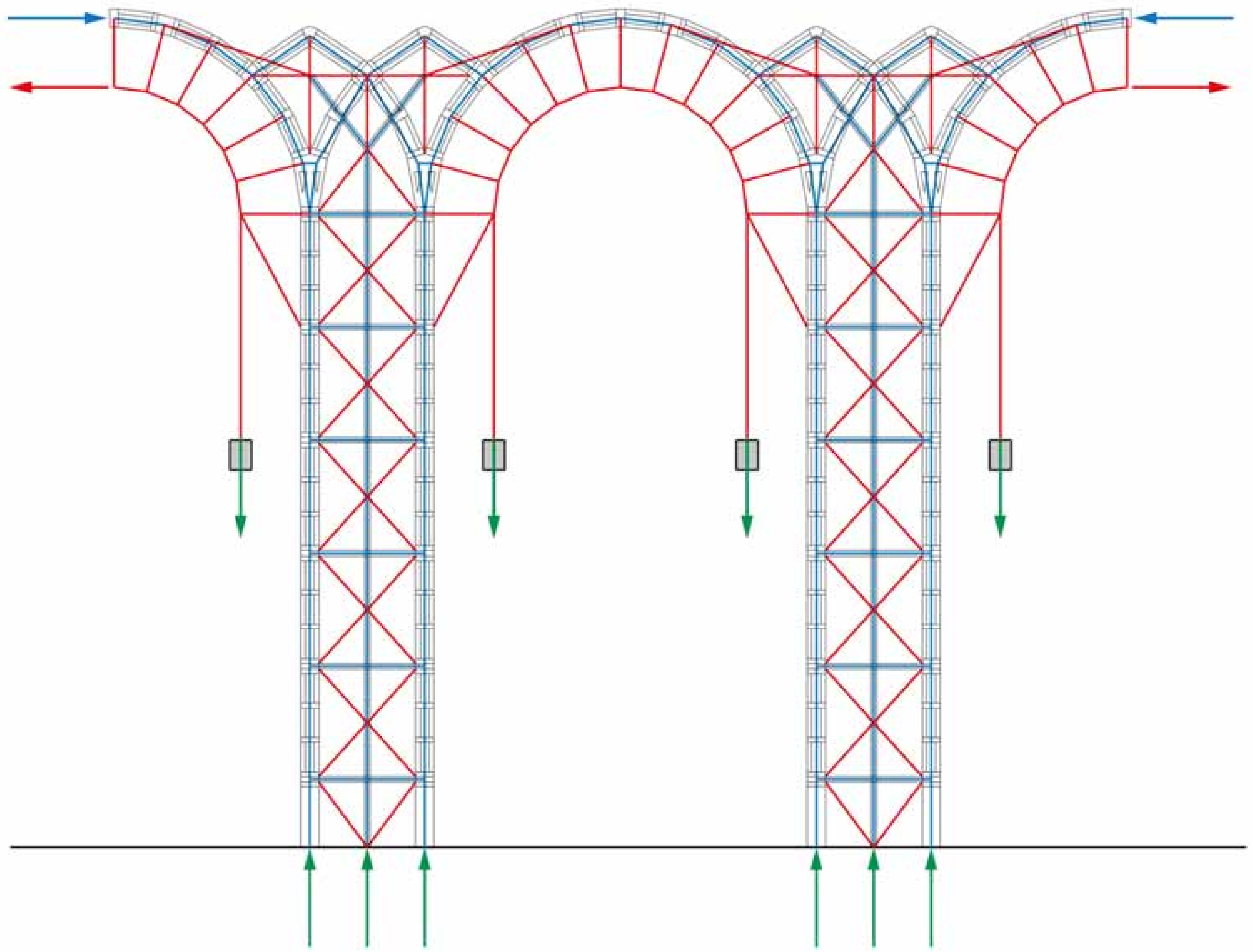


Vorderansicht eines Teils der Bogenseilkonstruktion

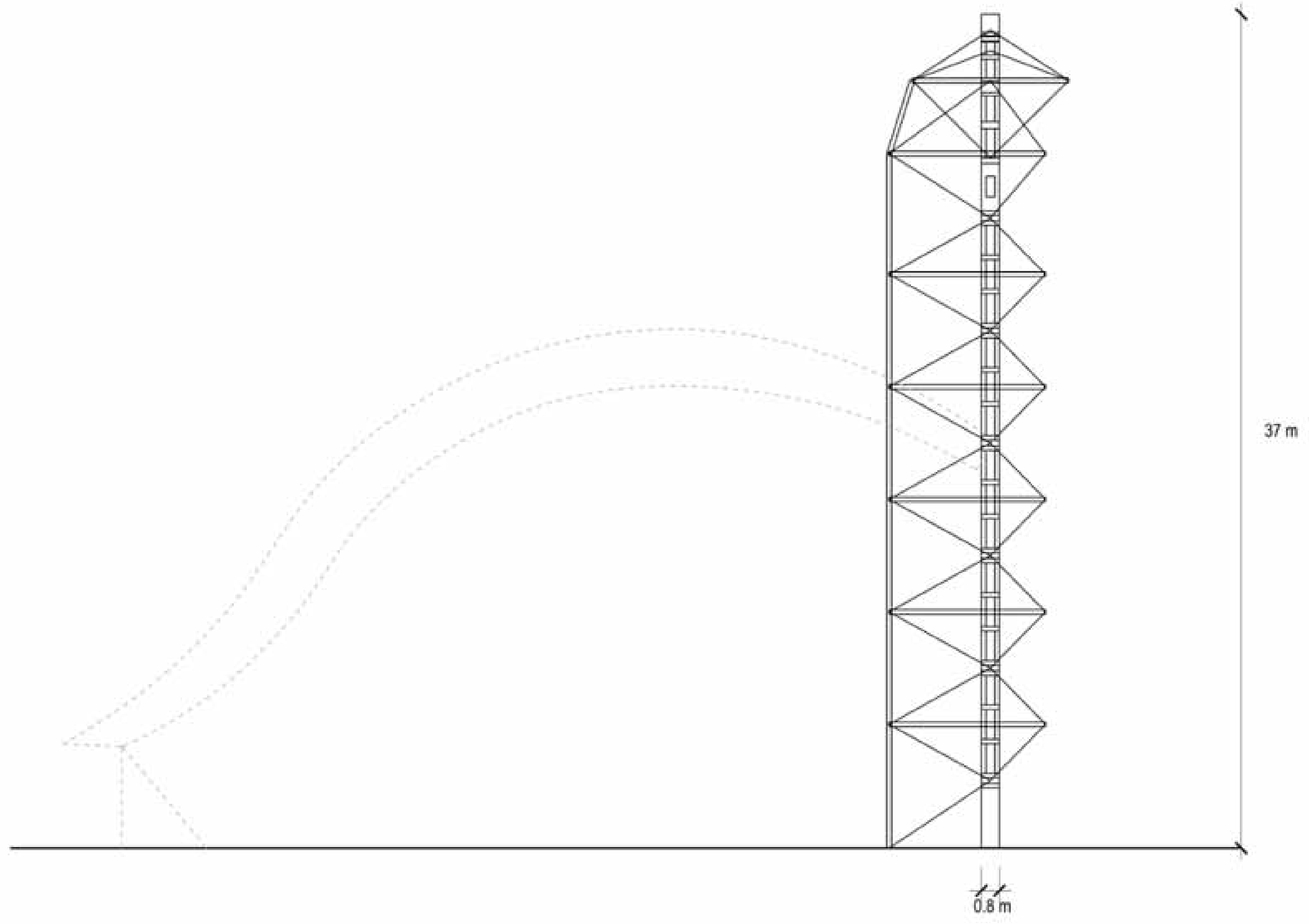
Front elevation of a portion of the arch-cable structure



Vorderansicht eines Teils der Bogenseilkonstruktion
Front elevation of a portion of the arch-cable structure

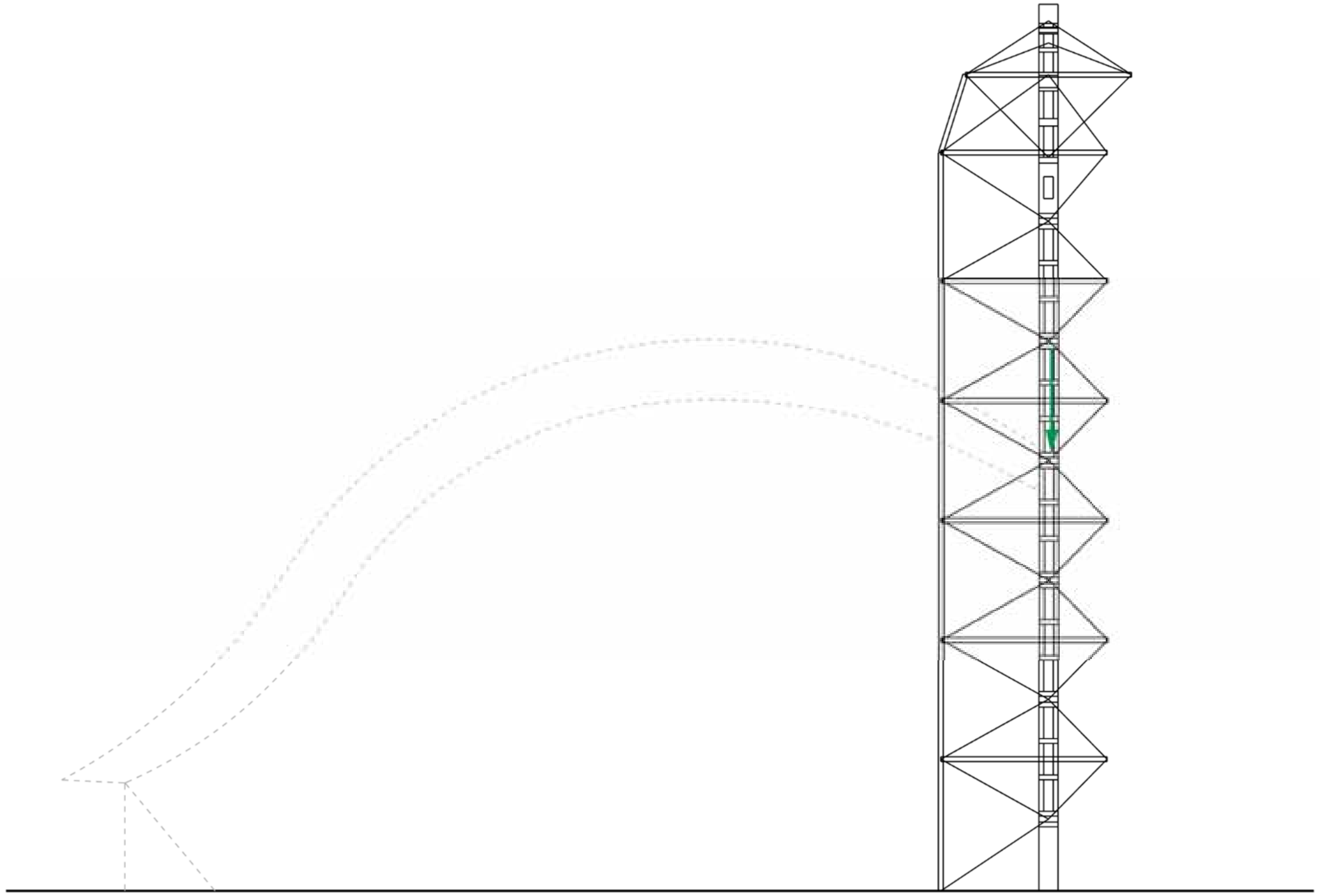


Statisches Gleichgewicht der Bogenseilkonstruktion unter dem Gewicht des hängenden Daches
Static equilibrium of the arch-cable structure under the weight of the hanging roof



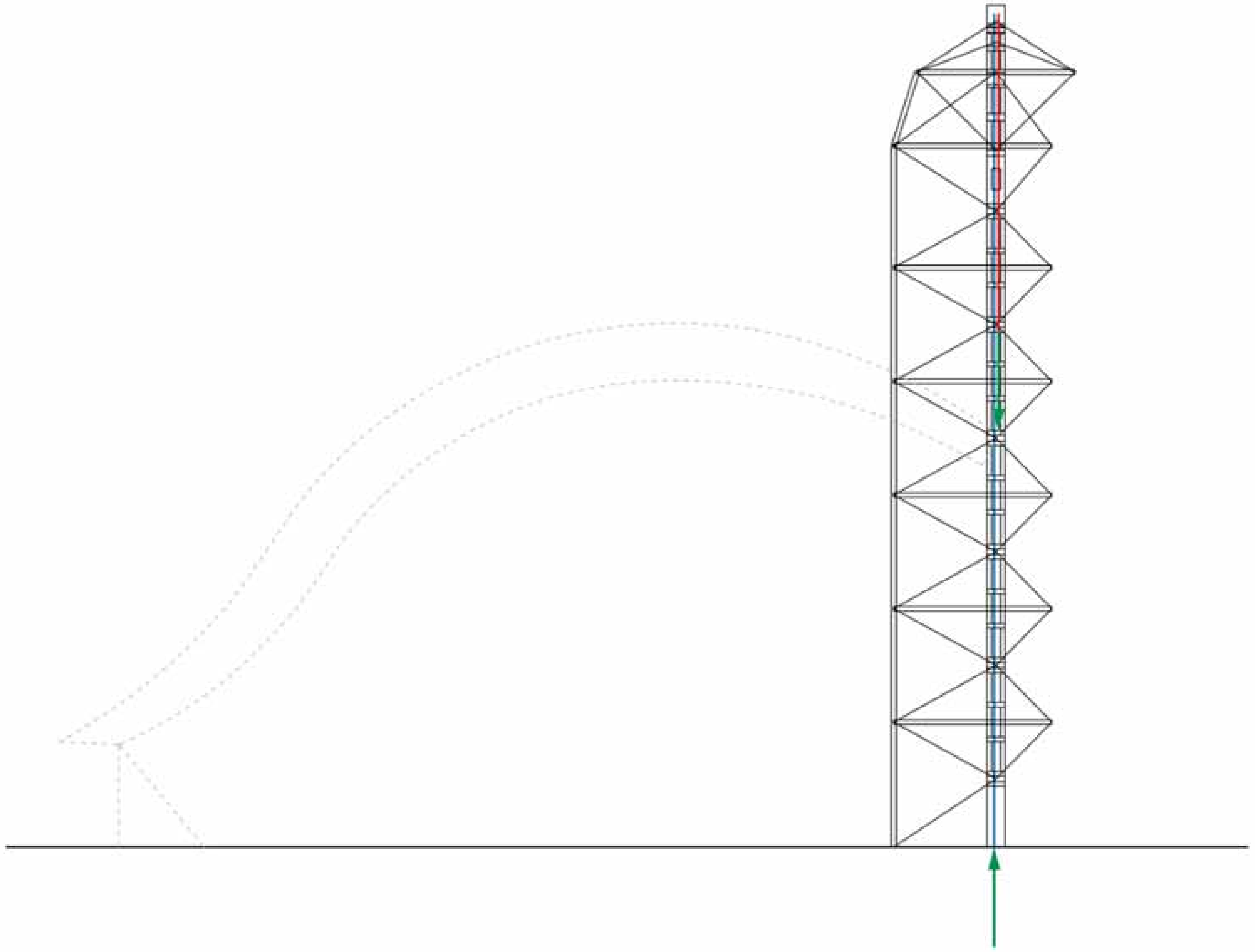
Querschnitt der Bogenseilkonstruktion

Traverse section of the arch-cable structure



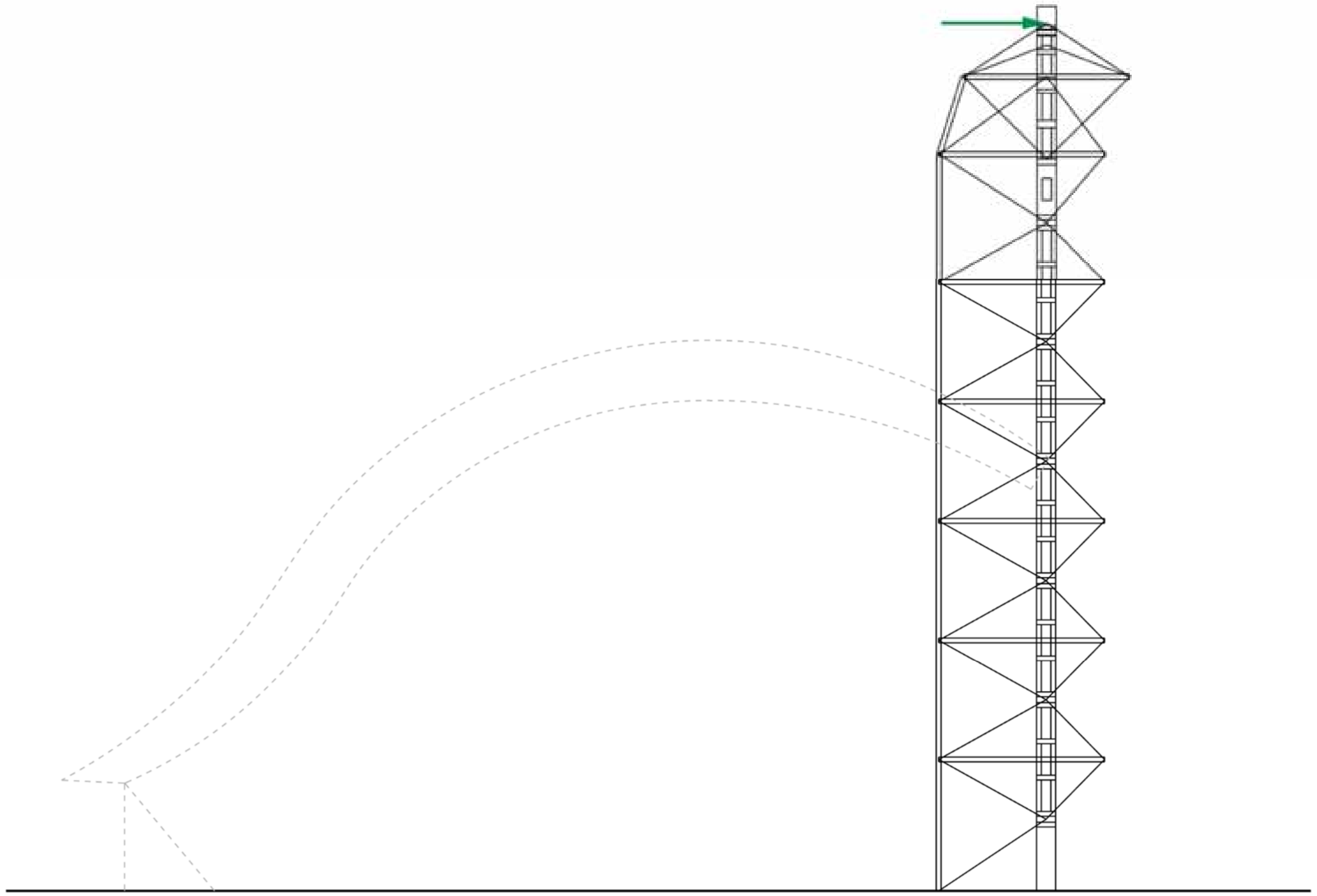
Statisches Gleichgewicht der Bogenseilkonstruktion unter dem Gewicht des Hängedachs

Static equilibrium of the arch-cable structure under the weigh of the hanging roof



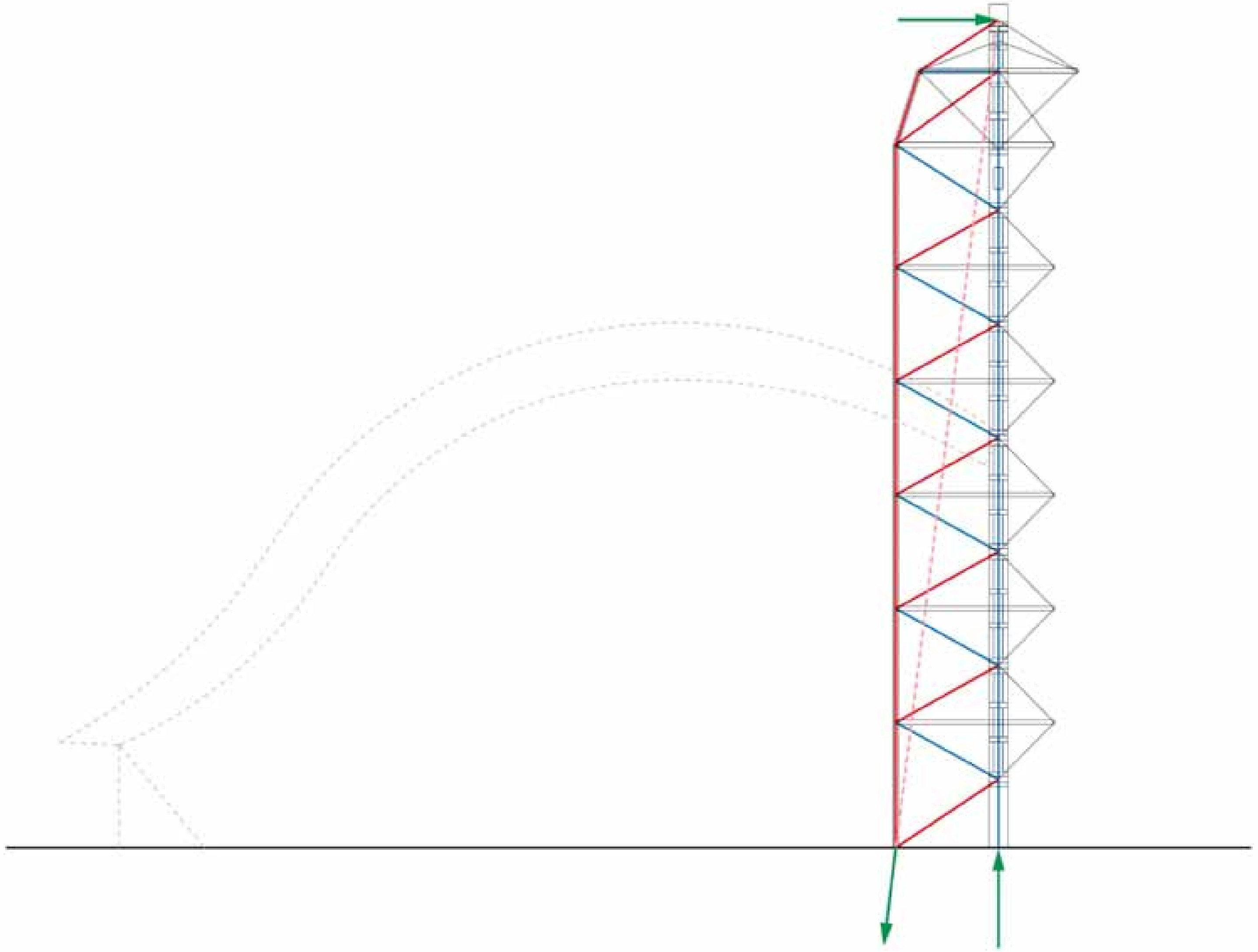
Statisches Gleichgewicht der Bogenseilkonstruktion unter dem Gewicht des Hängedachs

Static equilibrium of the arch-cable structure under the weigh of the hanging roof

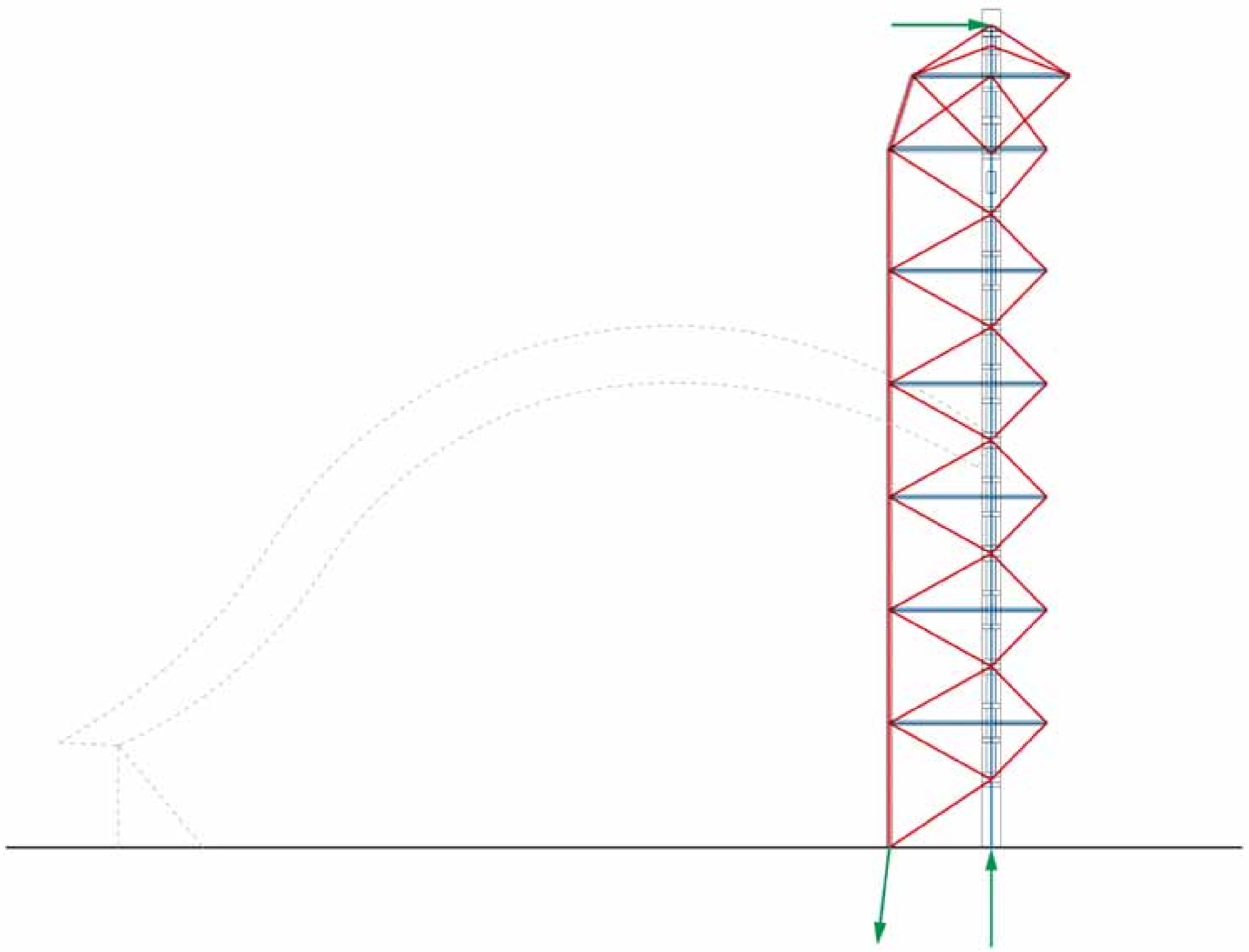


Statisches Gleichgewicht der Bogenseilkonstruktion horizontalen Einwirkungen

Static equilibrium of the arch-cable structure under lateral forces

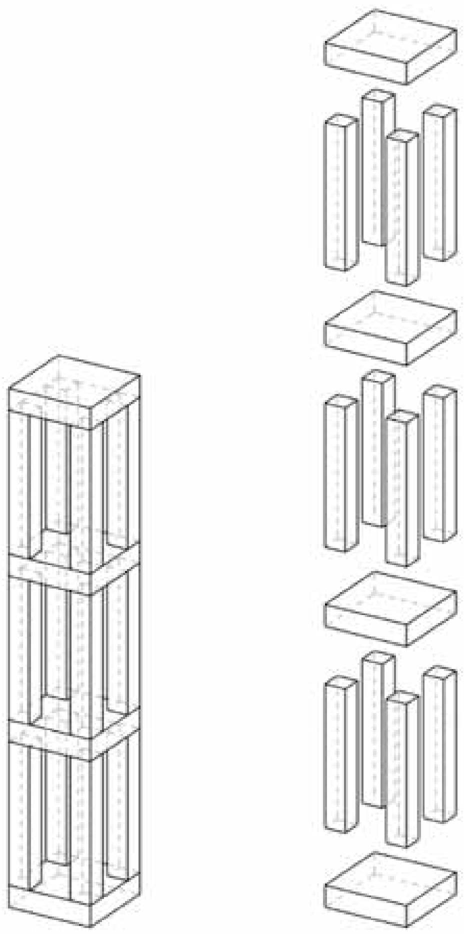


Statisches Gleichgewicht der Bogenseilkonstruktion unter horizontalen Einwirkungen
Static equilibrium of the arch-cable structure under lateral forces



Statisches Gleichgewicht der Bogenseilkonstruktion unter horizontalen Einwirkungen

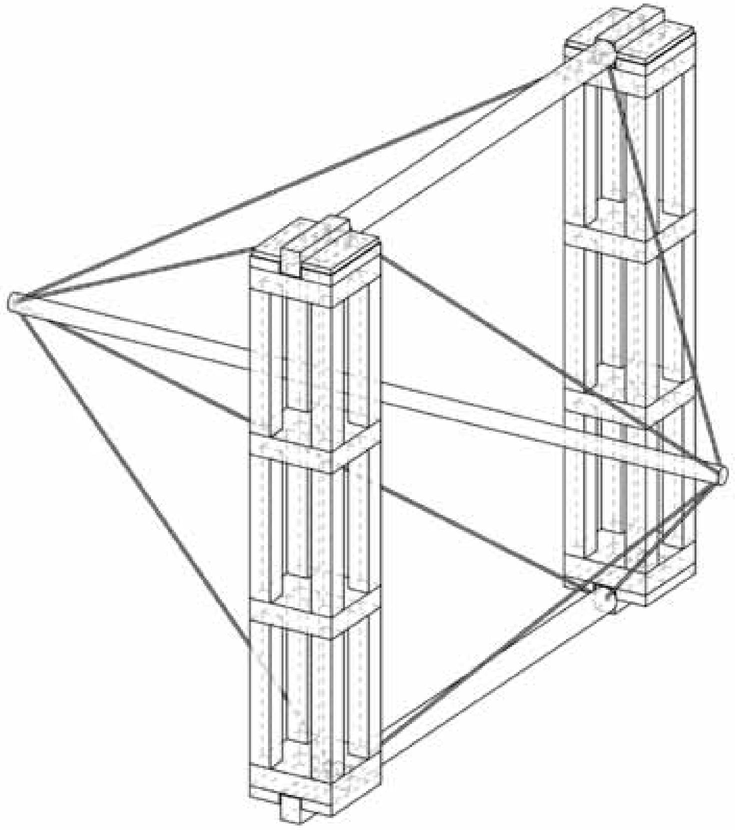
Static equilibrium of the arch-cable structure under lateral forces

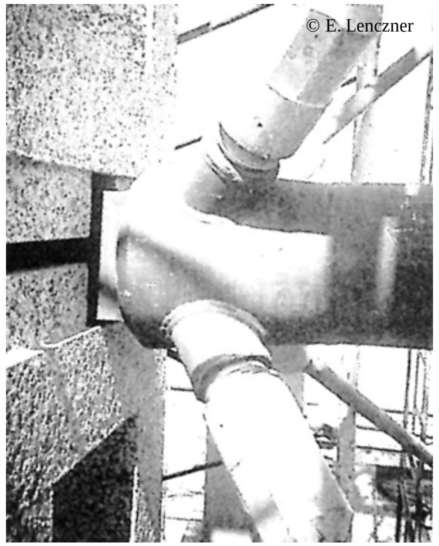


© Bruce Danzigger

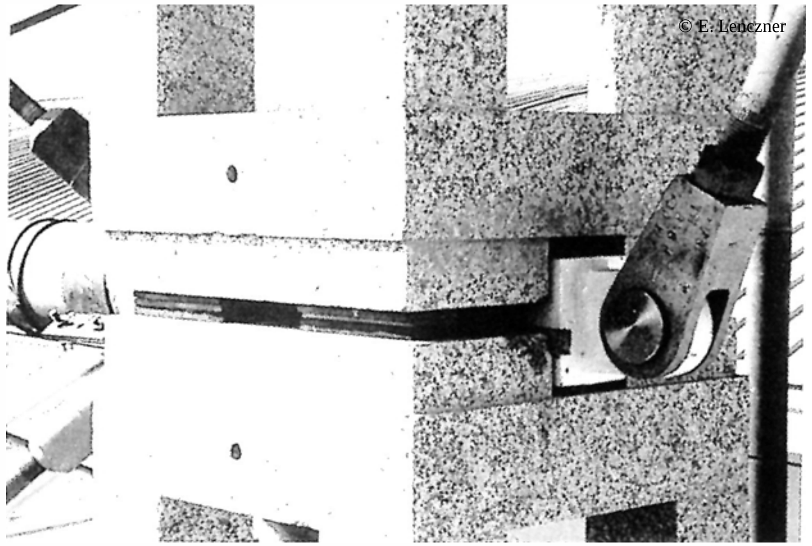
Steinsäuleneinheiten

Stone column units





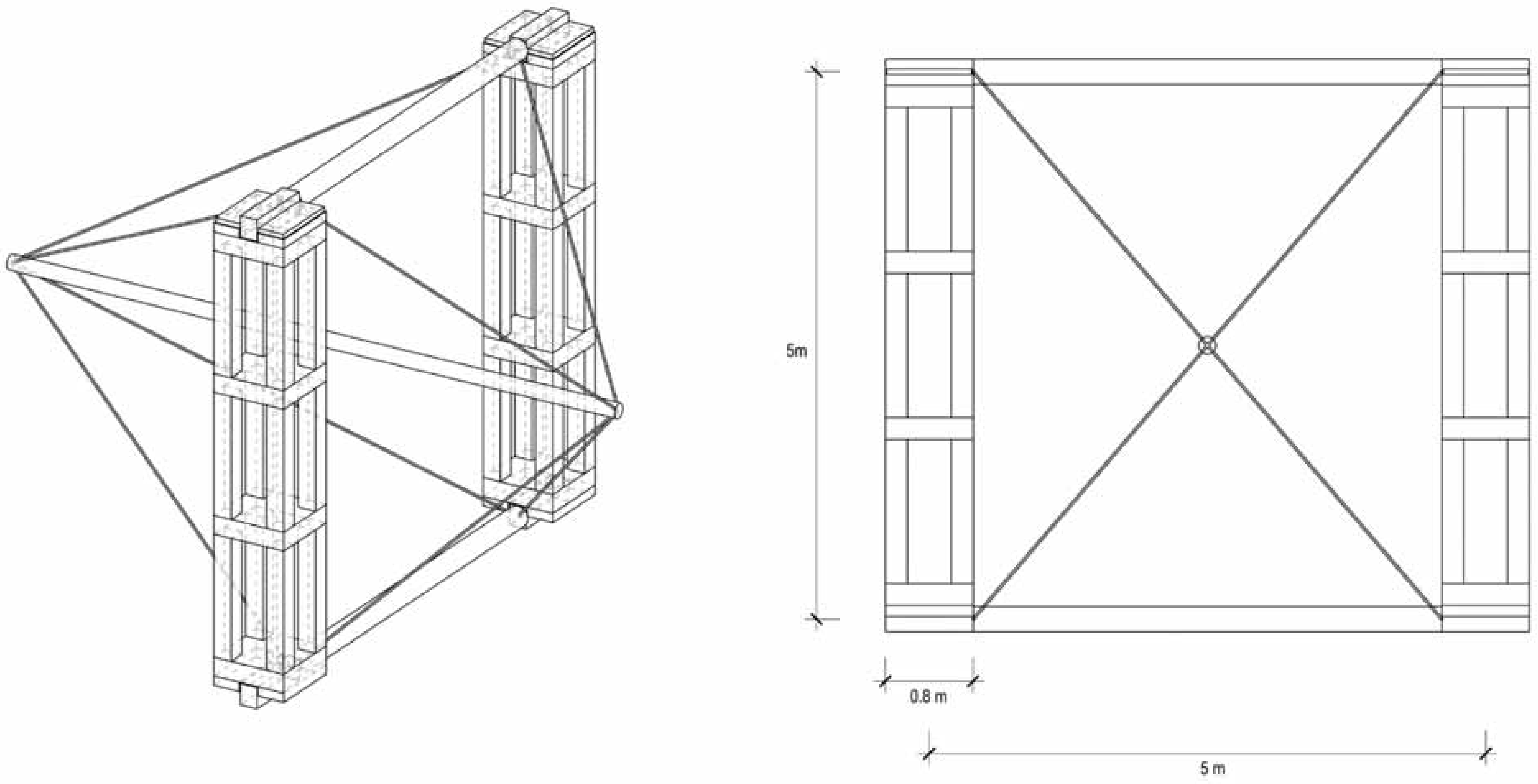
© E. Lenczner



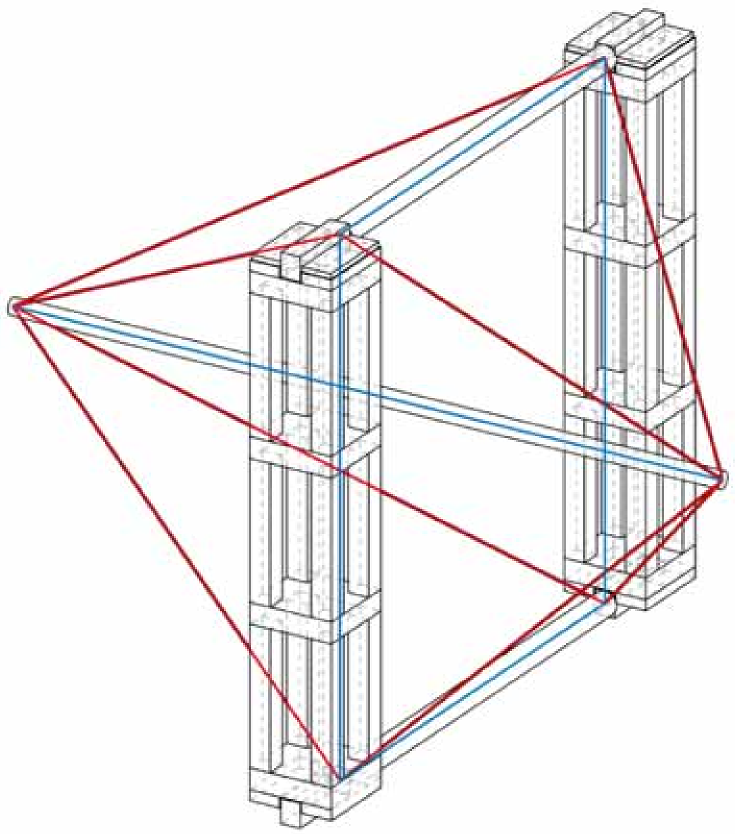
© E. Lenczner

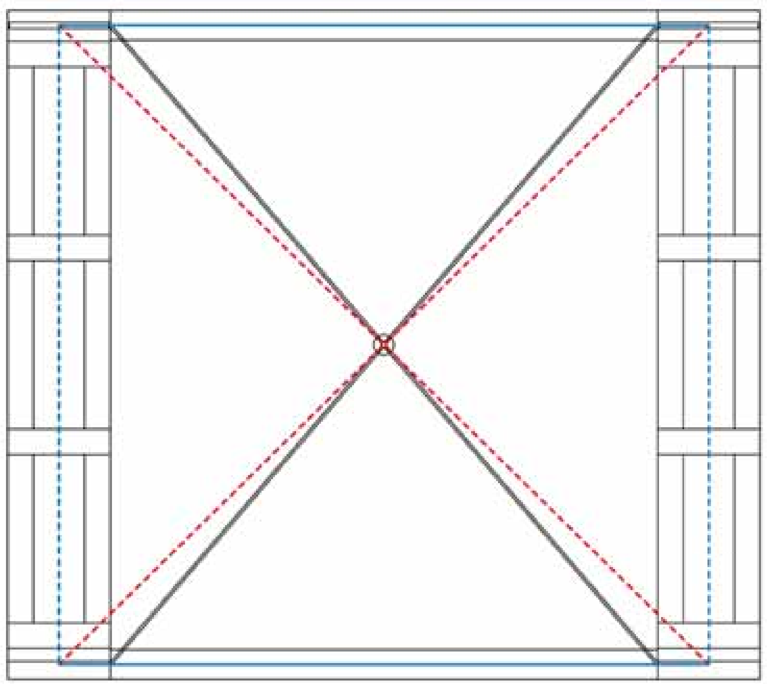
Turm-Modul

Tower module

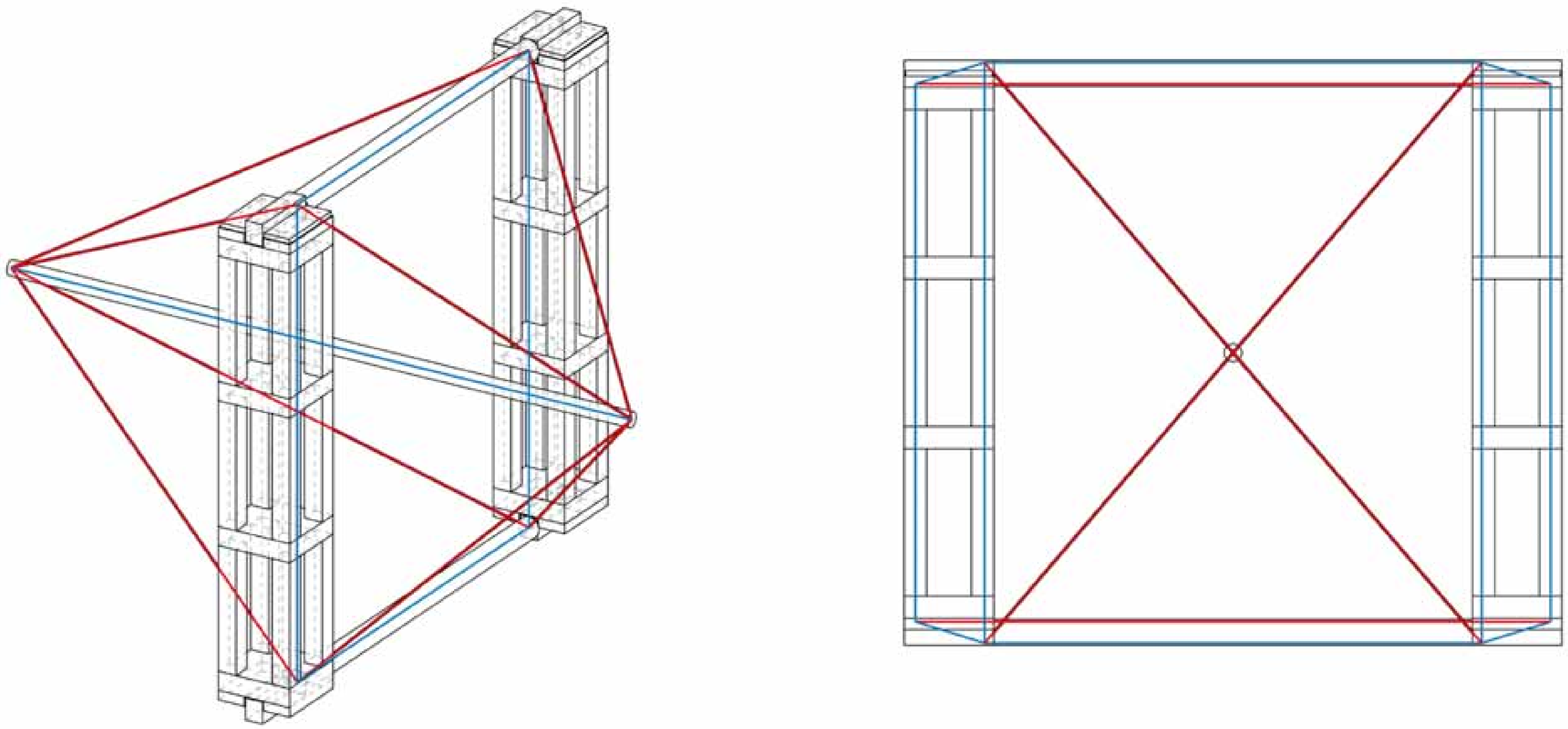


Turm-Modul
Tower module





Turm-Modul
Tower module



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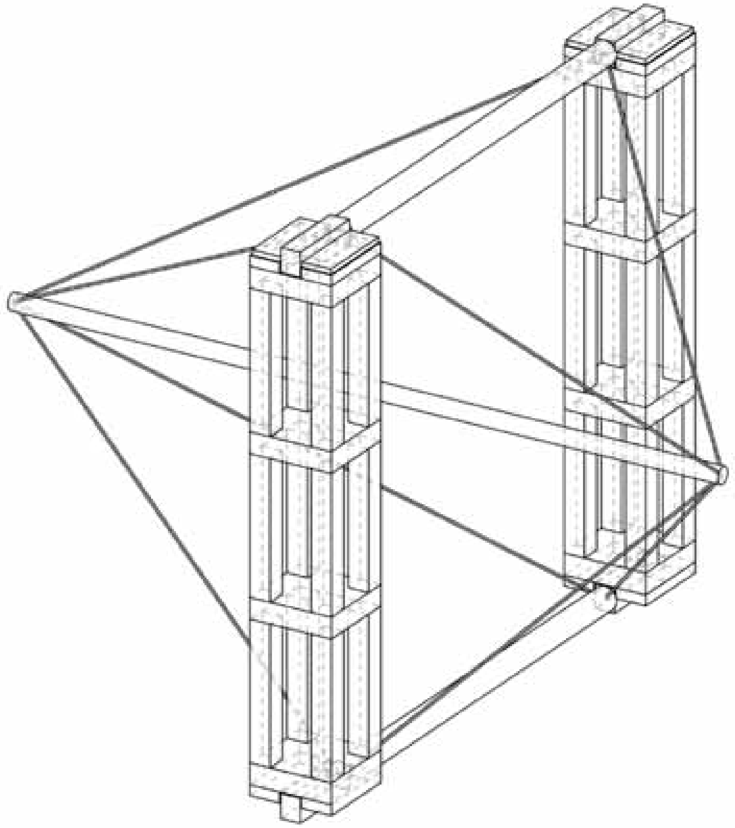
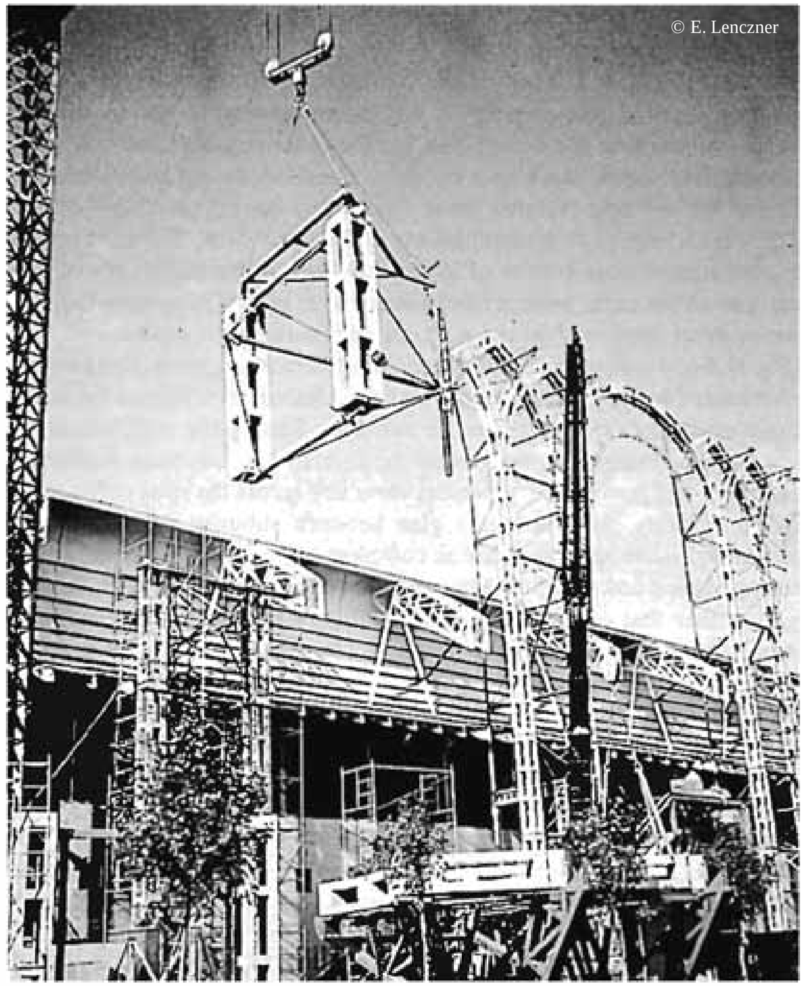
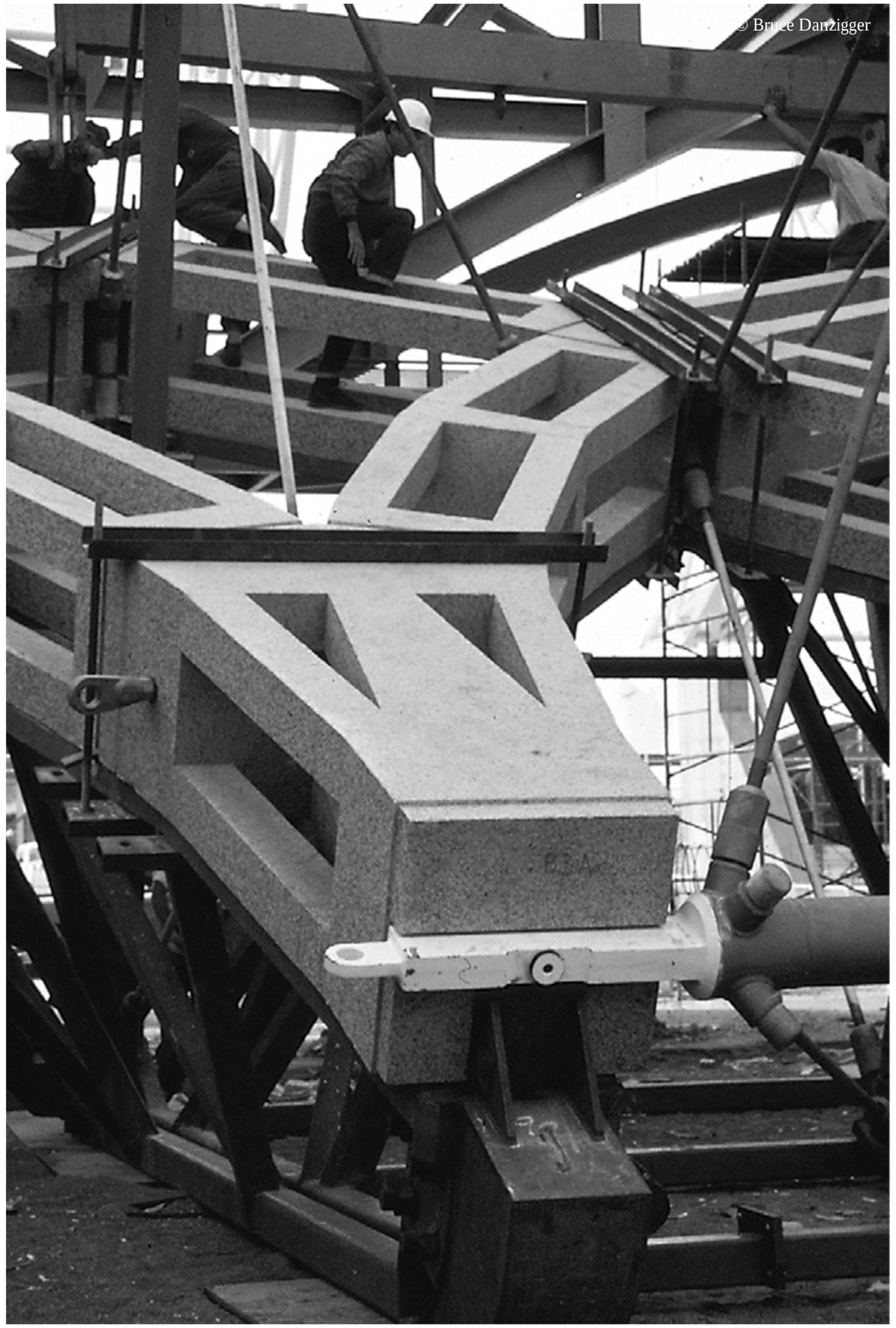
Tower module





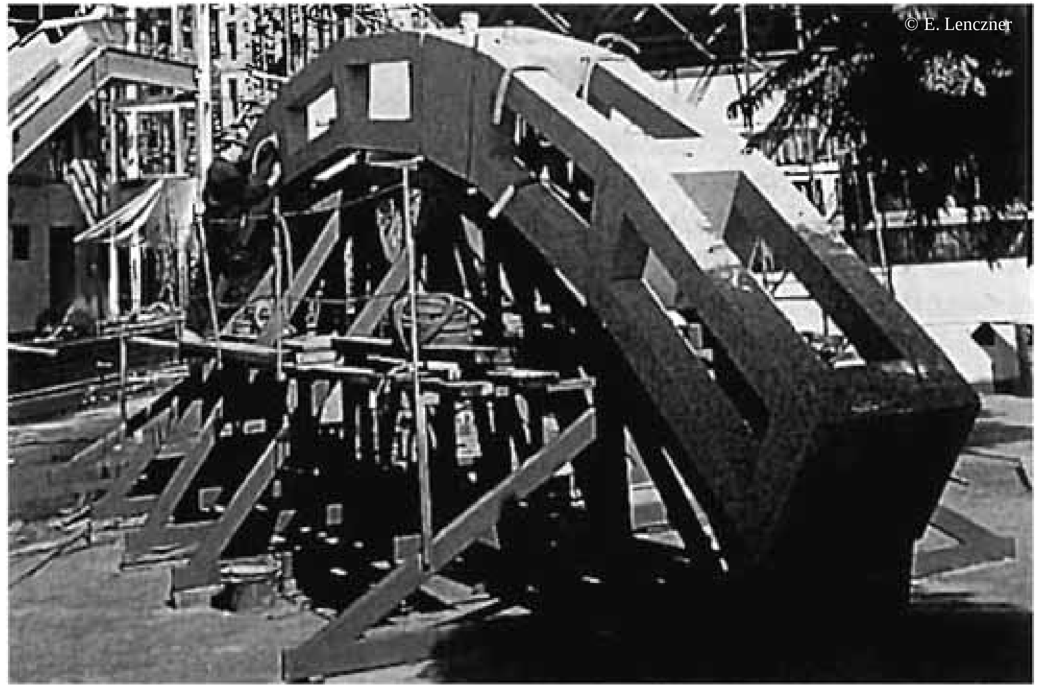
Turm-Modul

Tower module



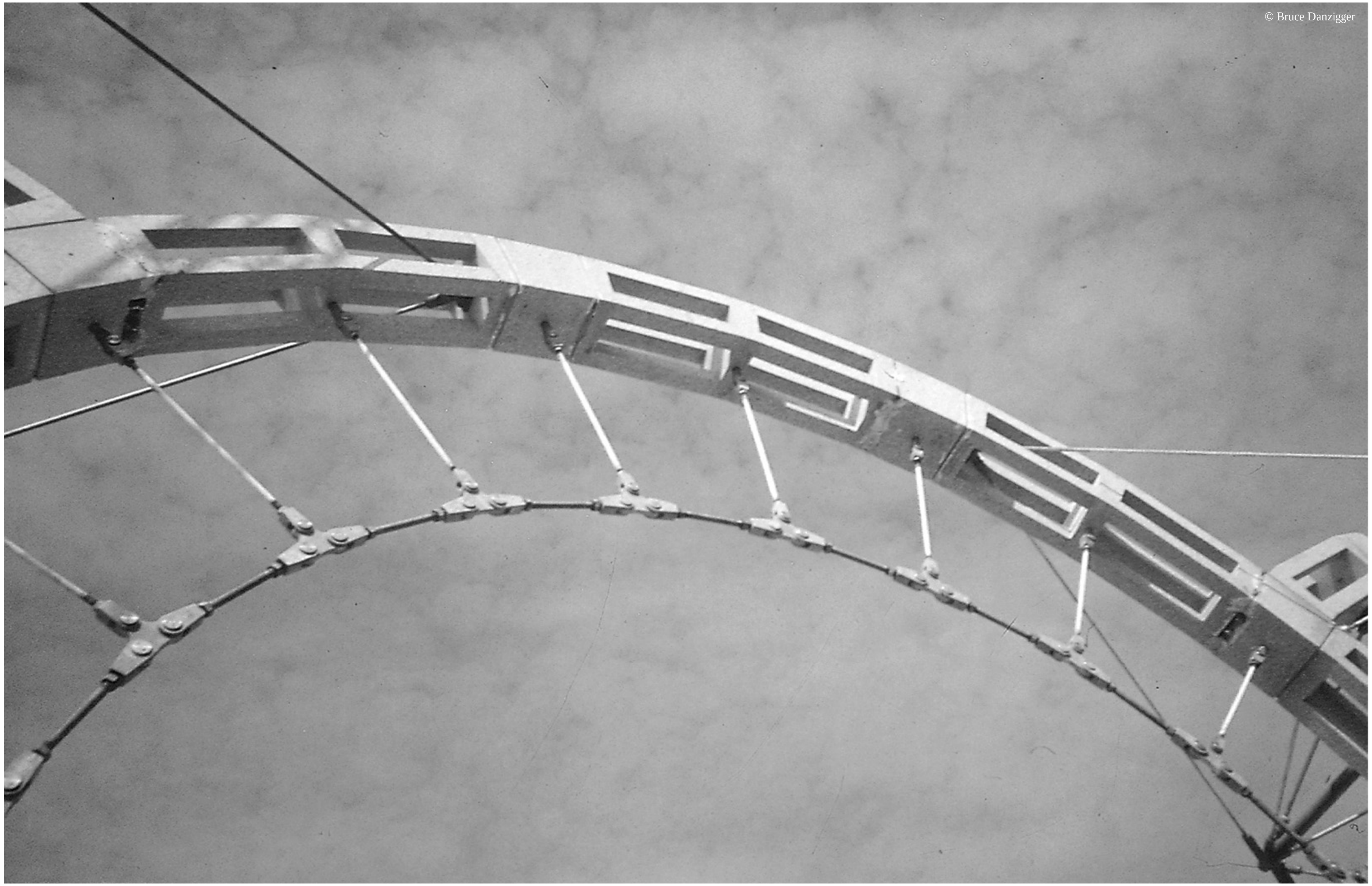
Module zwischen den Säulenmodulen und Bögen

Modules between the column-modules and arches



Steinbogen vor dem Einheben und Bogen und Verankerungssystem vor dem Spannen des verankerten Innenrings

Stone arch prior to being hoisted and arch and tie system before tensioning of the tied inner ring

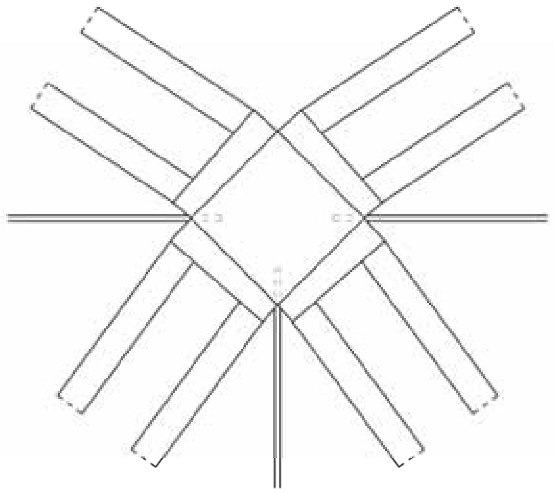


Steinbogen und Spannring

Stone arch and tension ring

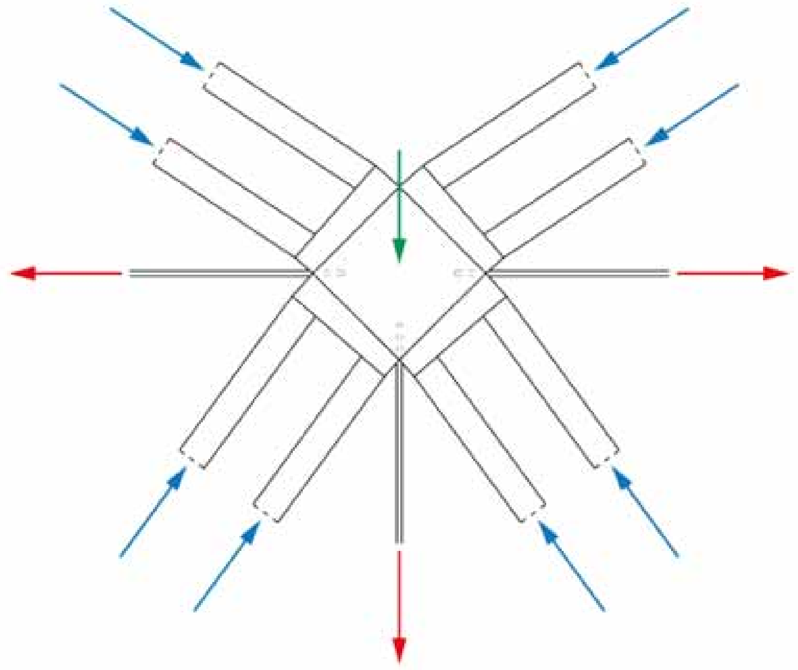
Steinbogen und Spannring

Stone arch and tension ring



Details der Spannstahlseilverbindungen mit den Steinblöcken des Bogens

Details of prestressing steel cables connections to stone blocks within arch



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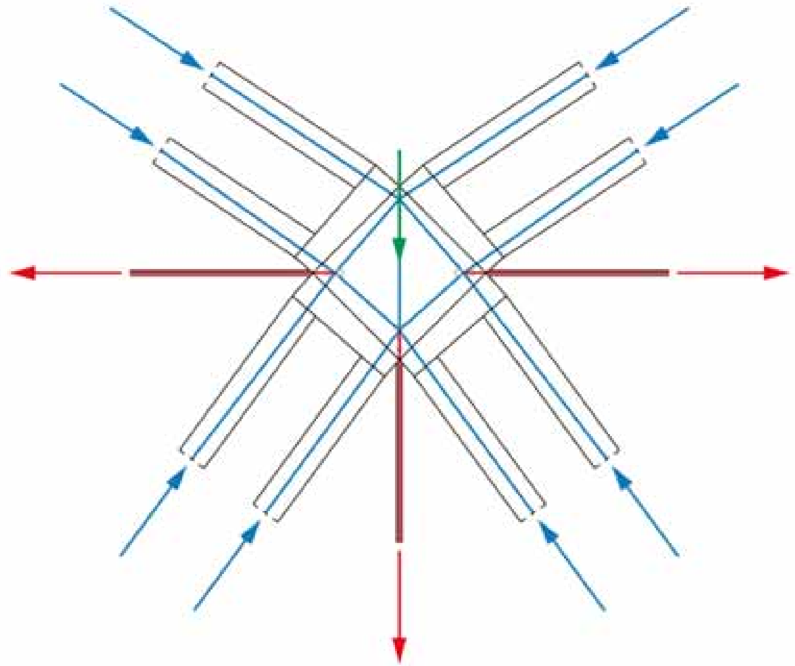

Details der Spannstahlseilverbindungen mit den Steinblöcken des Bogens

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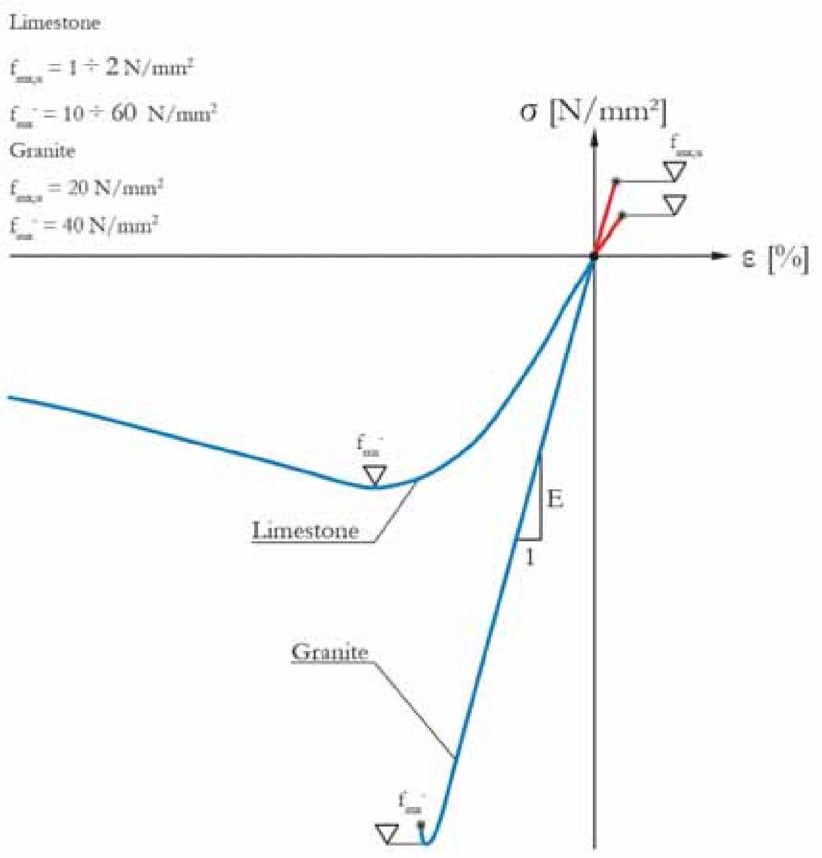
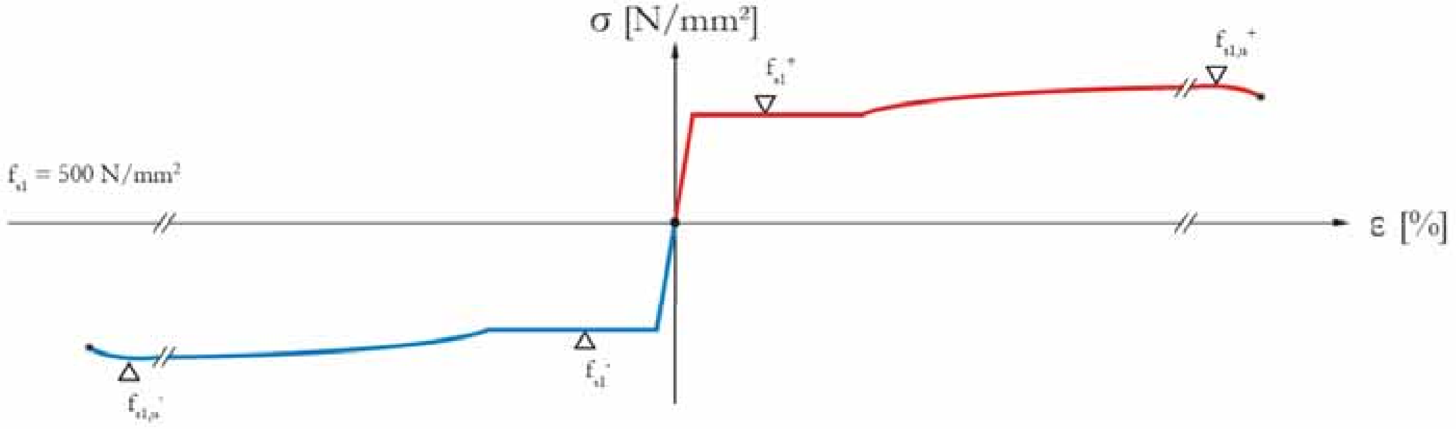


Mauerwerk (Kalkstein und Granit), Spannungs-Dehnungs-Diagramm

Masonry (limestone and granite), stress-strain diagram



Stahl, Spannungs-Dehnungs-Diagramm

Steel, stress-strain diagram

Fertige Bögen mit an Hängern aufgehängten Dachbalken
Completed arches with roof beams suspended from hangers

Konstruktionsdetails
Construction details

Seiltragwerke
Cable structures

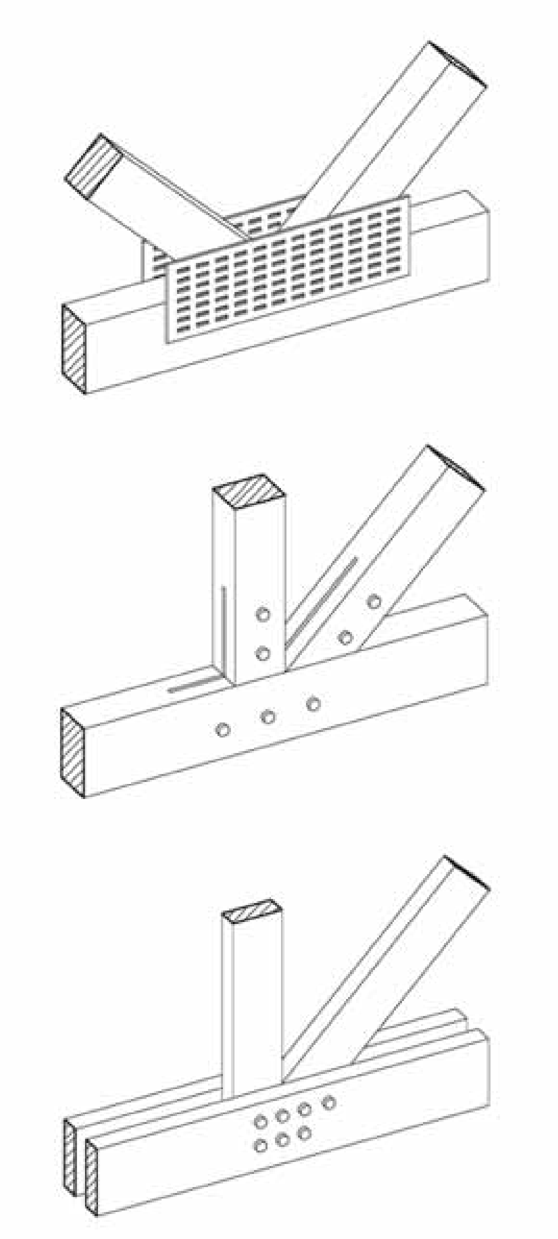
Bogenkonstruktionen
Arch structures

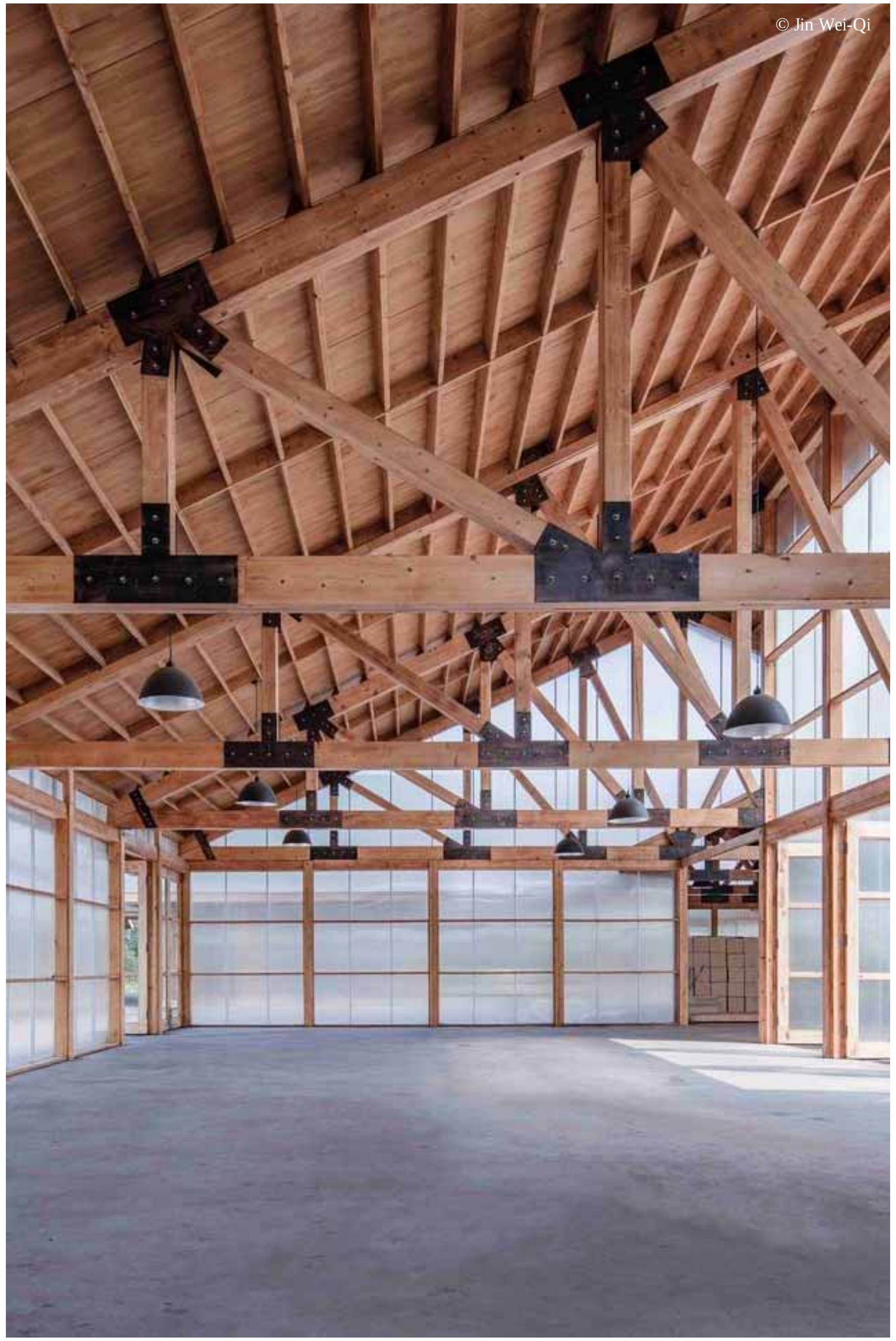
Bogenseilkonstruktionen
Arch-cable structures

>> Fachwerkstrukturen
Trusses

Balken
Beams

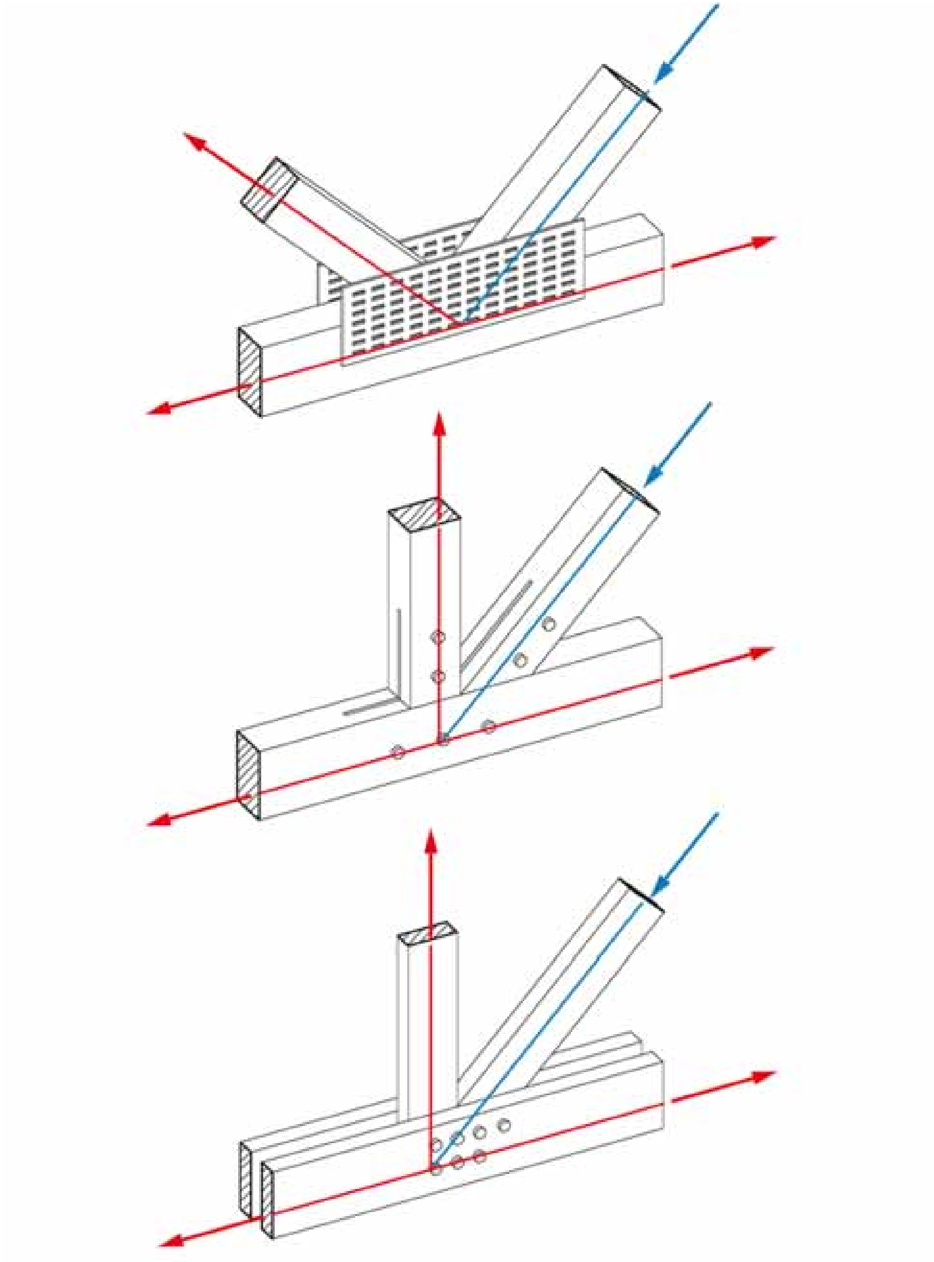
Rahmen
Frames

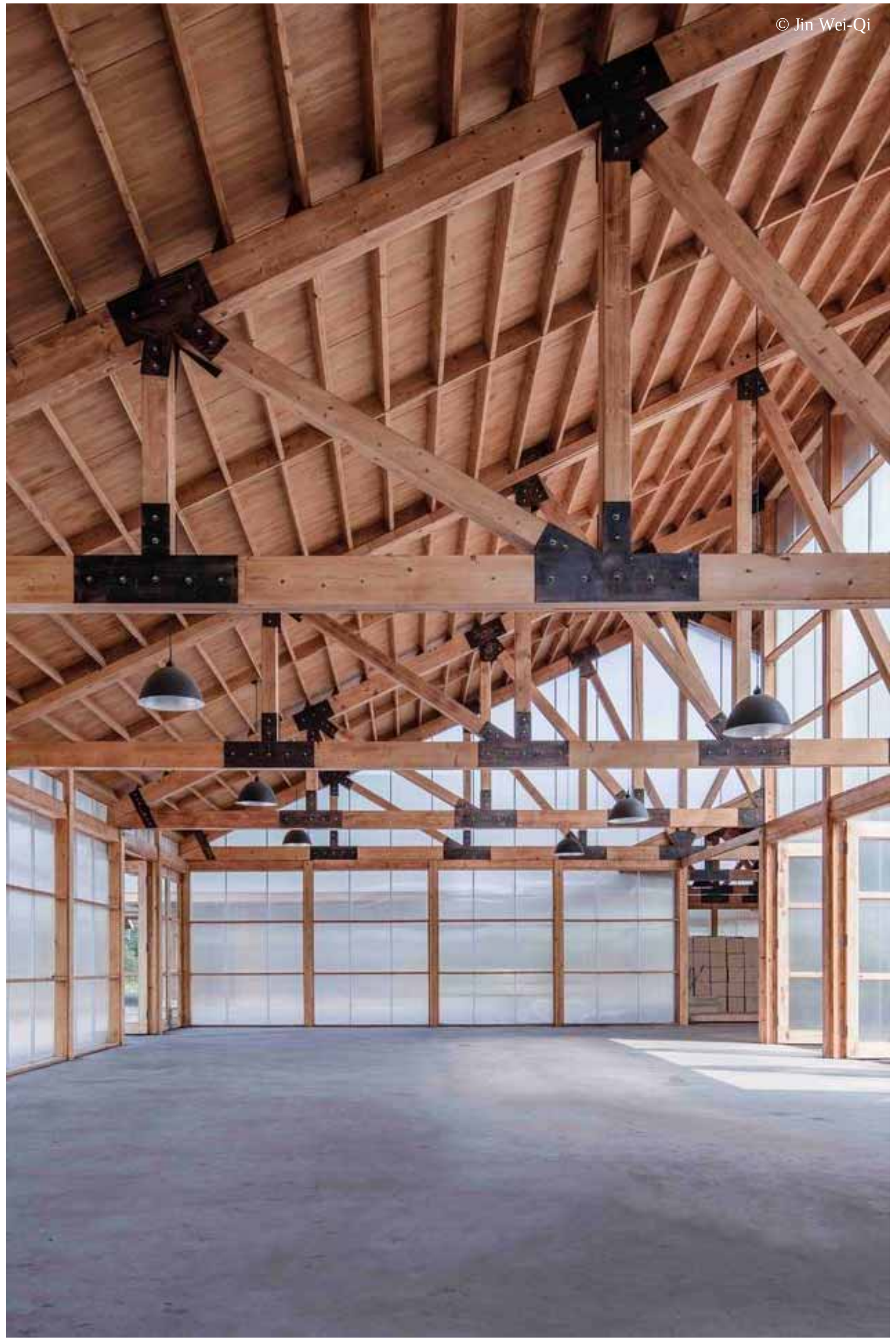




Beispiele für 2D-Fachwerkverbindungen im Holzbau

Examples of 2D trusses joints in timber construction





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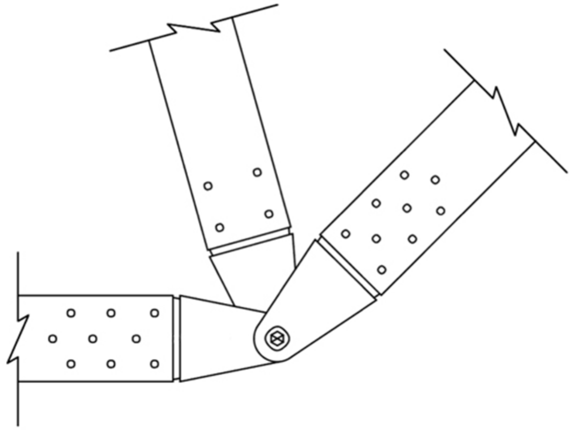

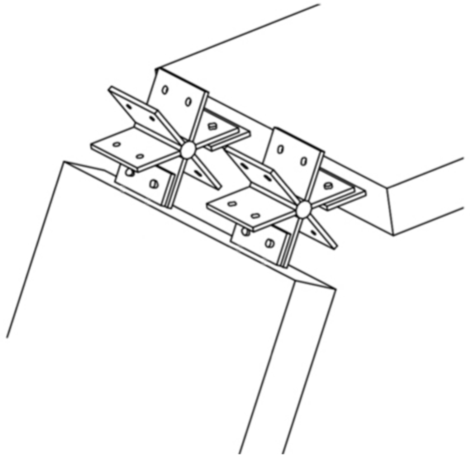

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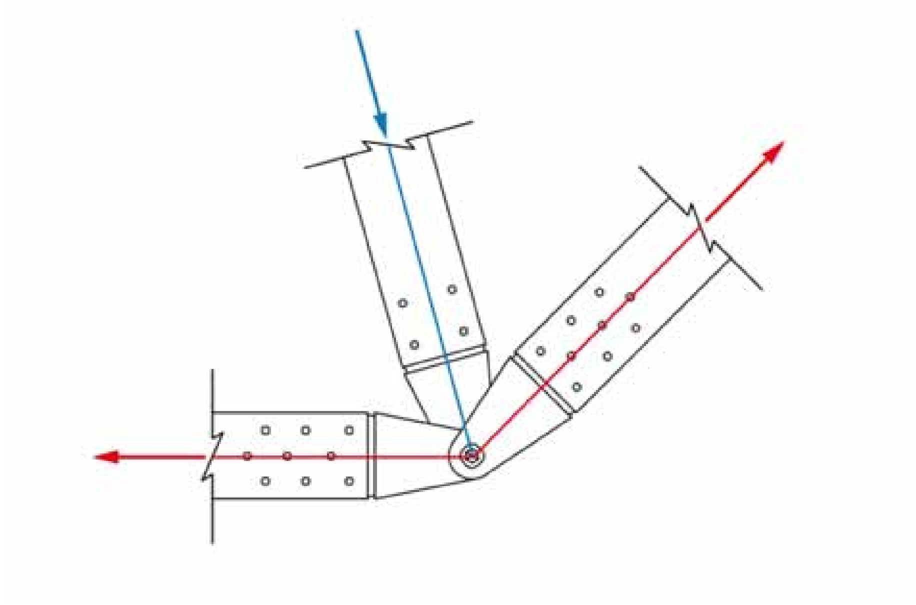
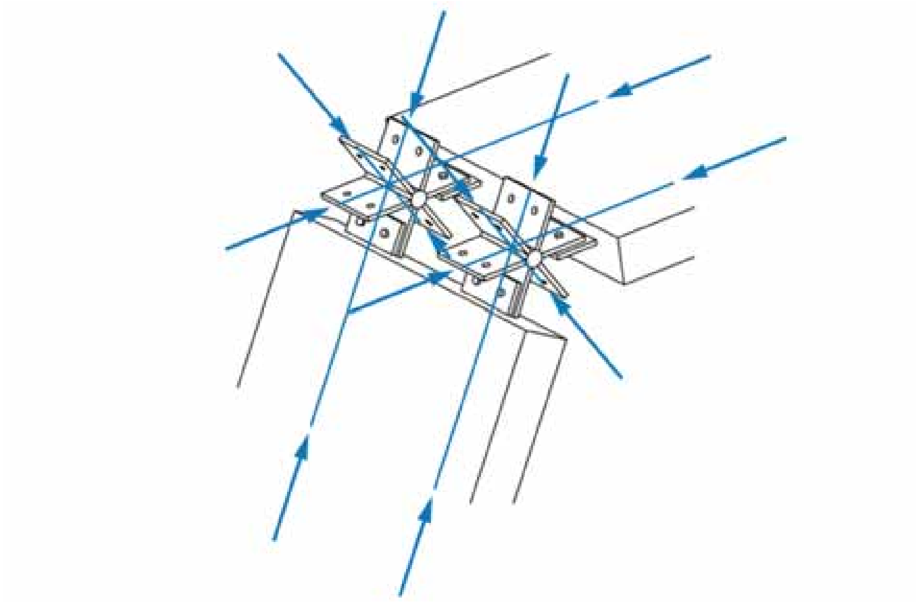
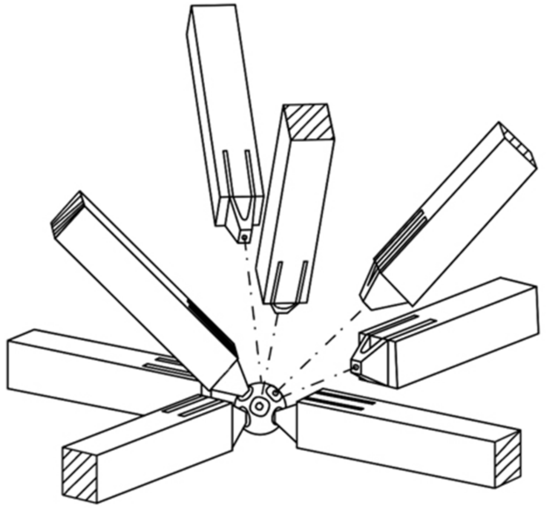




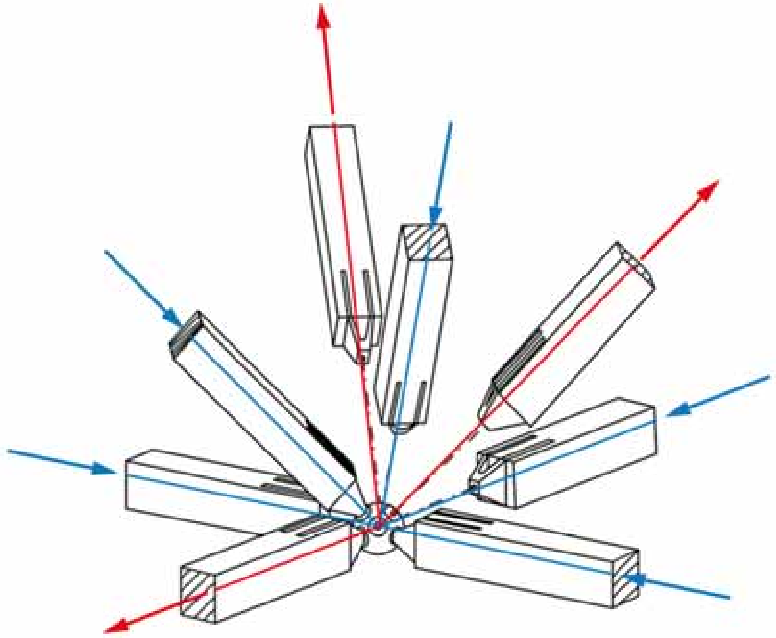
Beispiele für 2D-Fachwerkverbindungen im Holzbau

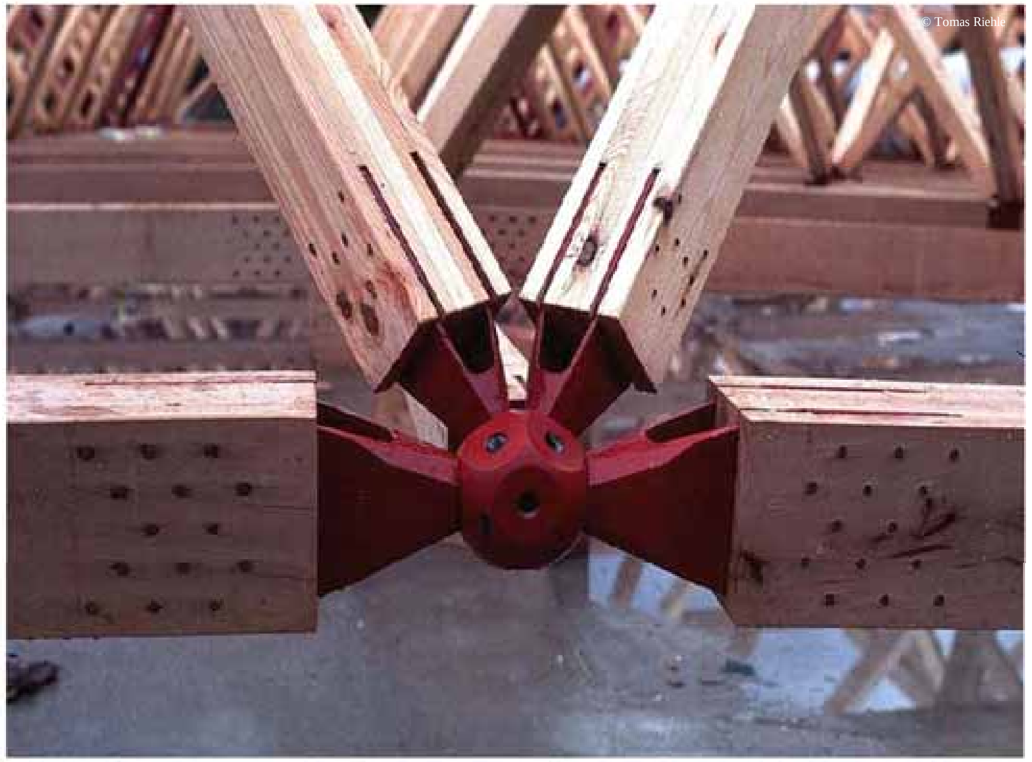
Examples of 2D trusses joints in timber construction



Beispiele für 3D-Fachwerkverbindungen im Holzbau (Christ König Kirche, Wuppertal, 1960, Arch. Joachim Schürmann)

Examples of 3D trusses joints in timber construction (Christ König Kirche, Wuppertal, 1960, arch. Joachim Schürmann)





Beispiele für 3D-Fachwerkverbindungen im Holzbau

Examples of 3D trusses joints in timber construction

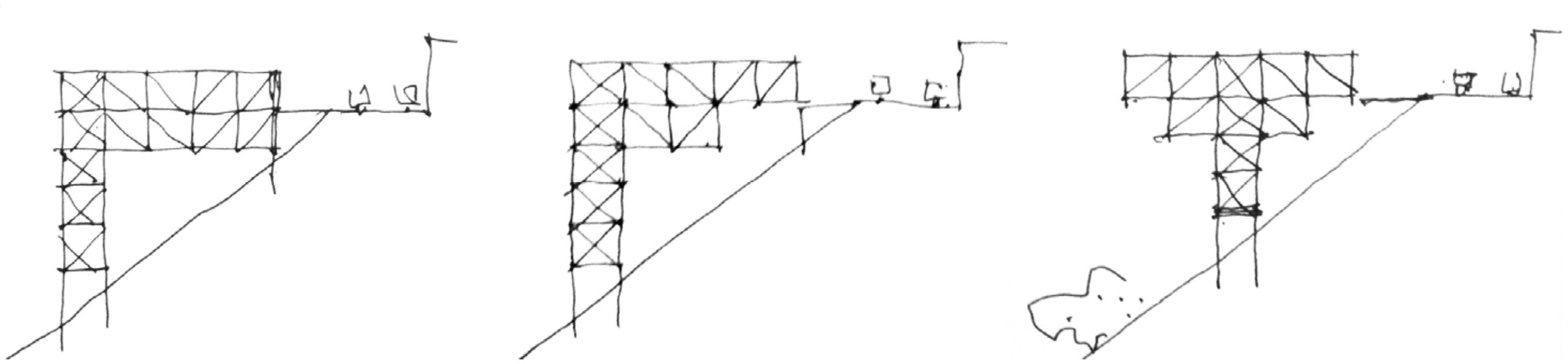
Hélio Olga's House

São Paulo, 1990

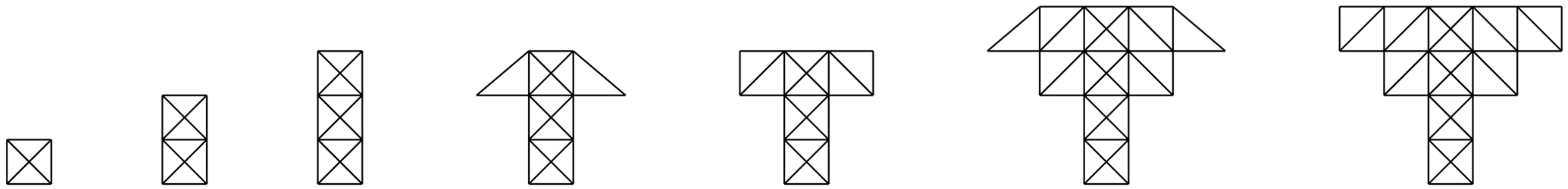
Architect: Marcos Acayaba

Engineer: Hélio Olga

Allgemeine Ansicht des Hauses
General view of the house

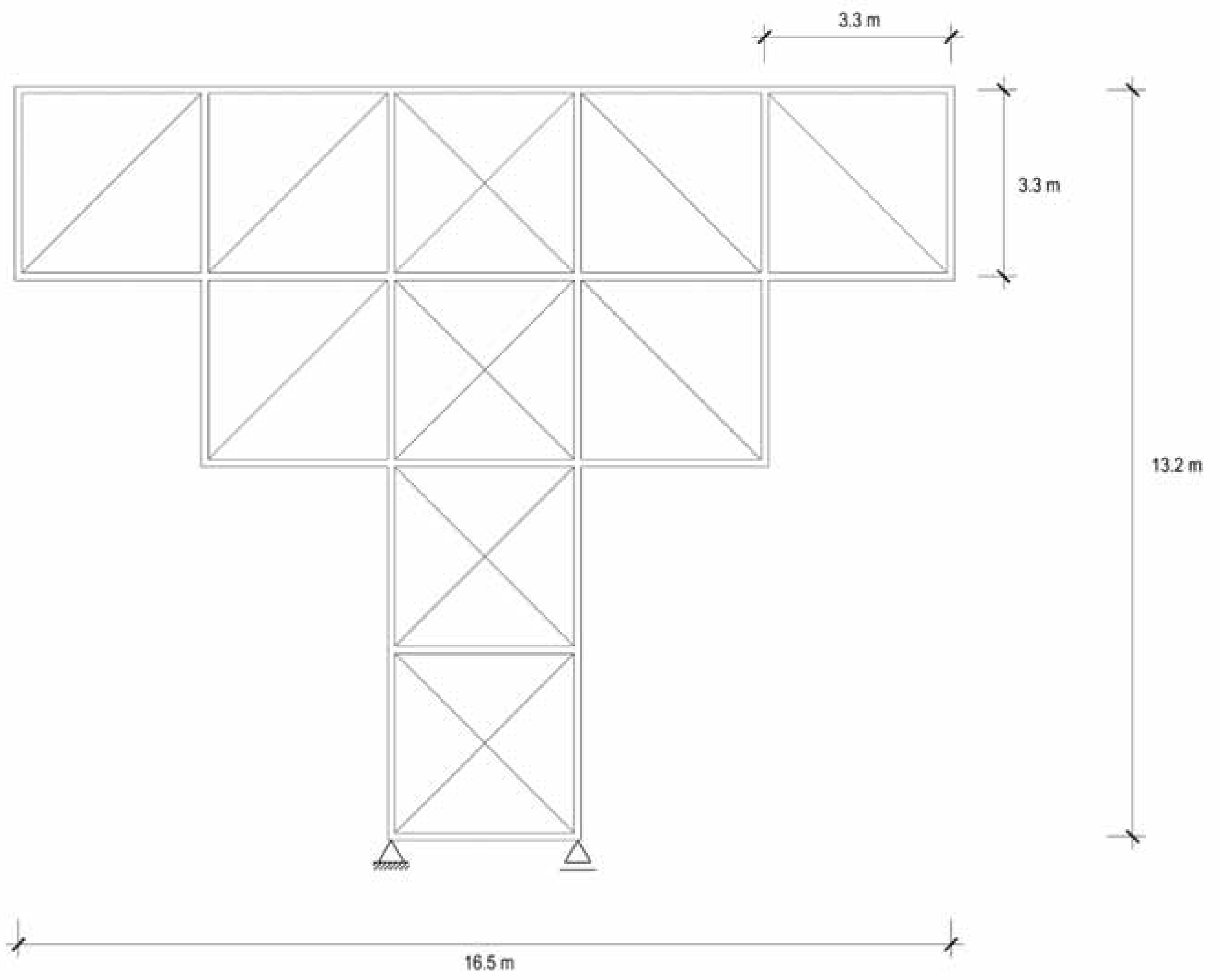


Entwurfsskizzen
Design sketches

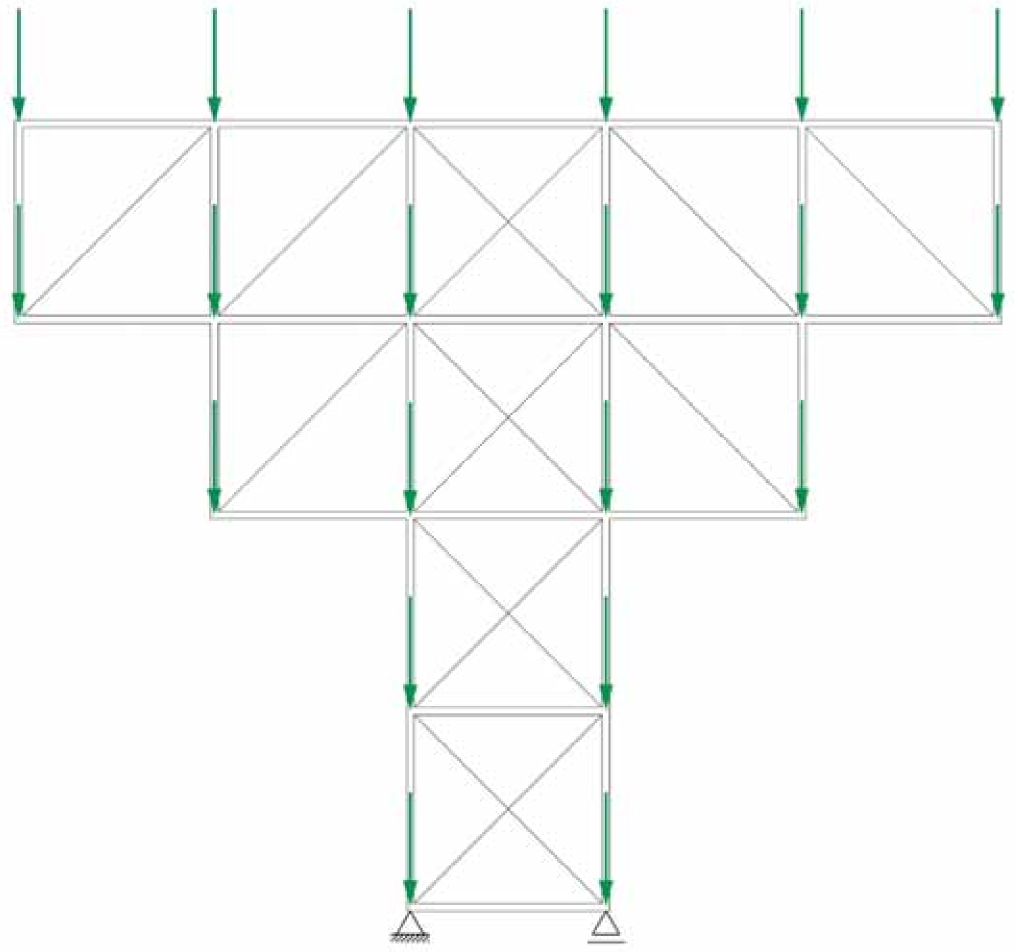


Bauprozess
Construction process

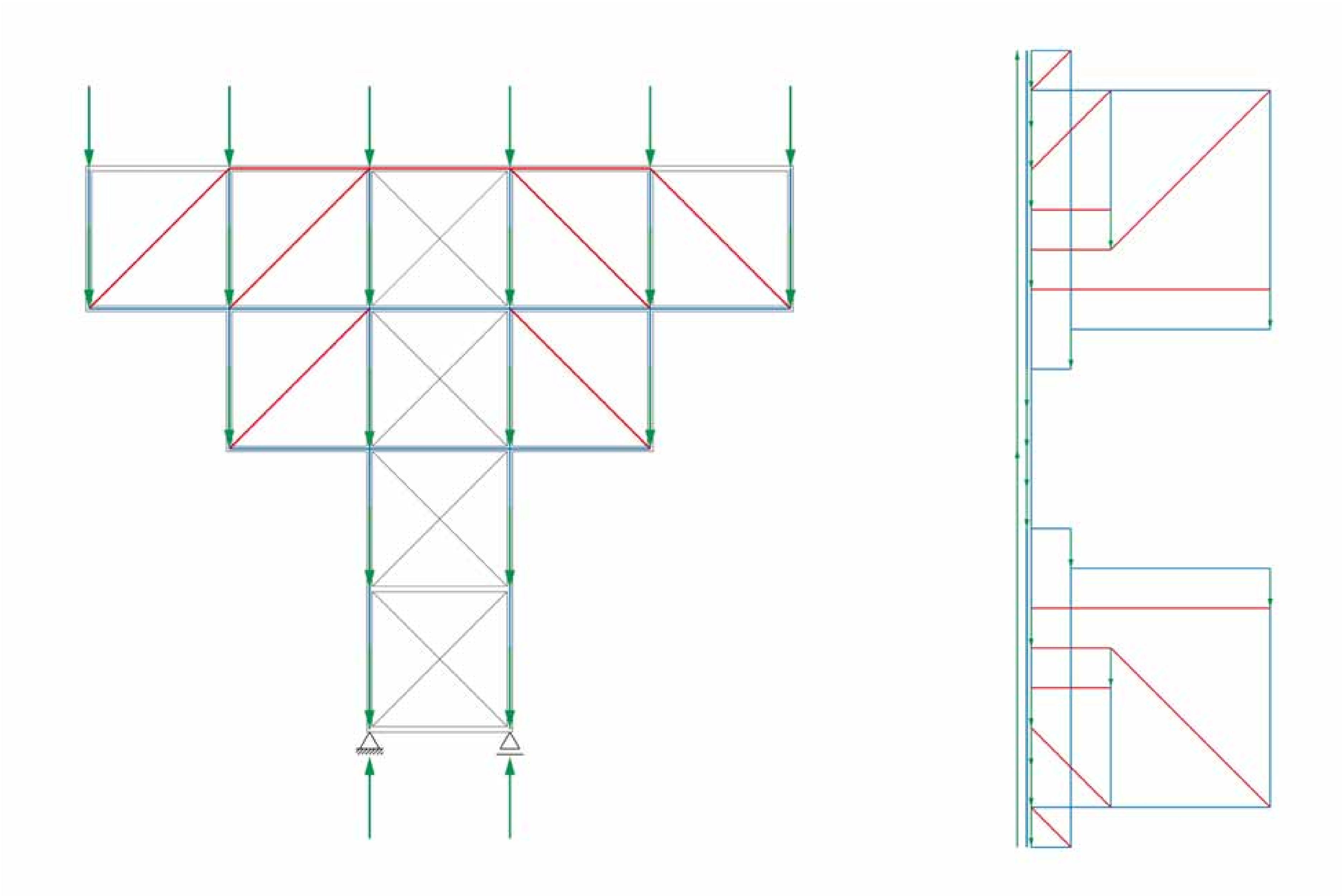
Gebäude-Skelett
Building skeleton



Fachwerkstruktur
Truss structure



Statisches Gleichgewicht unter Eigengewicht
Static equilibrium under self-weight



Statisches Gleichgewicht unter Eigengewicht
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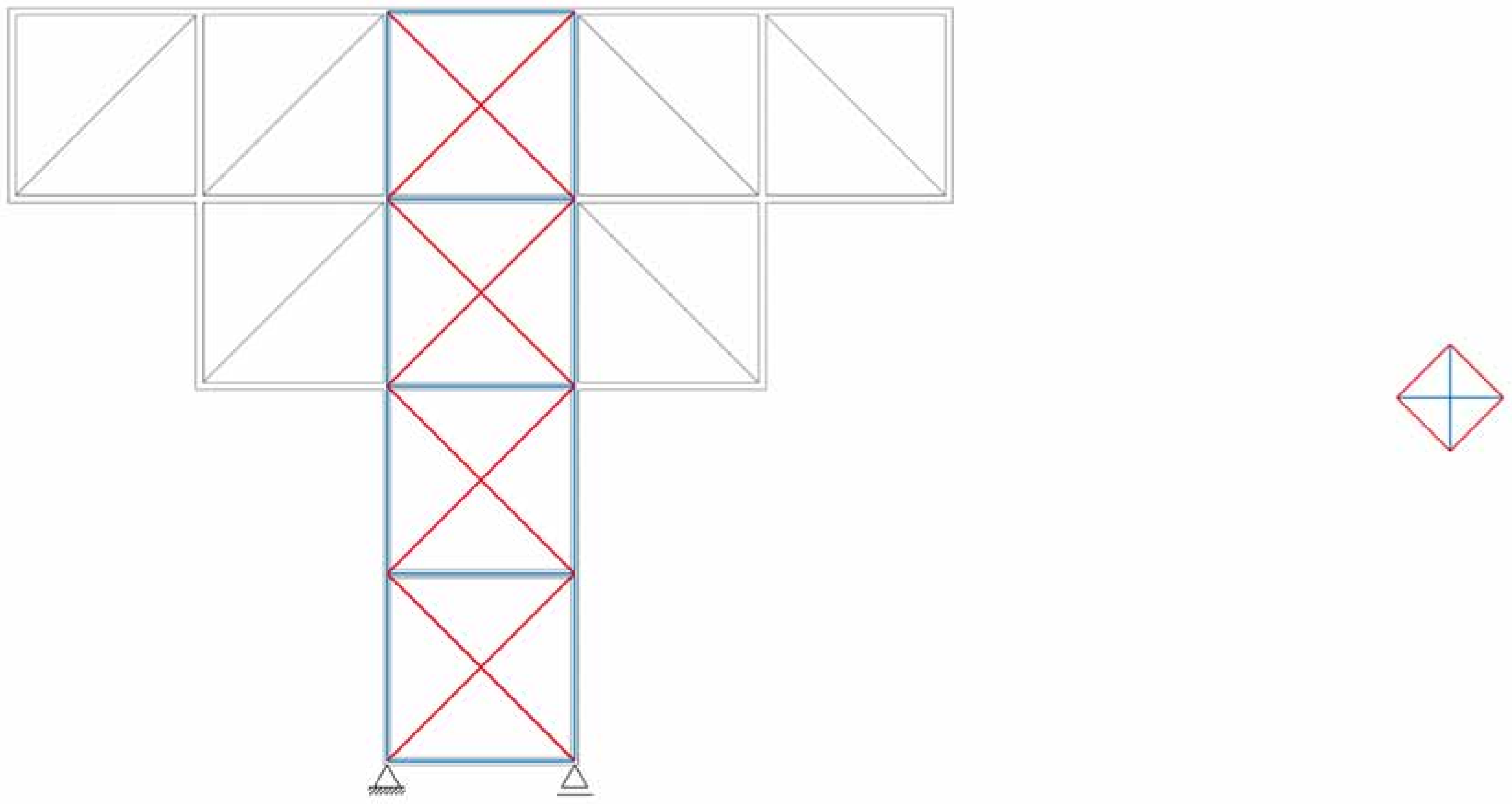
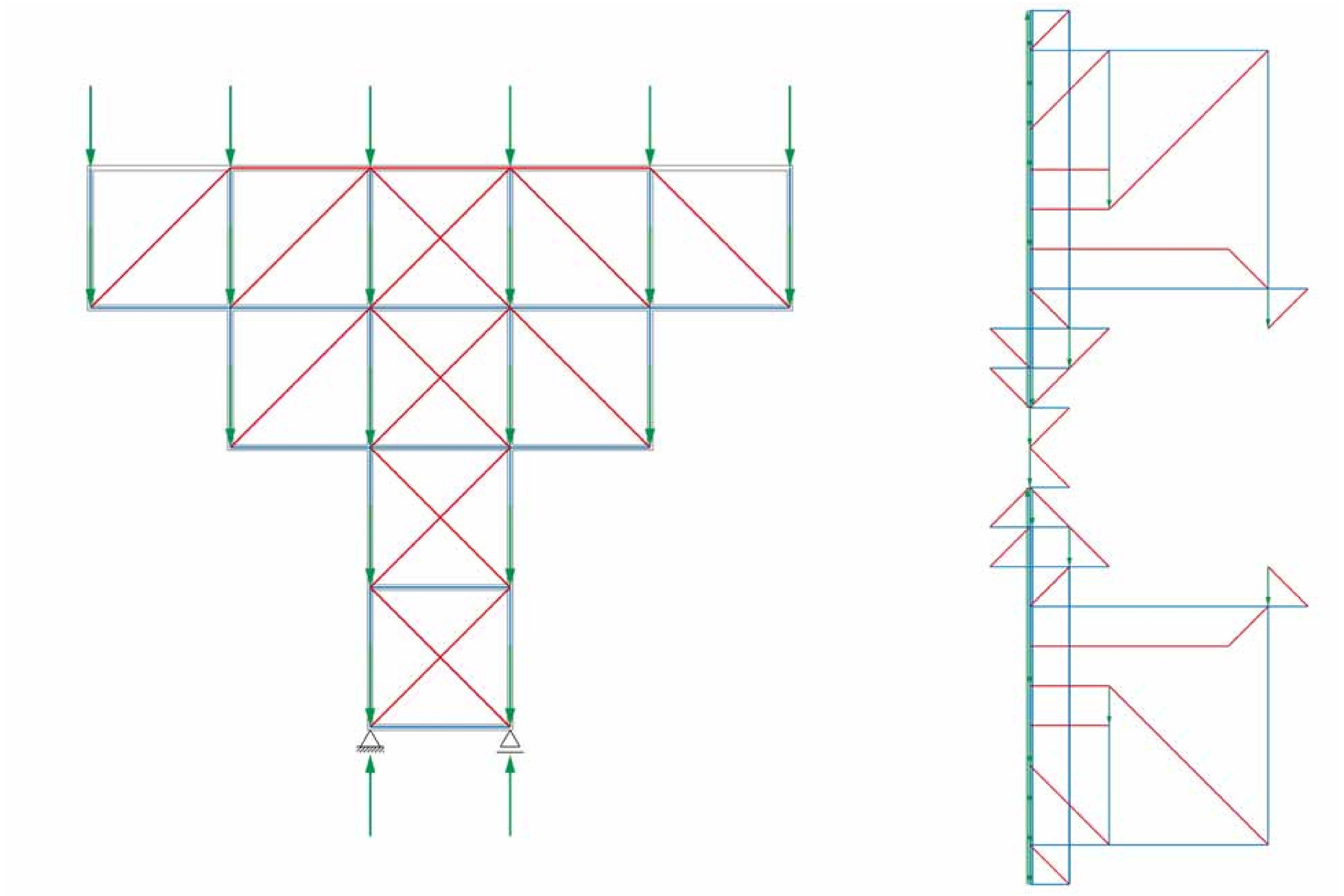
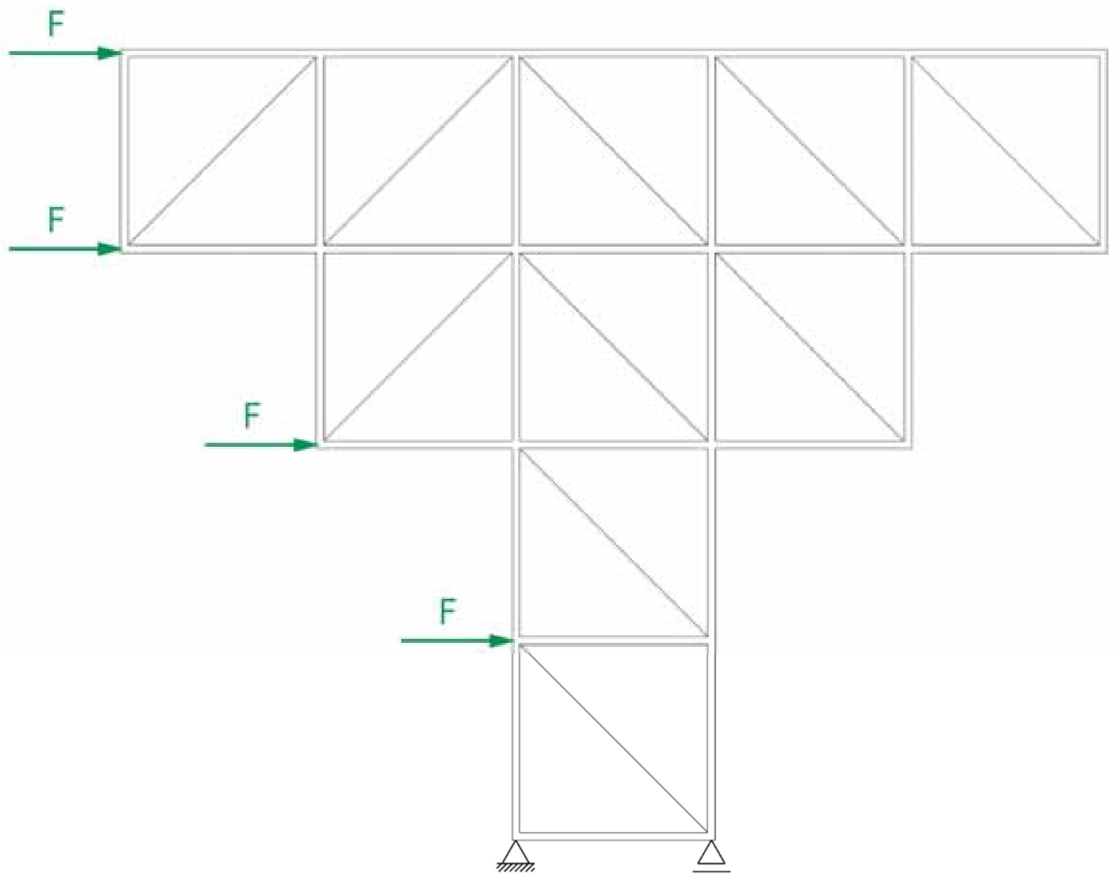


Vorspannung

Prestressing

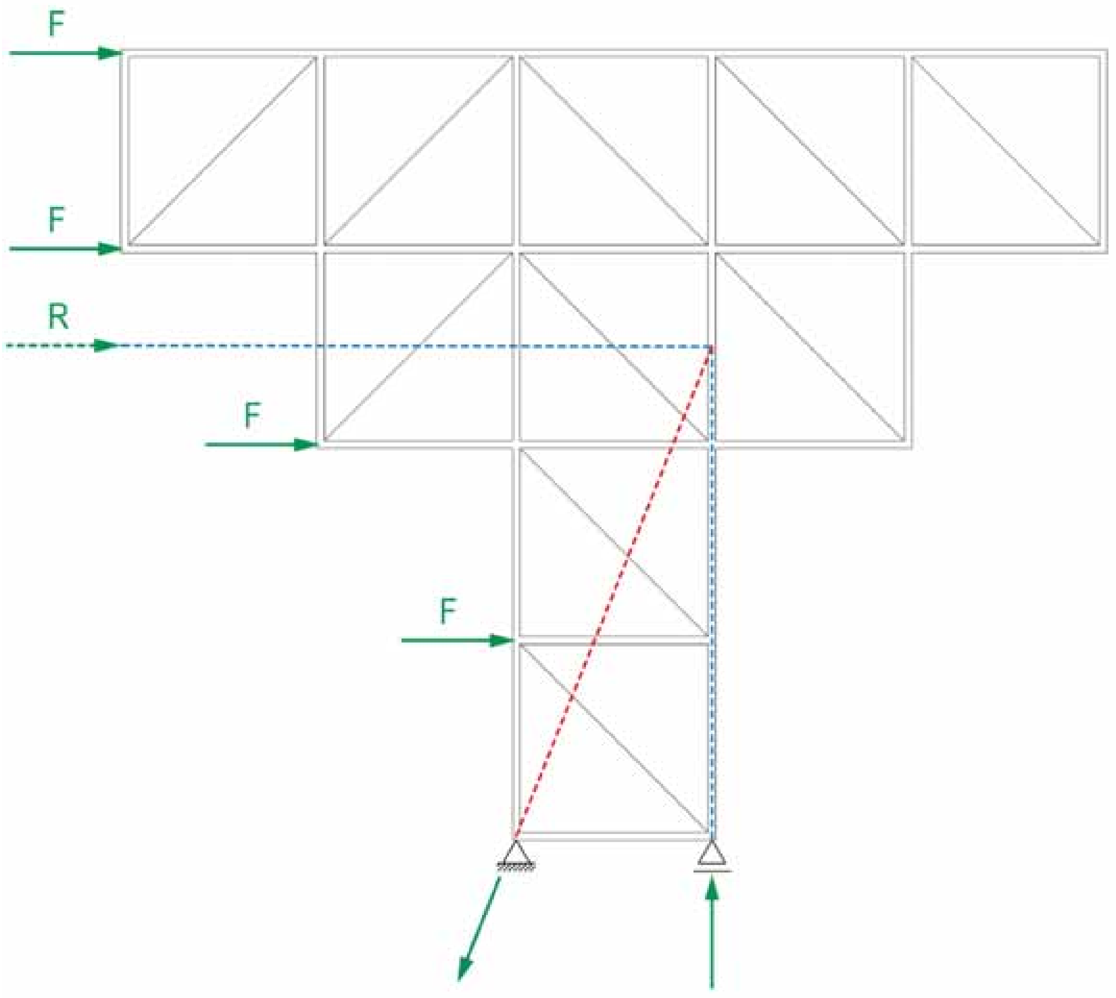


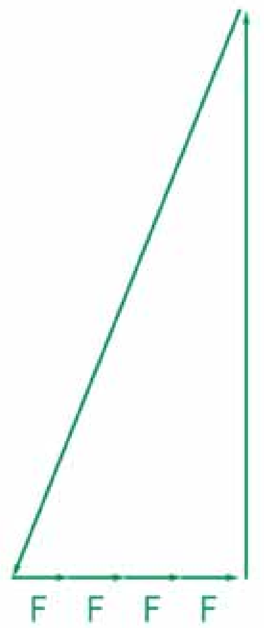
Globales statisches Gleichgewicht
Global static equilibrium



Statisches Gleichgewicht unter horizontalen Einwirkungen

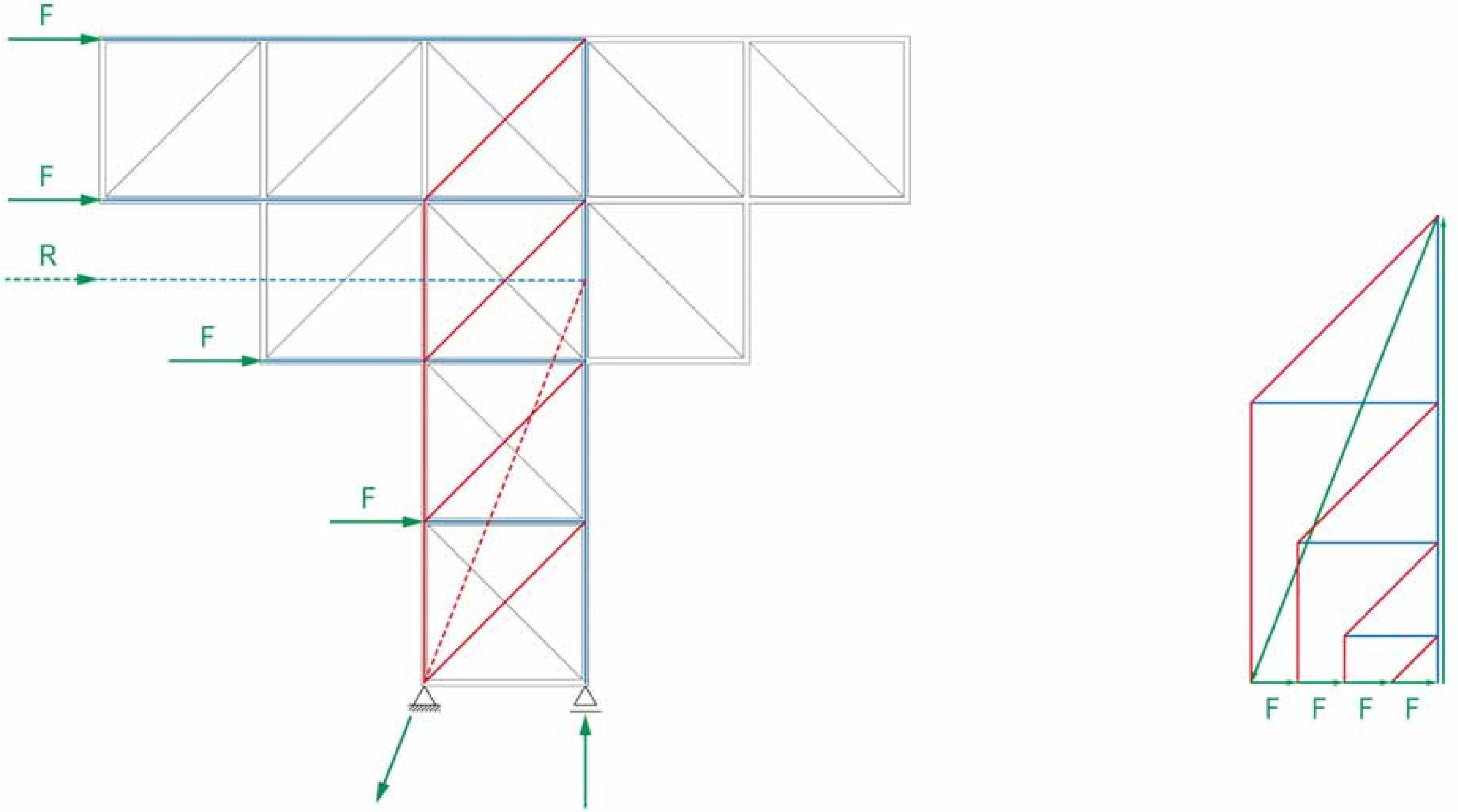
Static equilibrium under horizontal loads



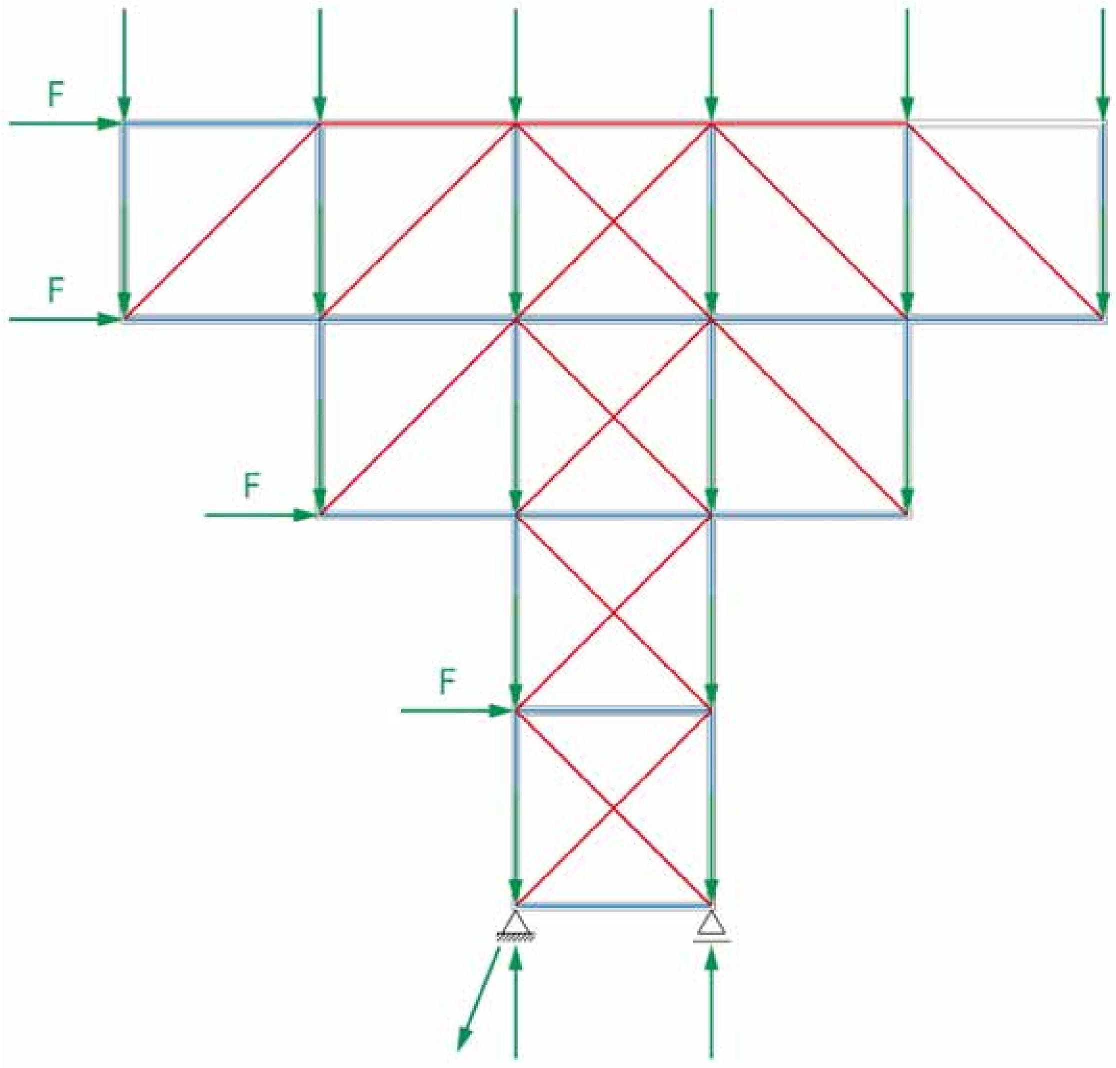


Statisches Gleichgewicht unter horizontalen Einwirkungen

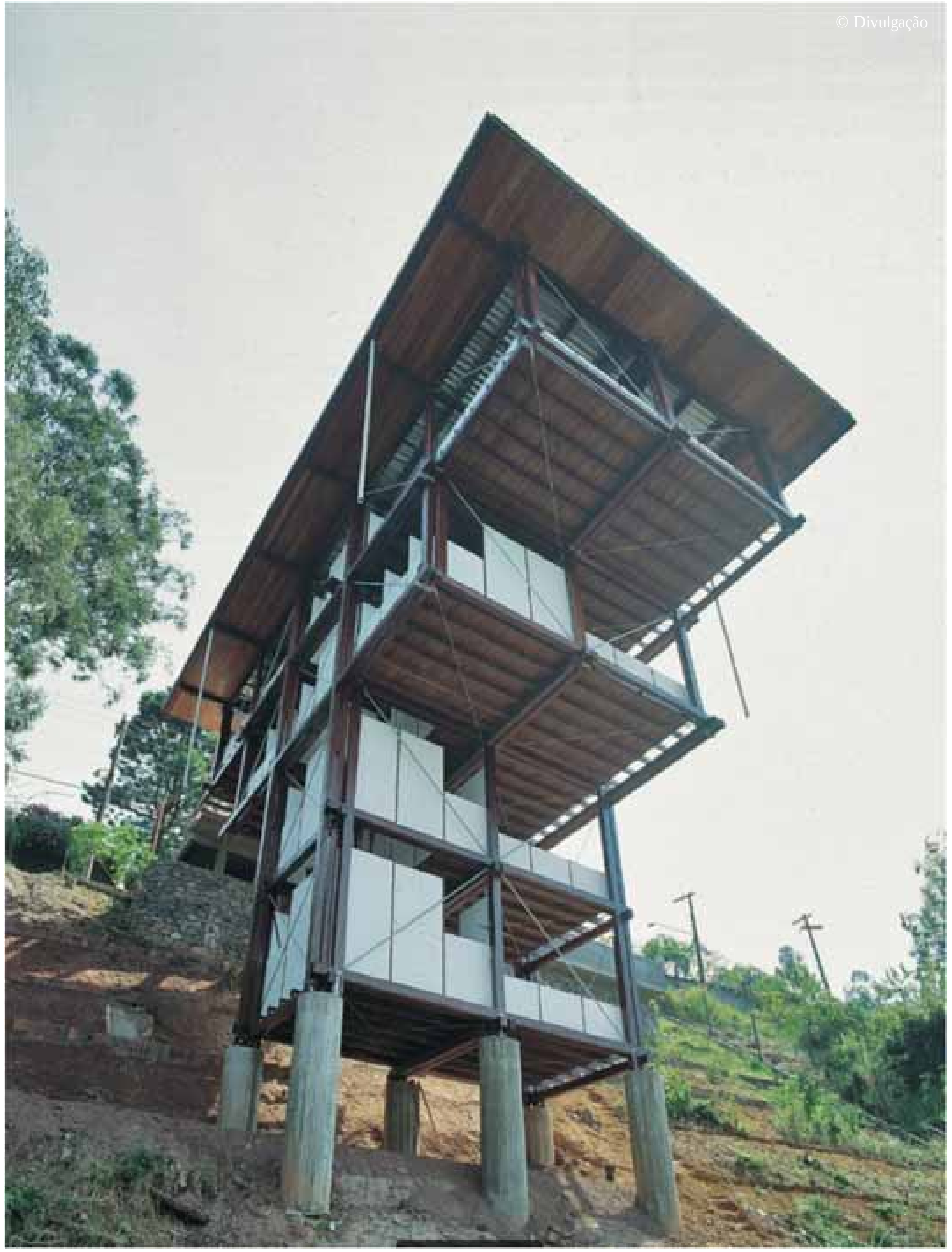
Static equilibrium under horizontal loads



Statisches Gleichgewicht unter horizontalen Einwirkungen
Static equilibrium under horizontal loads

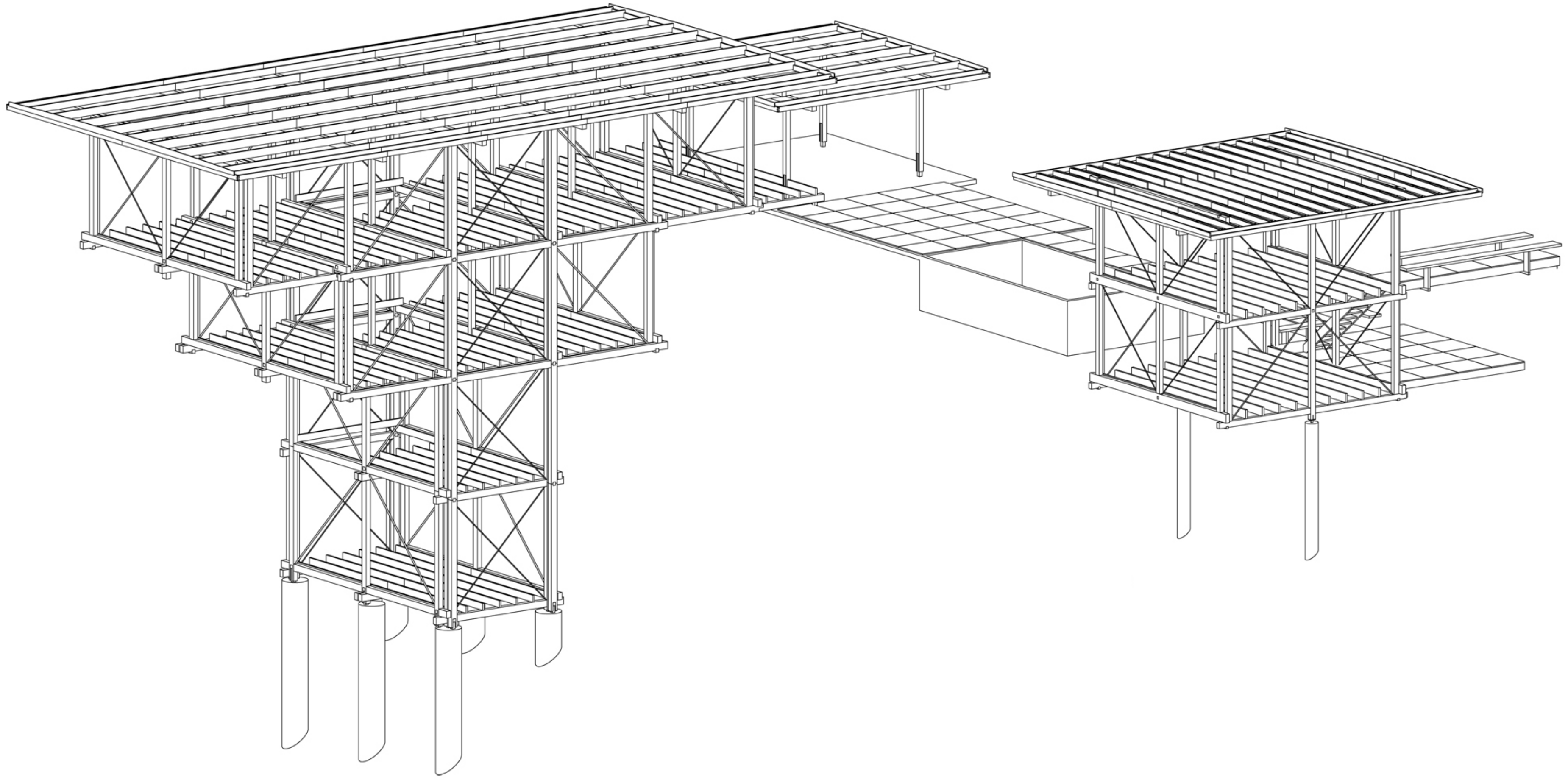


Statisches Gleichgewicht unter horizontalen Einwirkungen mit Berücksichtigung des Eigengewichts
Static equilibrium under horizontal loads considering self-weight

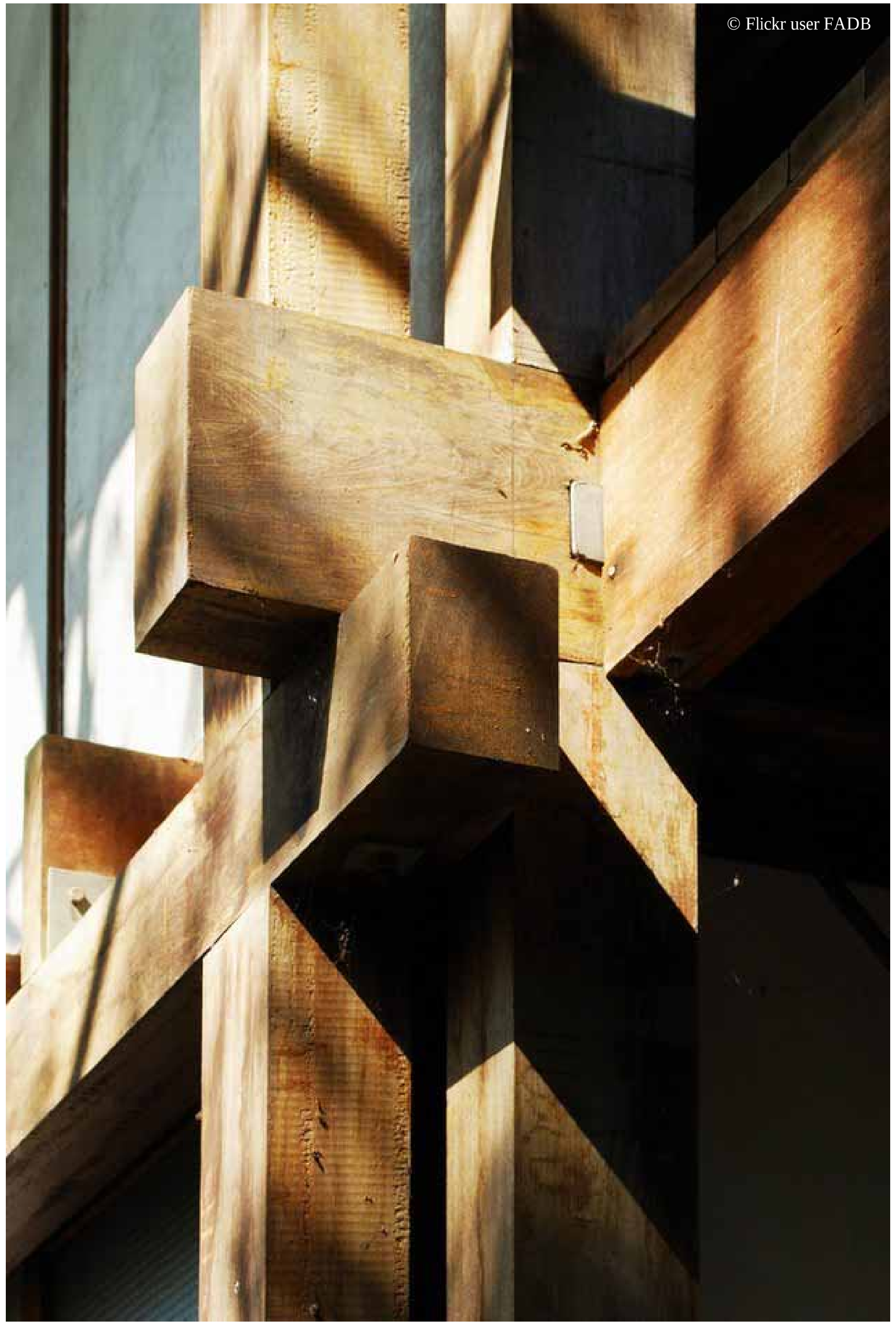


Vertikale Aussteifung der Platten

Vertical bracing of the slabs

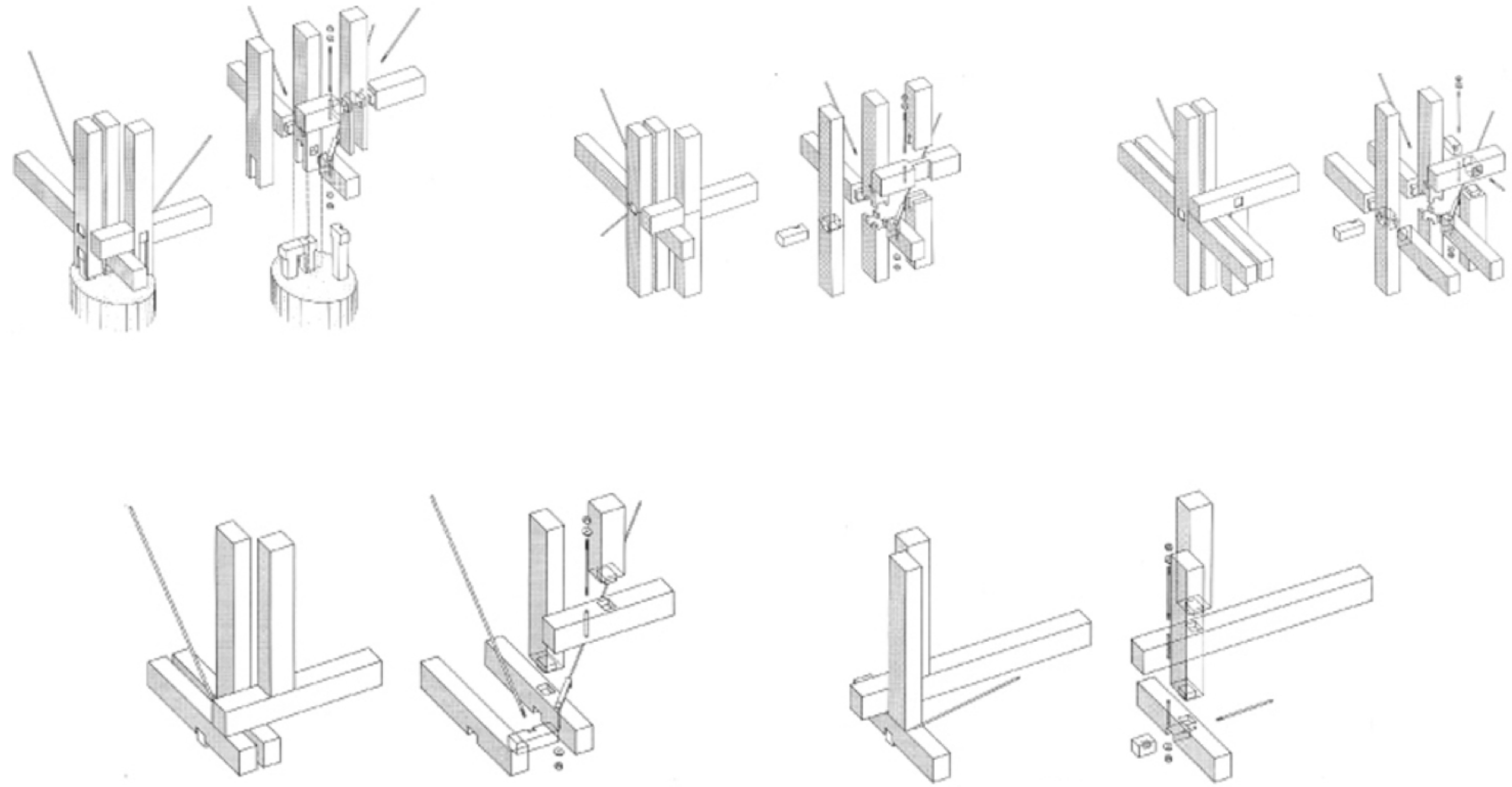


Axonometrische Ansicht der Struktur
Axonometric view of the structure

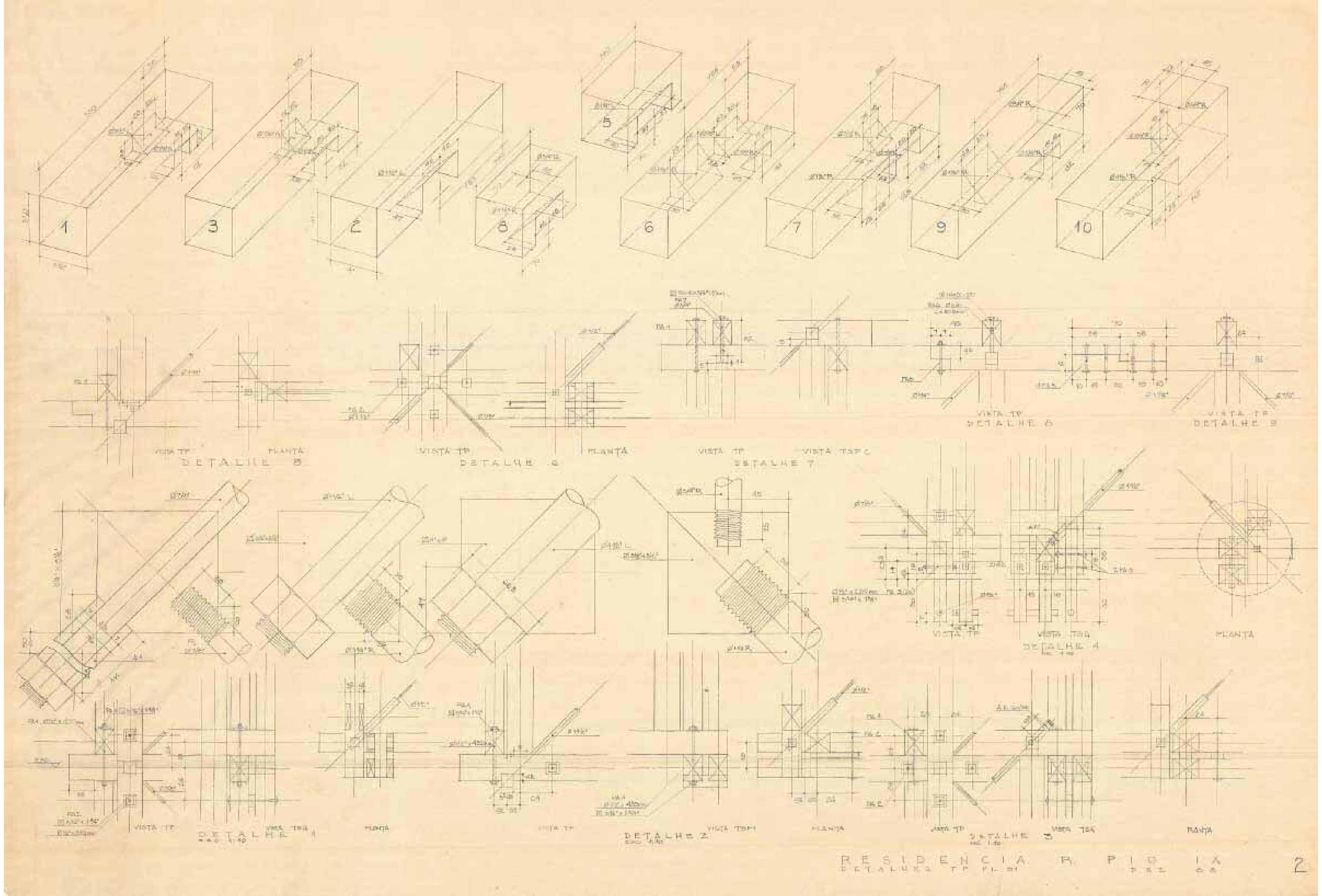


Knoten

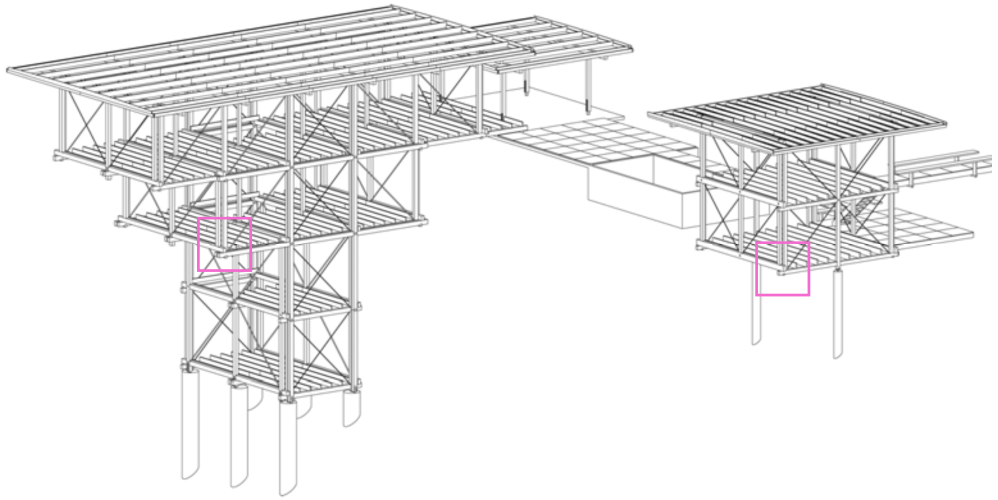
Structural nodes



Knoten
Structural nodes

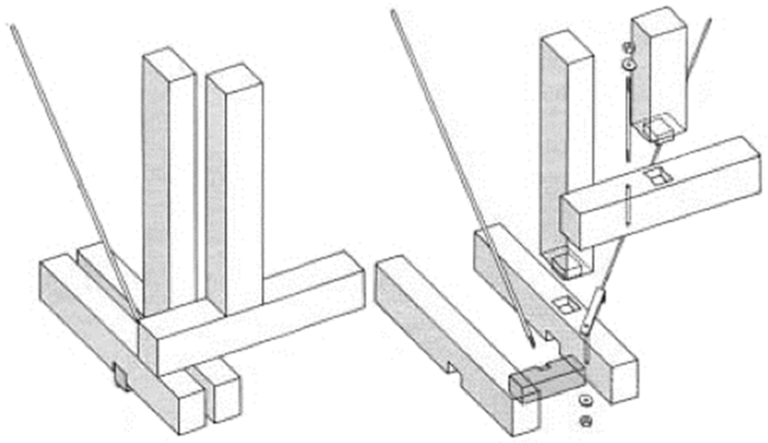


Knoten
Structural nodes



Detail der Fachwerkstruktur an einem auskragenden Knotenpunkt

Detail of the truss structure at a cantilevering node



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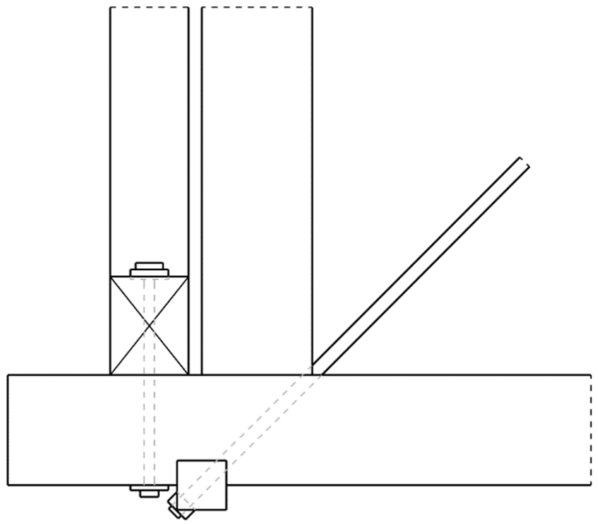

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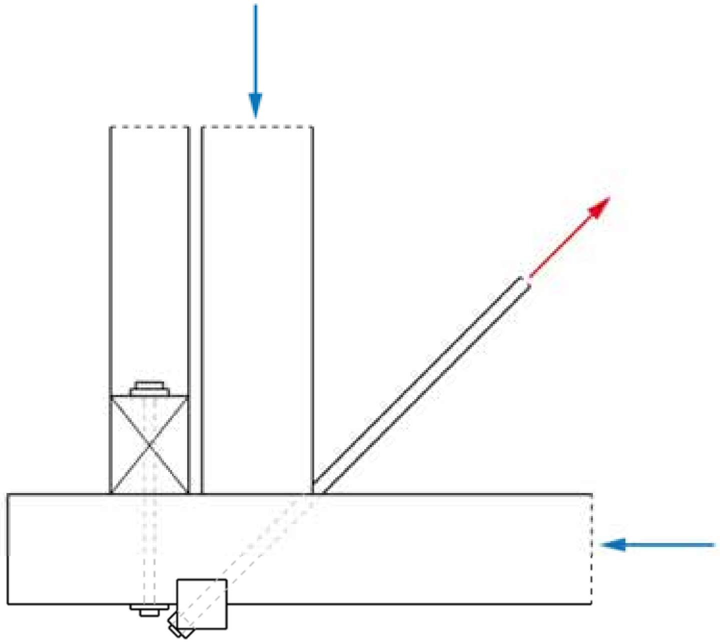

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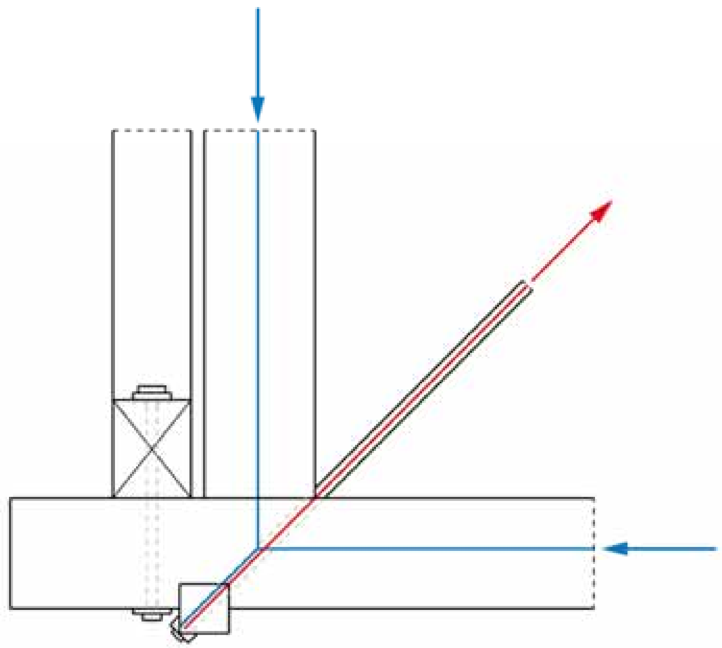

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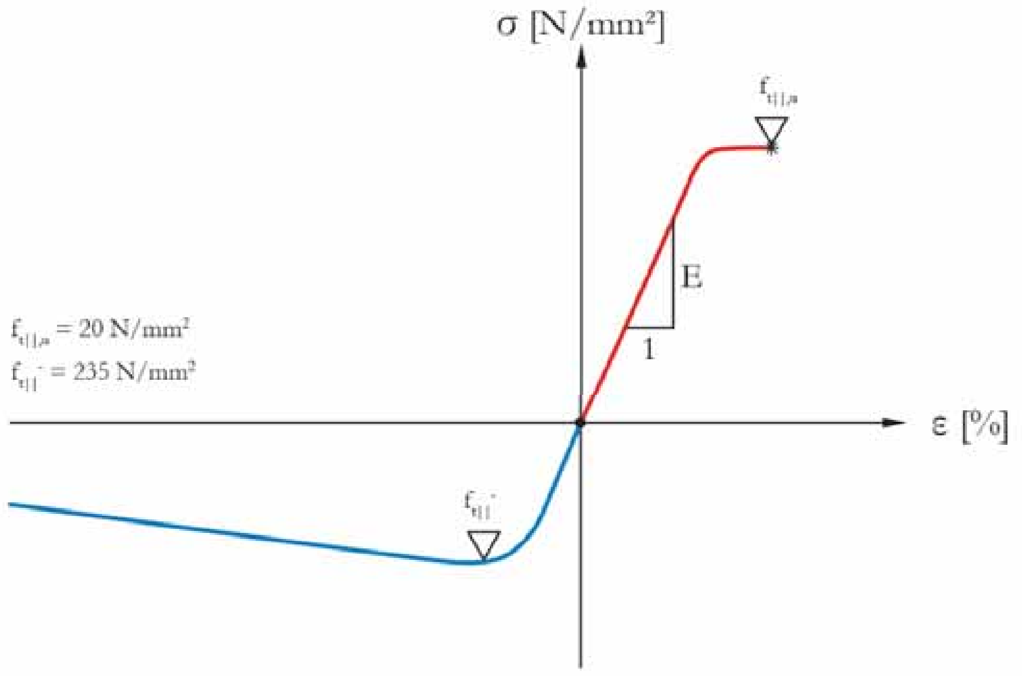
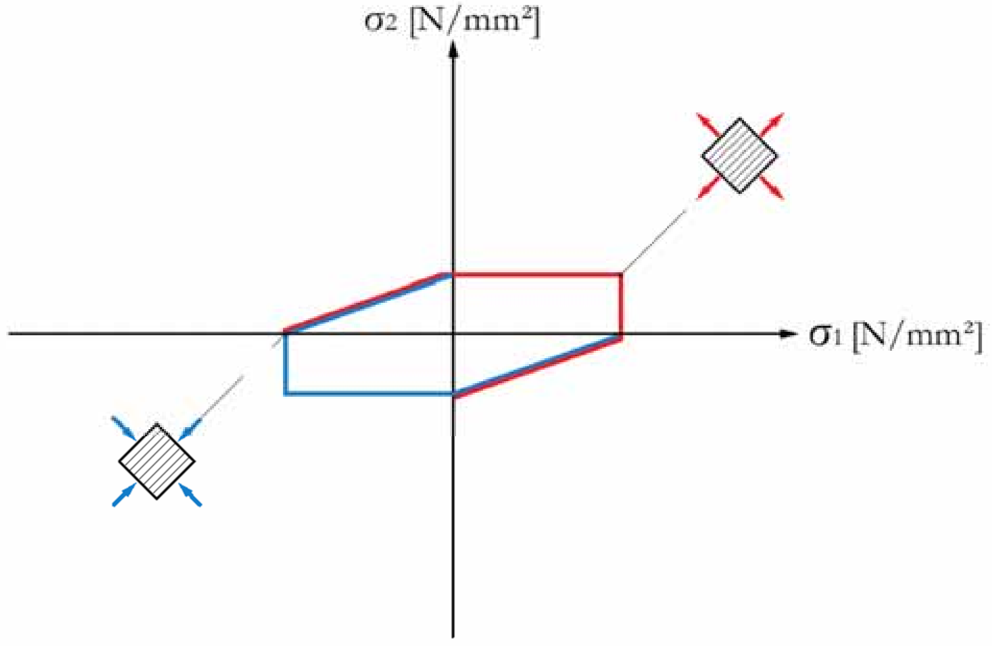
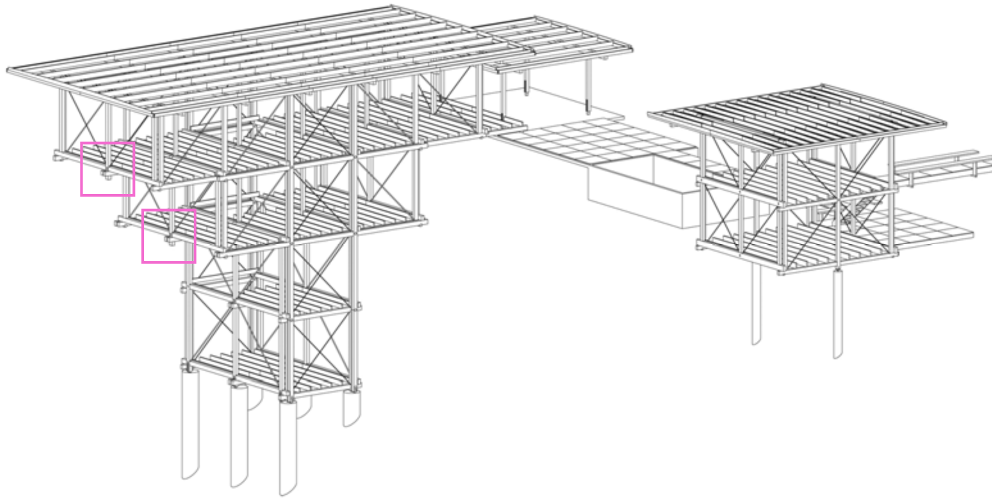


Stahl, Spannungs-Dehnungs-Diagramm
Steel, stress-strain diagram

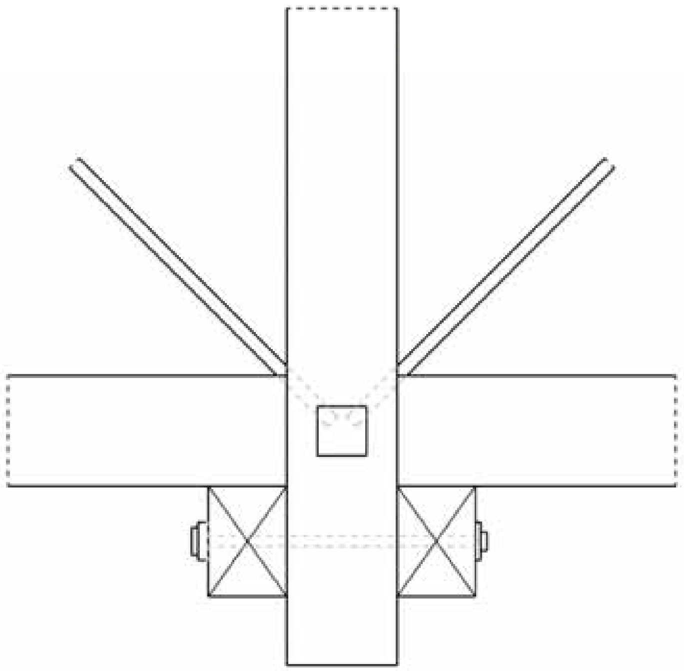


Holz, Versagenskriterien in 2D
Timber, failure criterion in 2D



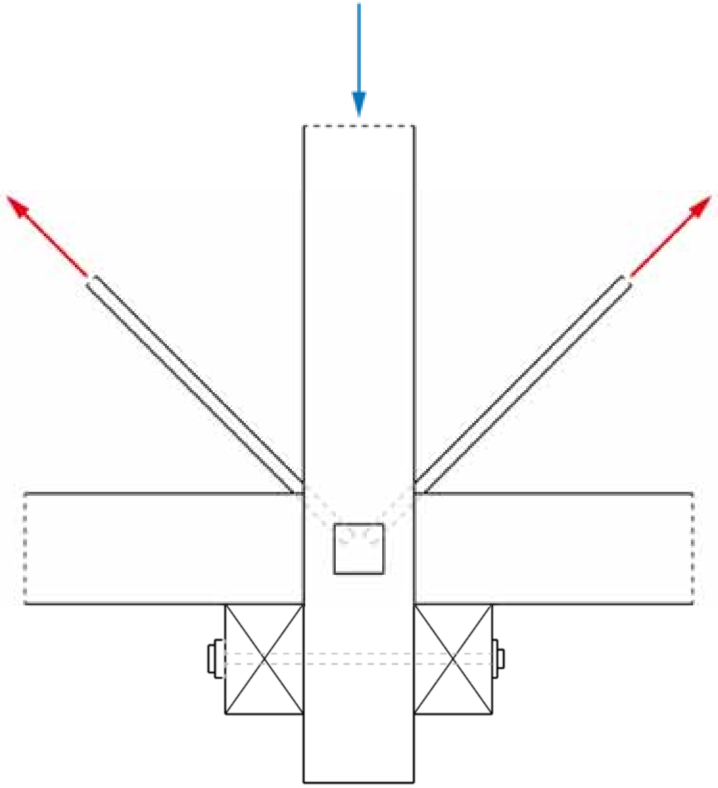
Detail eines hängenden Knotens der Fachwerkstruktur

Detail of the truss structure at a hanging node



Detail eines hängenden Knotens der Fachwerkstruktur

Detail of the truss structure at a hanging node



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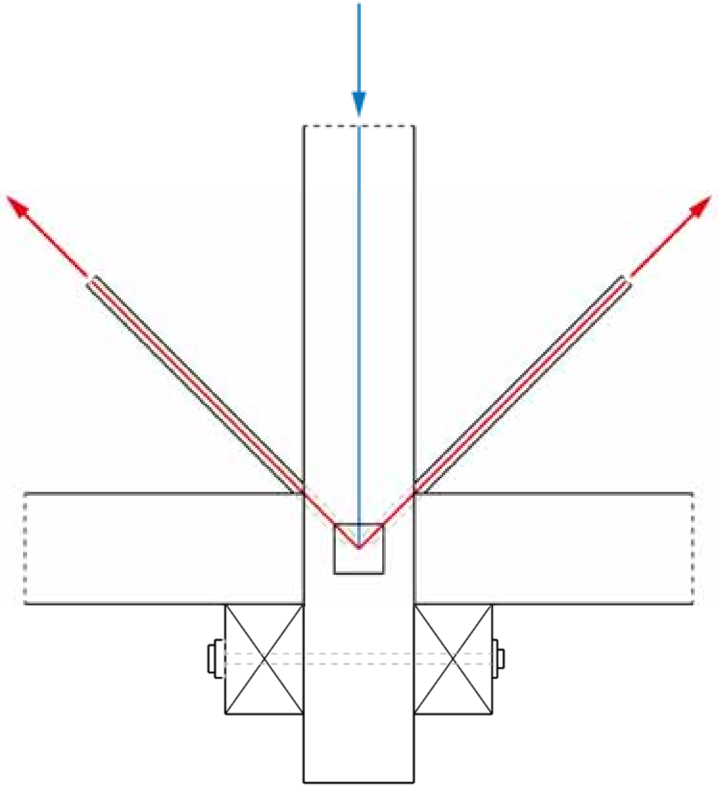

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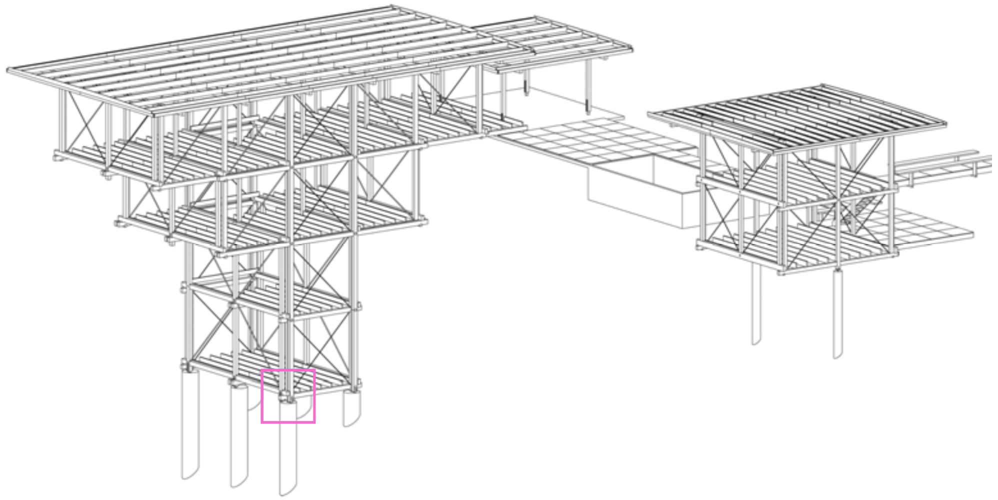
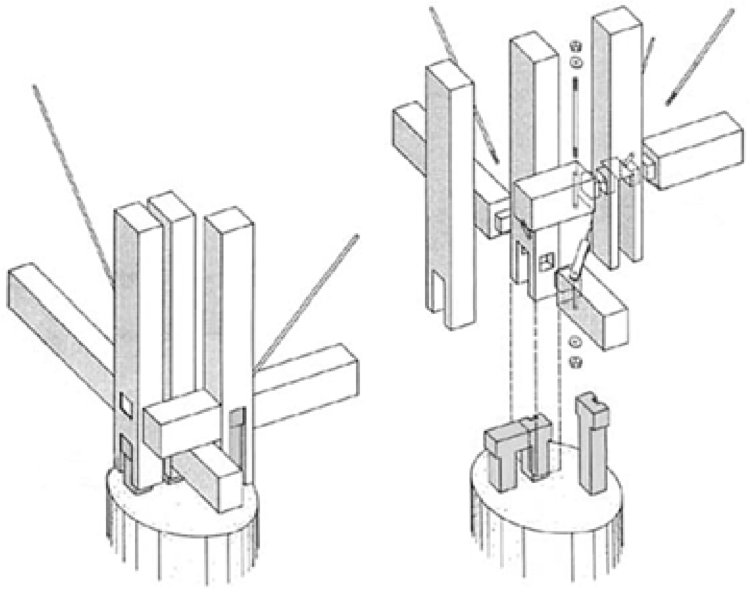


Detail der Fachwerkkonstruktion an den Stützenköpfen

Detail of the truss structure at the supports



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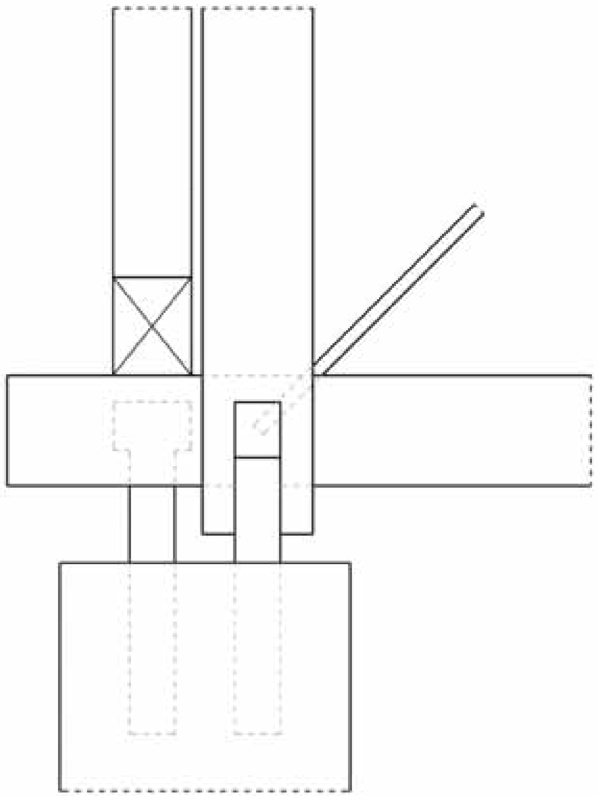

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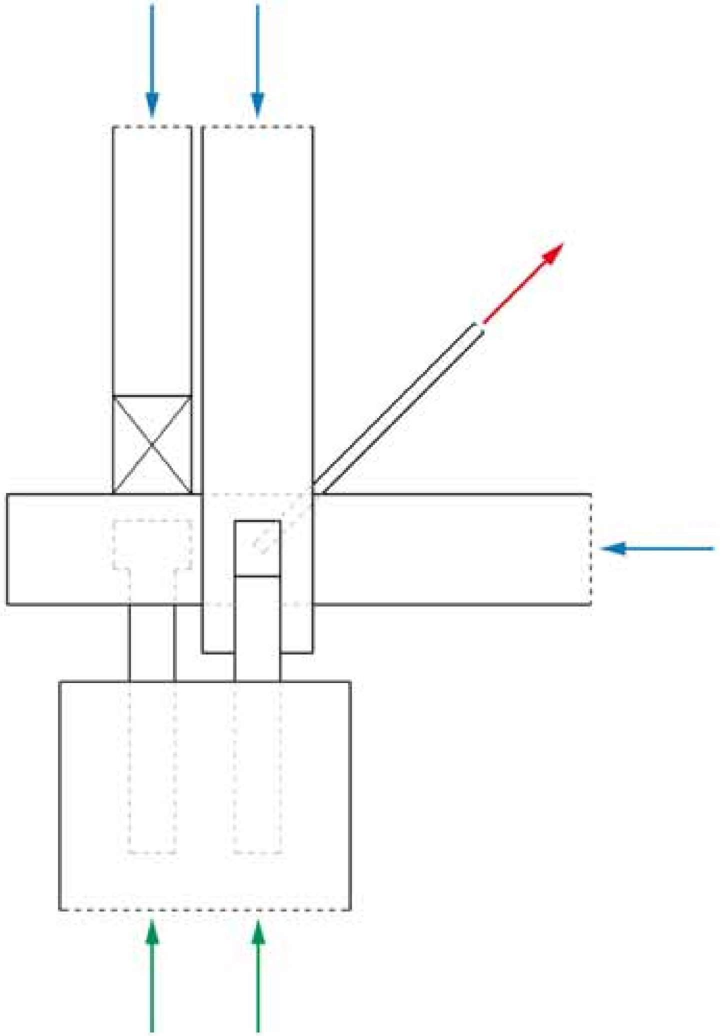

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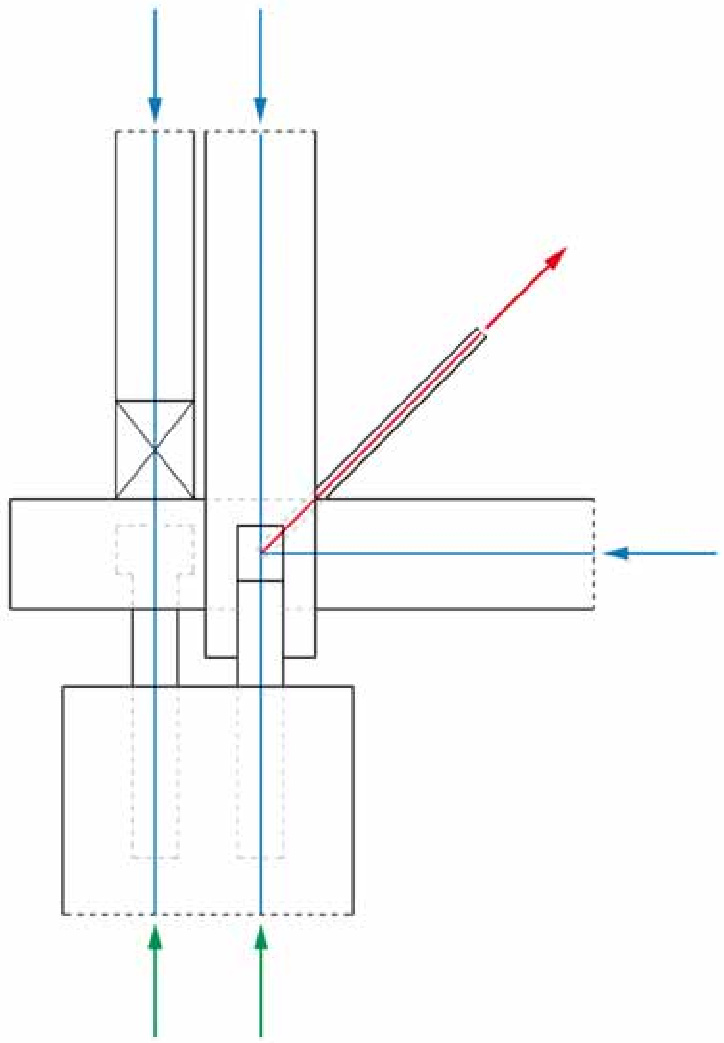


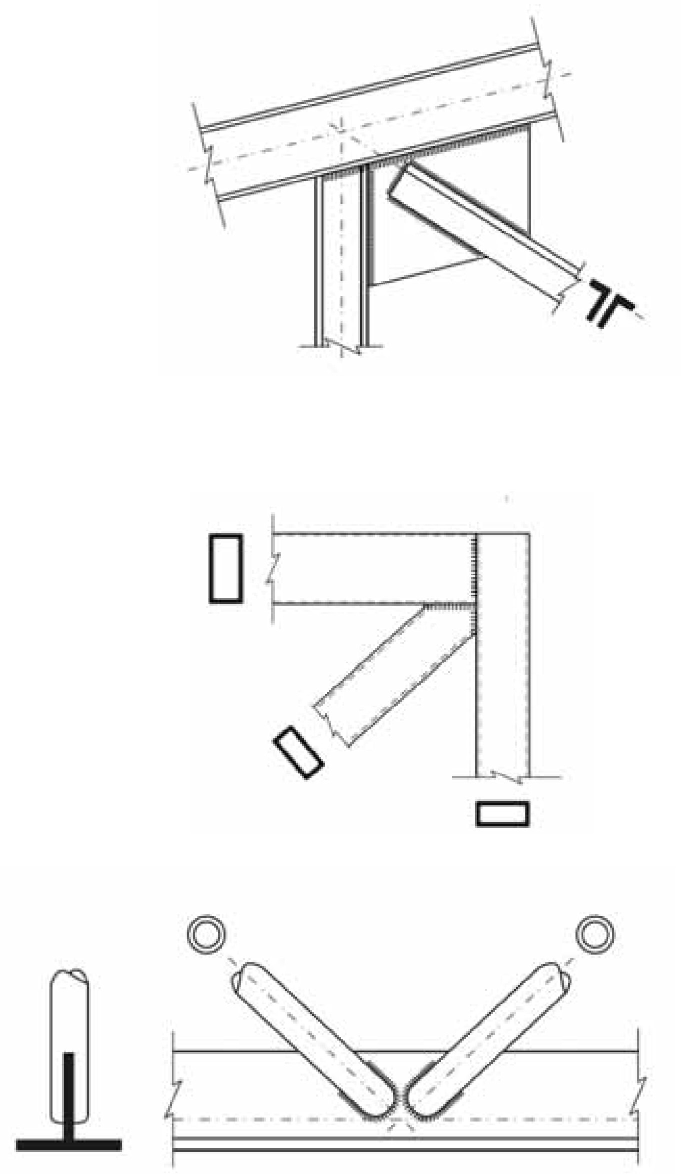
Detail der Fachwerkkonstruktion an den Stützenköpfen

Detail of the truss structure at the supports

Detail der Fachwerkkonstruktion an den Stützenköpfen

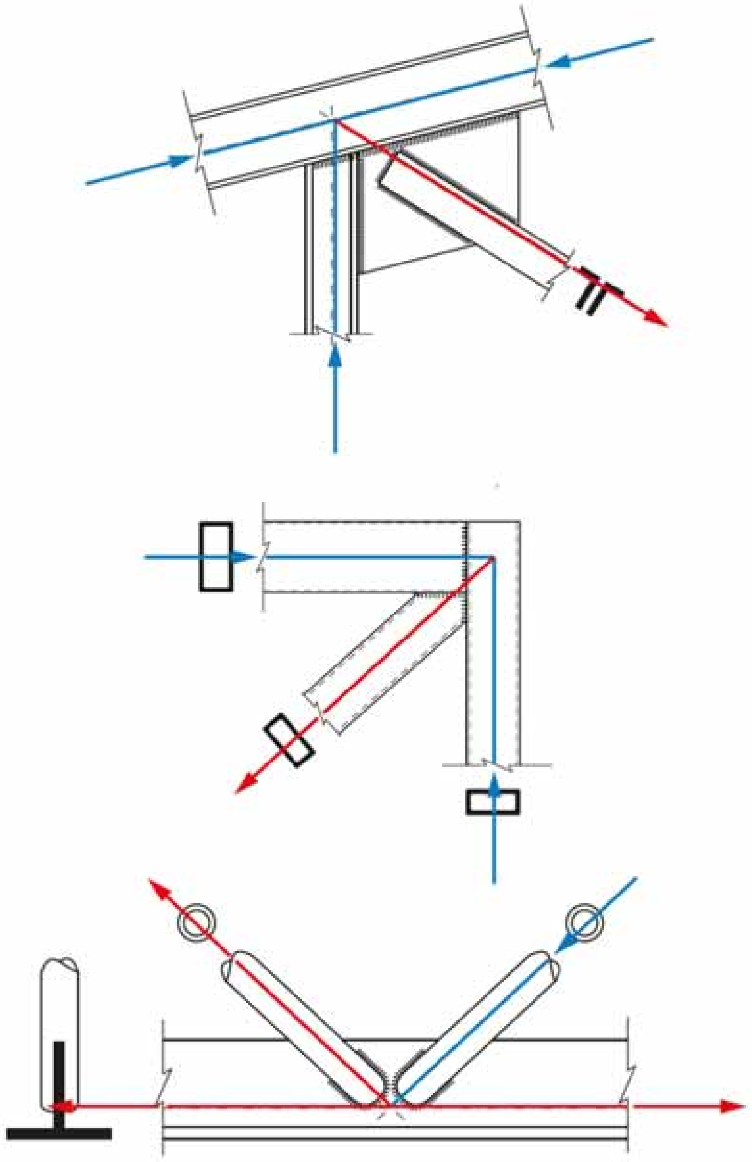
Detail of the truss structure at the supports


© Nelson Kon



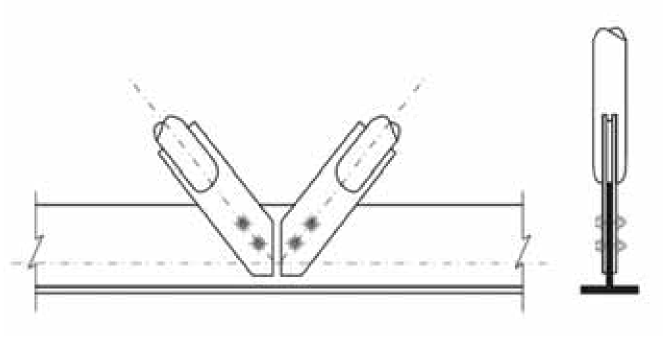
Beispiele für Fachwerkknoten im Stahlbau

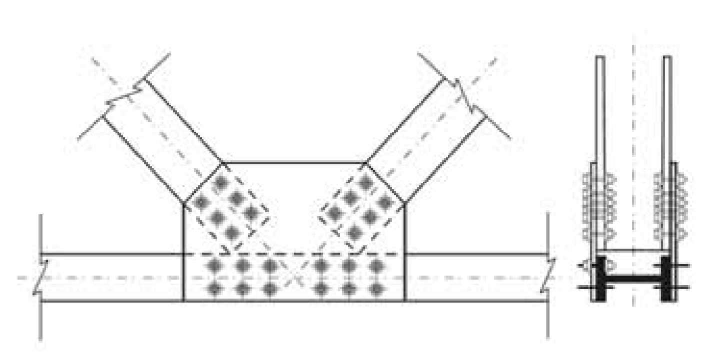
Examples of truss nodes in steel construction

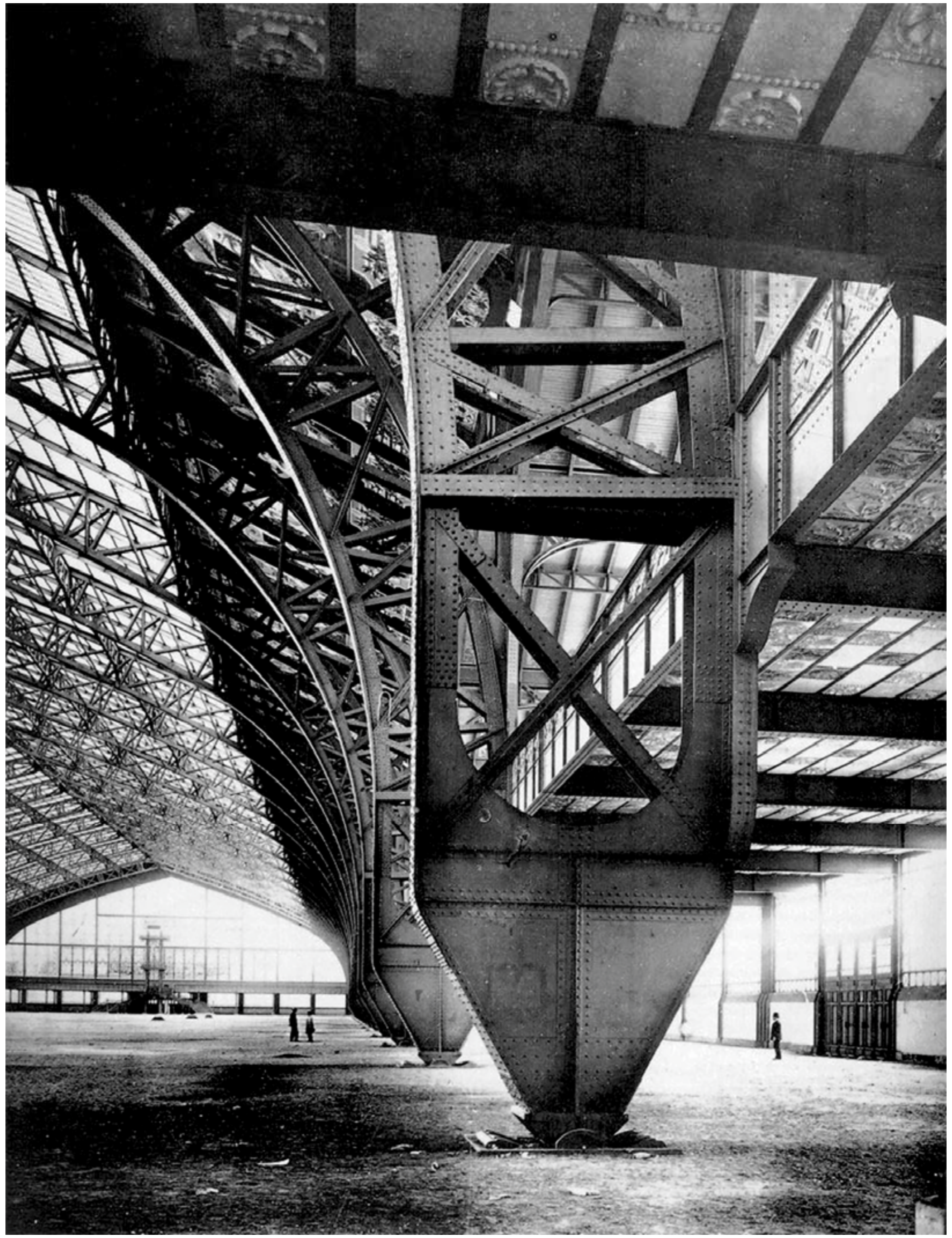


Beispiele für Fachwerkknoten im Stahlbau

Examples of truss nodes in steel construction

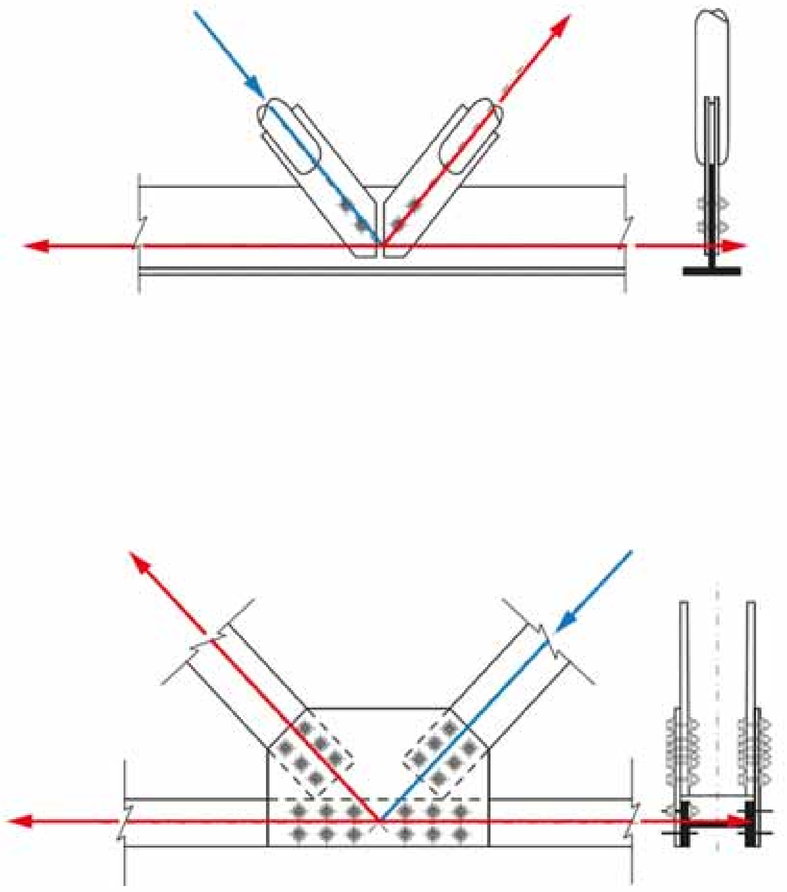


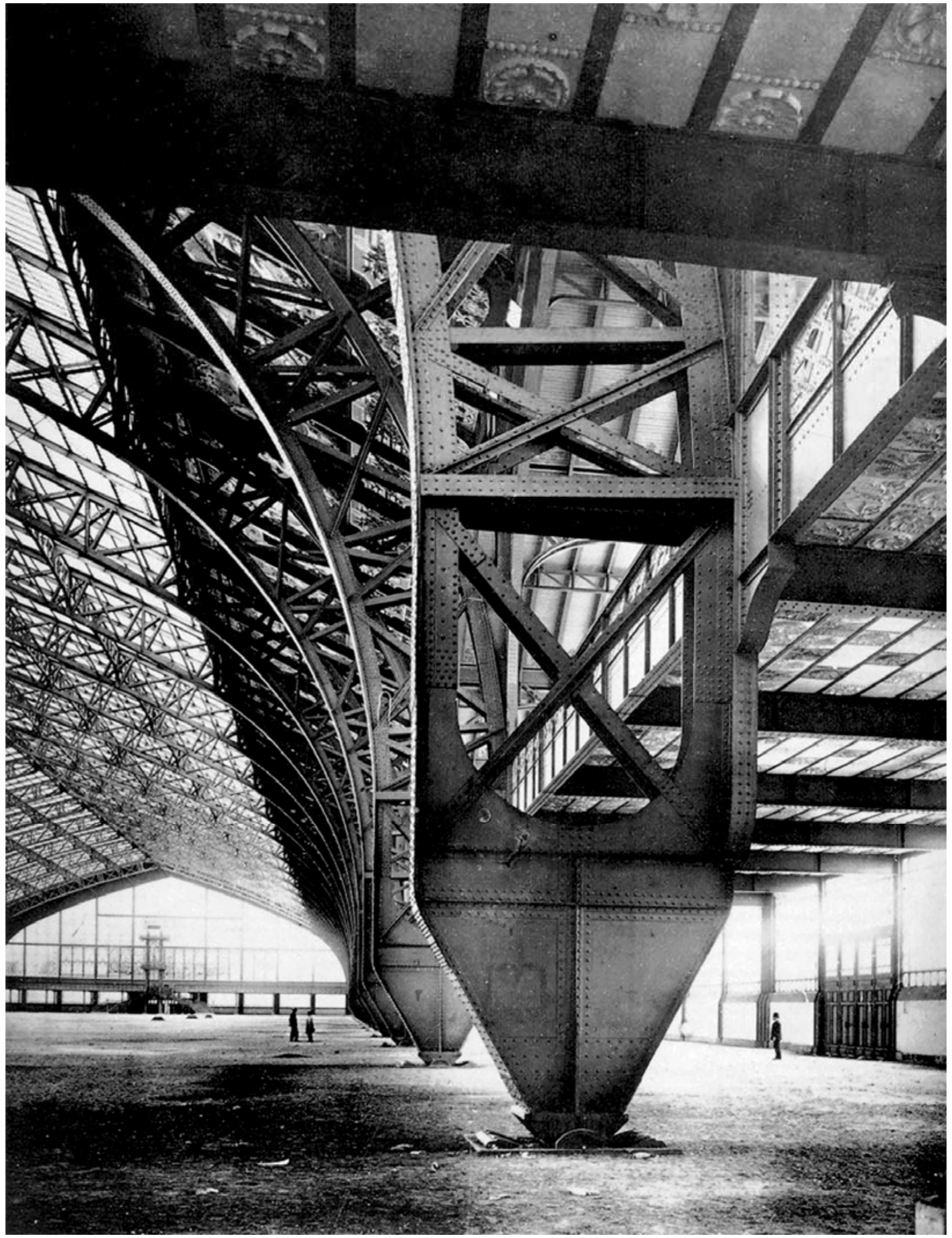




Beispiele für Fachwerkknoten im Stahlbau (Galerie des Machines, 1889, F. Dutert und S. Sauvestre)

Examples of truss nodes in steel construction (Galerie des Machines, 1889, F. Dutert and S. Sauvestre)





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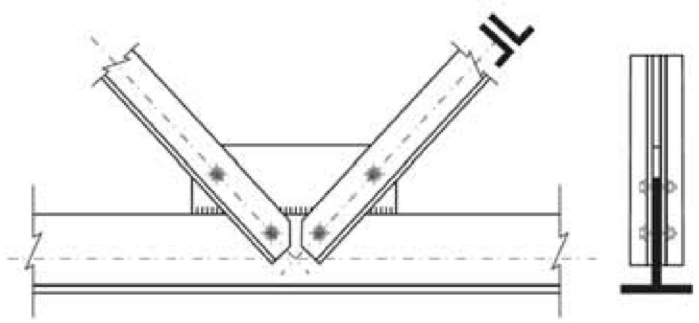
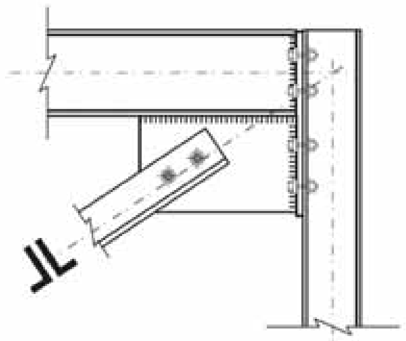
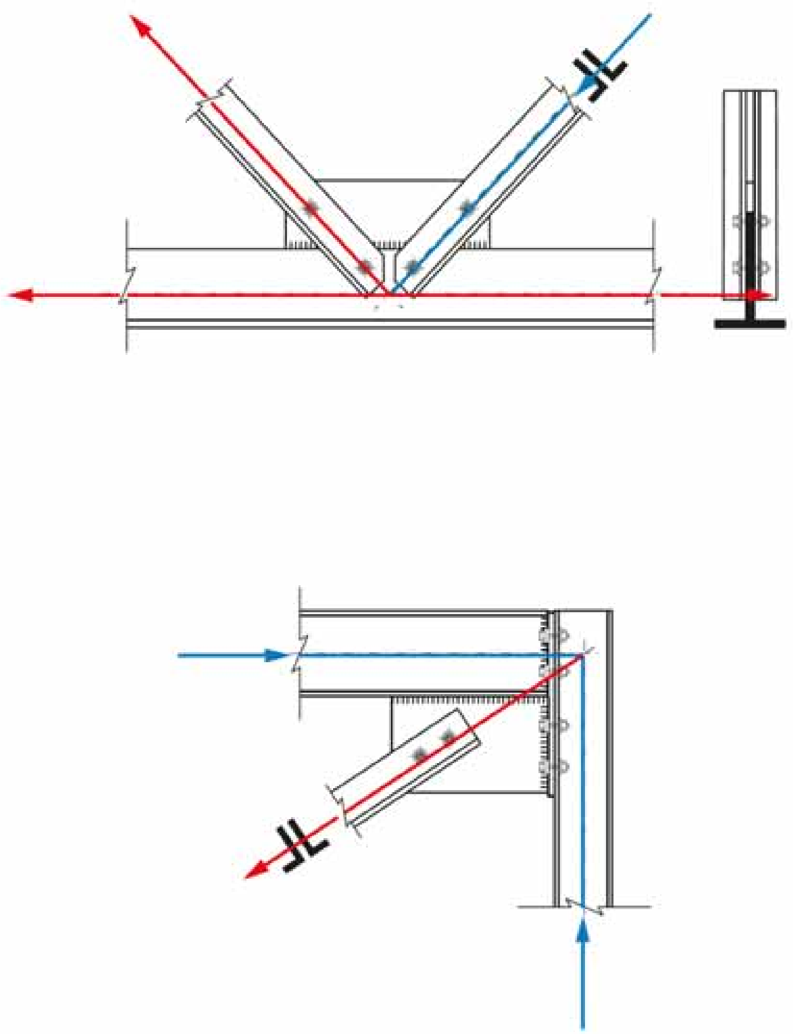




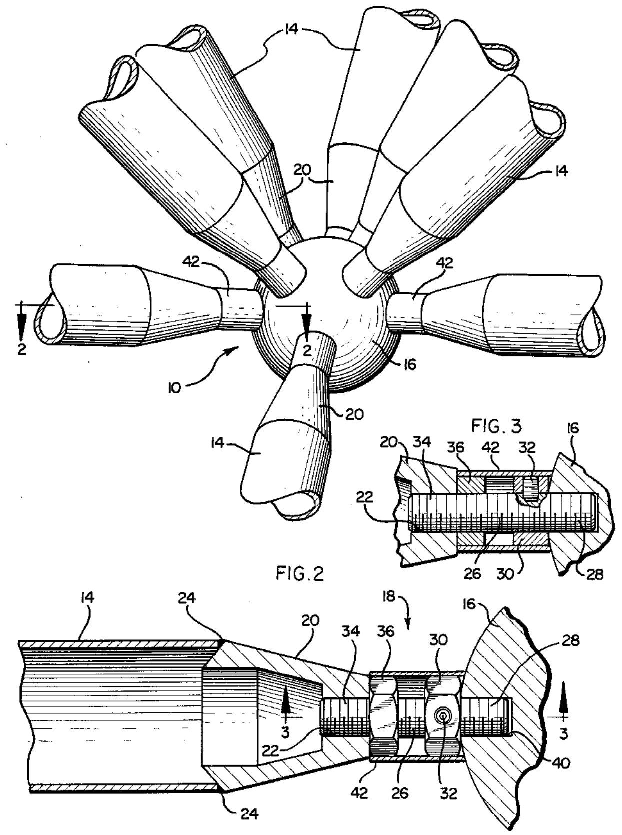
Beispiele für Fachwerkknoten im Stahlbau

Examples of truss nodes in steel construction



Beispiele für Fachwerkknoten im Stahlbau

Examples of truss nodes in steel construction



Beispiele für Fachwerkknoten im Stahlbau

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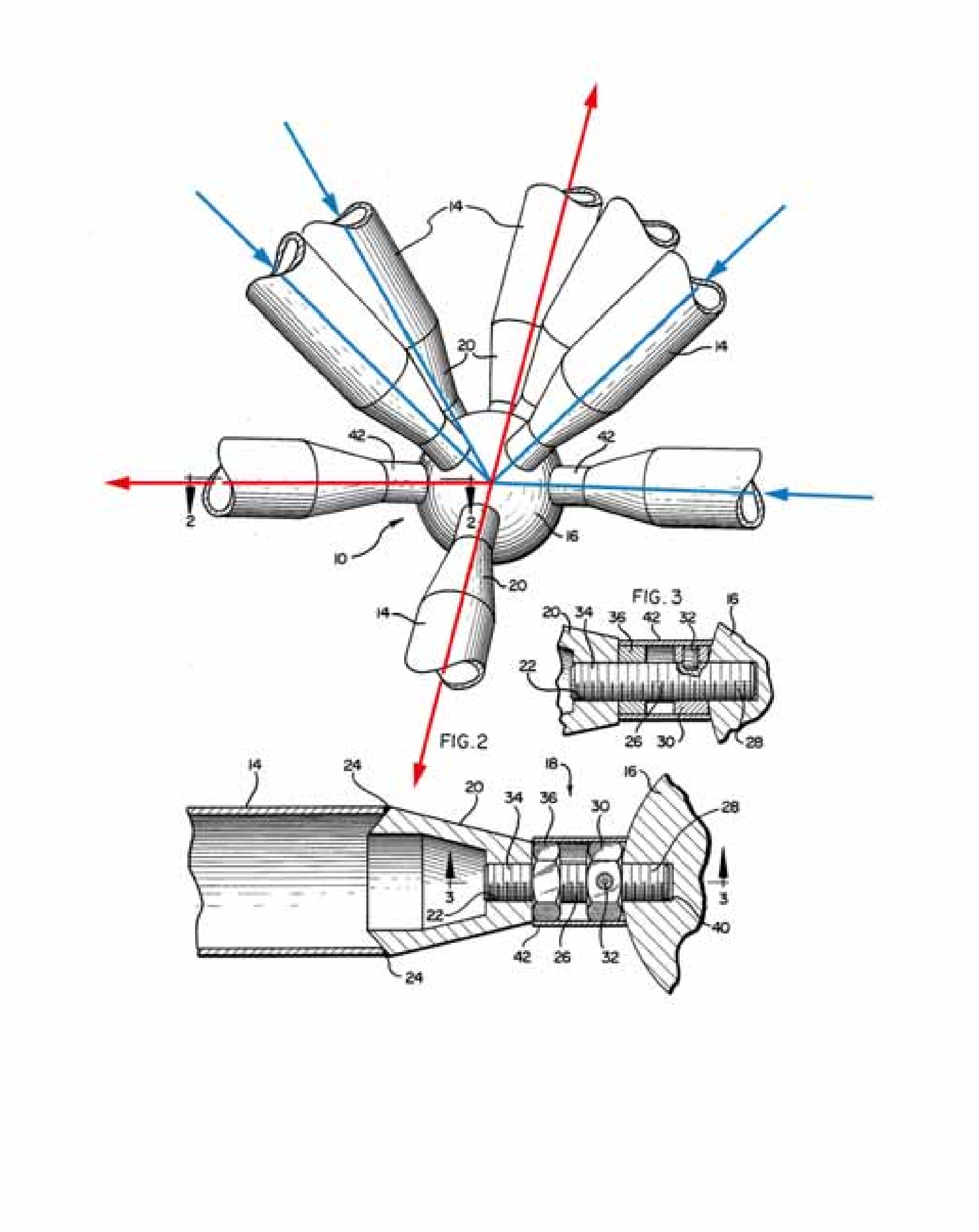


Beispiele für Fachwerkknoten im Stahlbau

Examples of truss nodes in steel construction

Leutschenbach School

Zurich, 2009

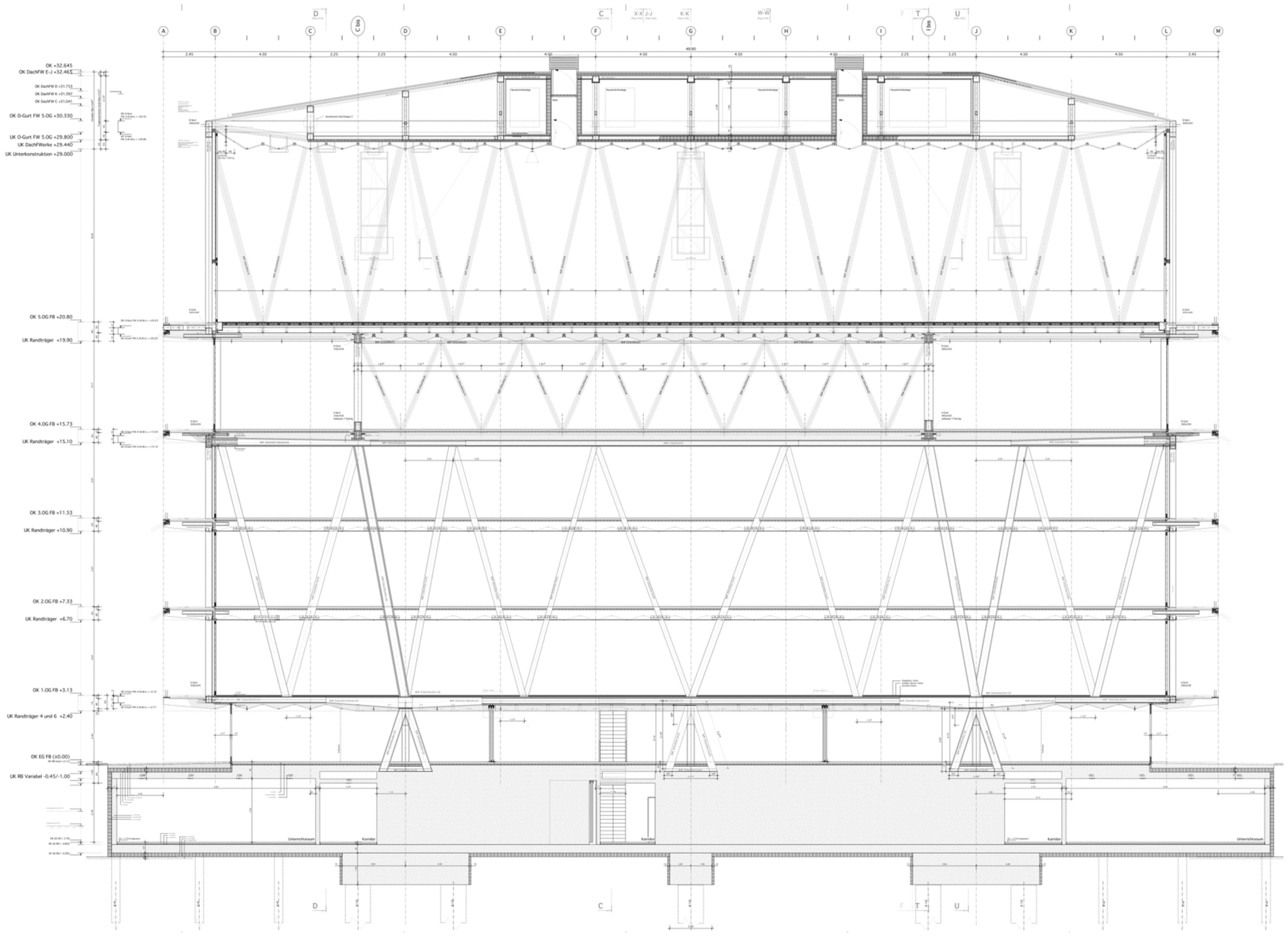
Architect: Christian Kerez

Engineer: Joseph Schwartz

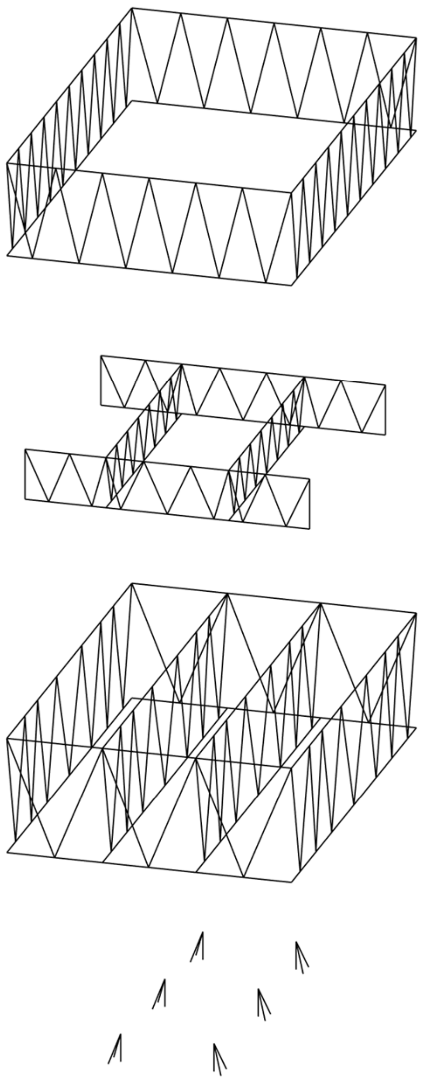
Gesamtansicht des Gebäudes

General view of the building

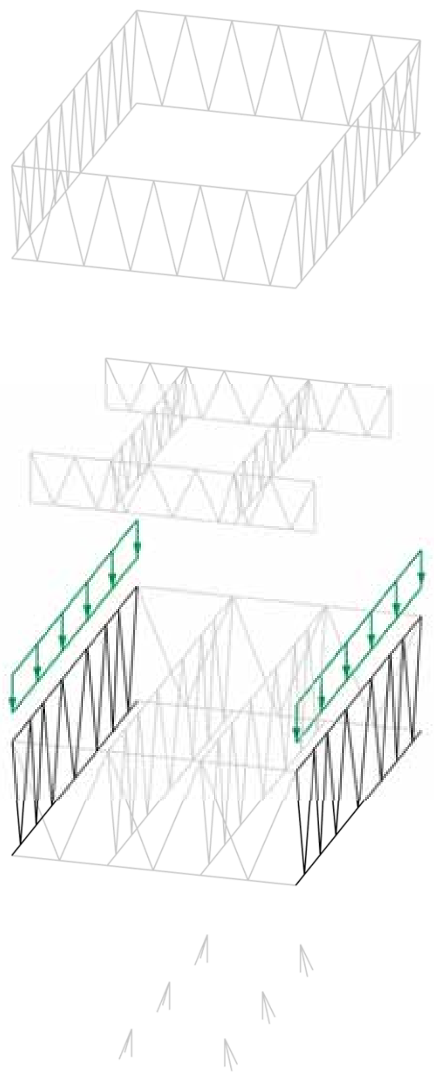
Massstäbliches Modell der Fachwerkstruktur
Scaled model of the truss structure



Schnitt
Section



Globales Gleichgewicht der Struktur
Global equilibrium of the structure



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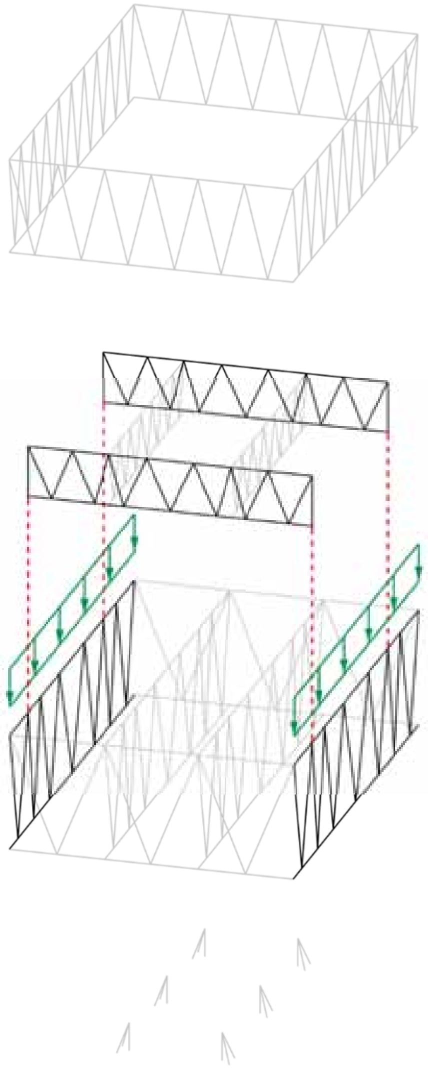

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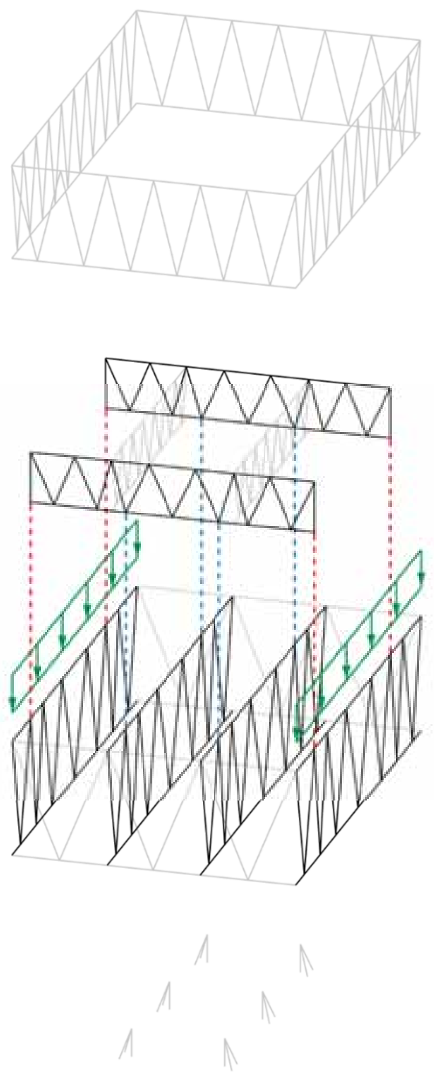

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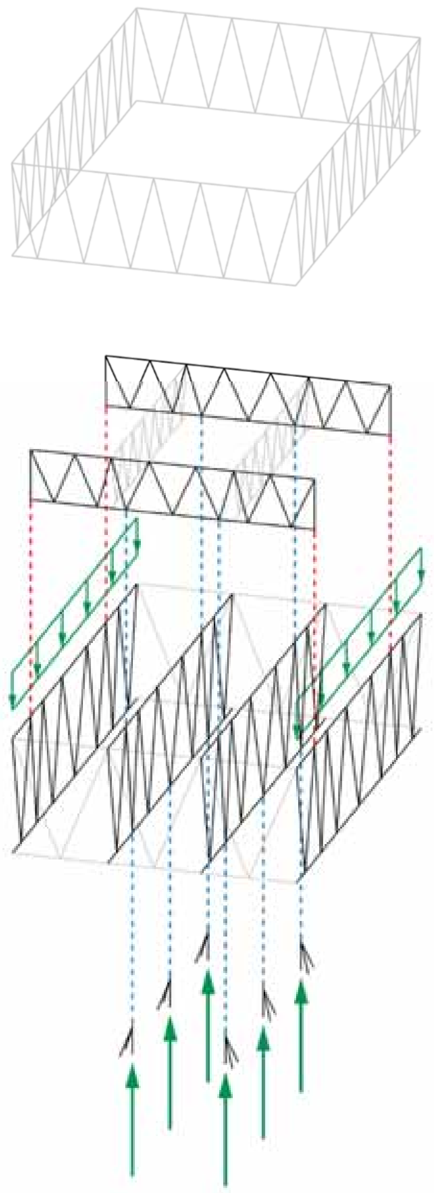

Globales Gleichgewicht der Struktur

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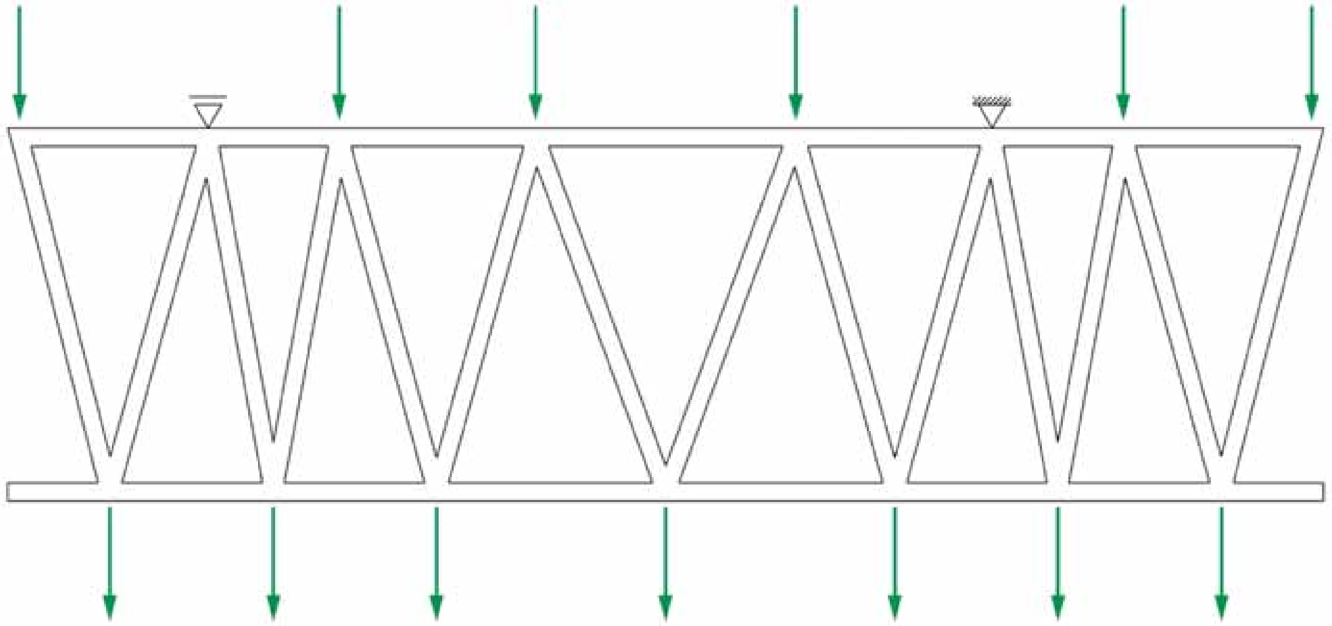
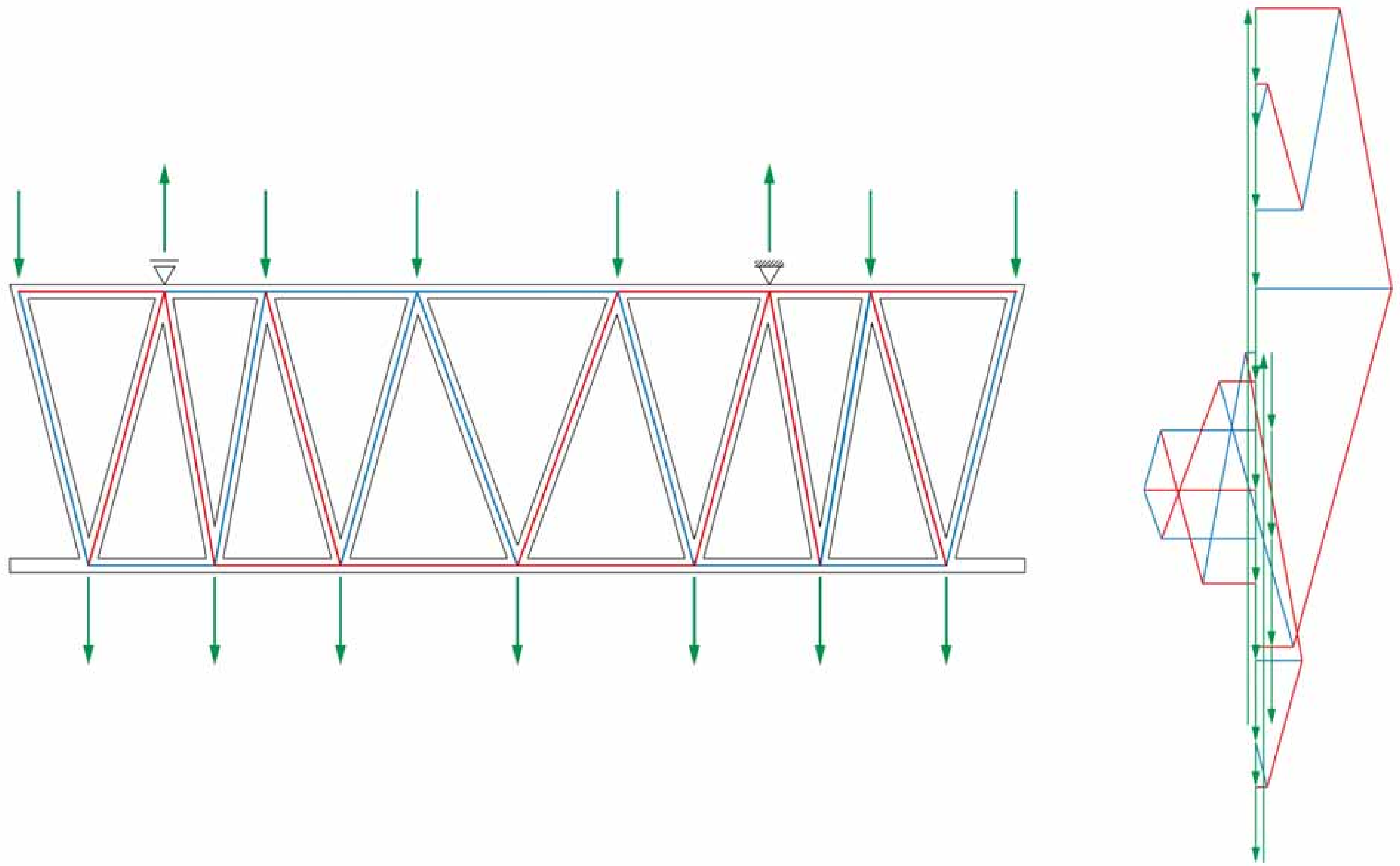


Seitlich hängendes Fachwerk
Lateral hanging truss

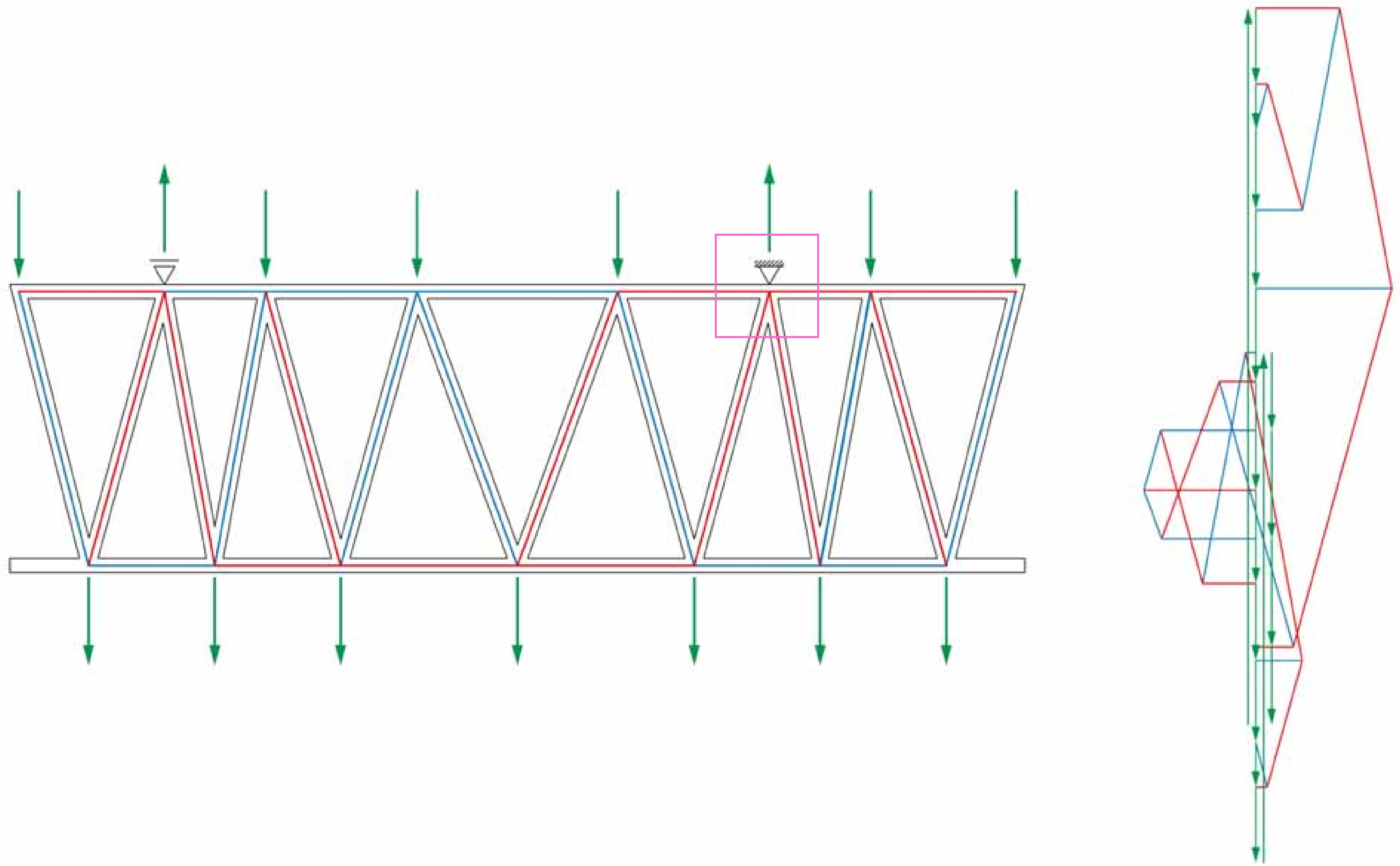


Seitlich hängendes Fachwerk
Lateral hanging truss

Fachwerkverbindung

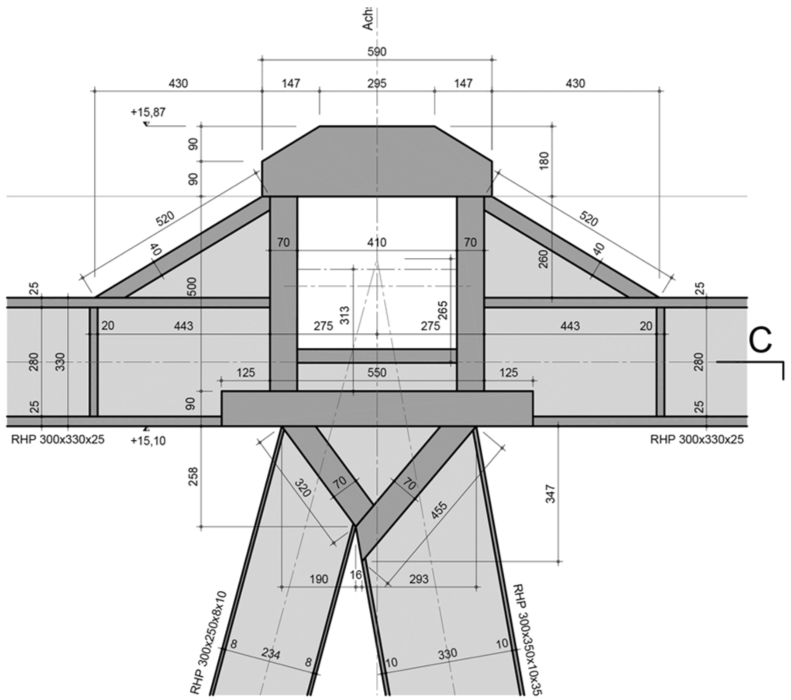
Trusses connection

Fachwerkverbindung
Trusses connection



Detail der Verbindung zwischen Fachwerkbindern

Detail of the connection between trusses



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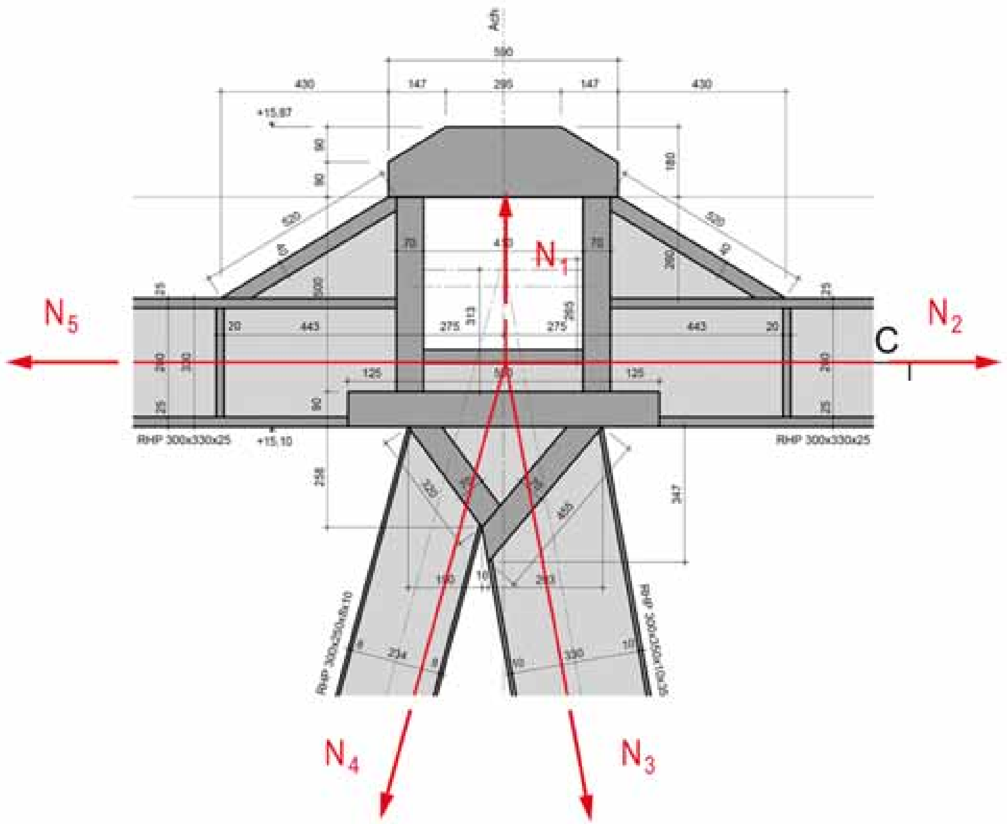

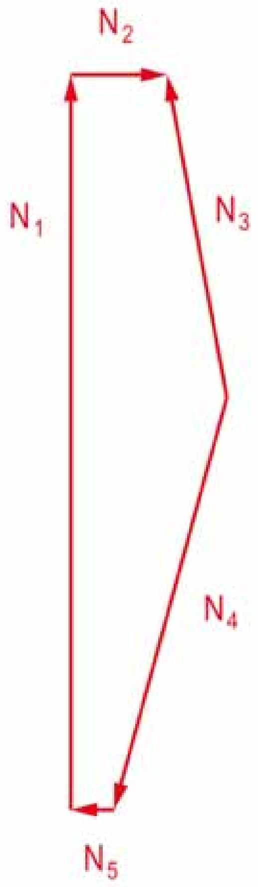

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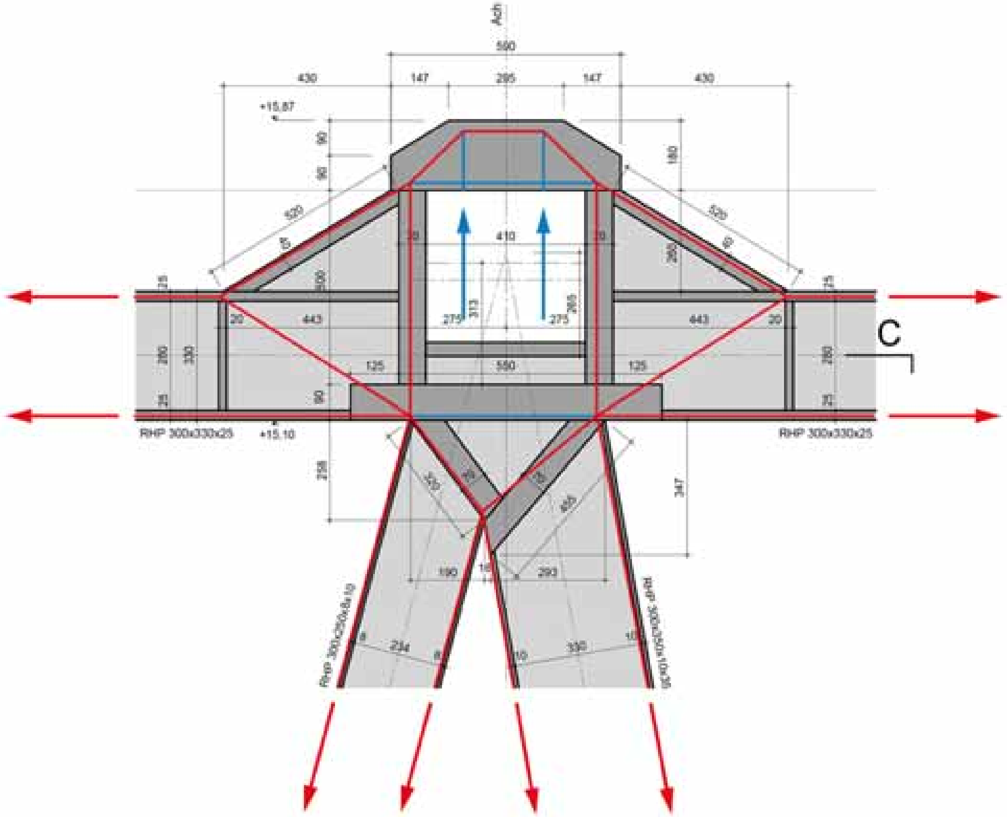

Detail der Verbindung zwischen Fachwerkbindern

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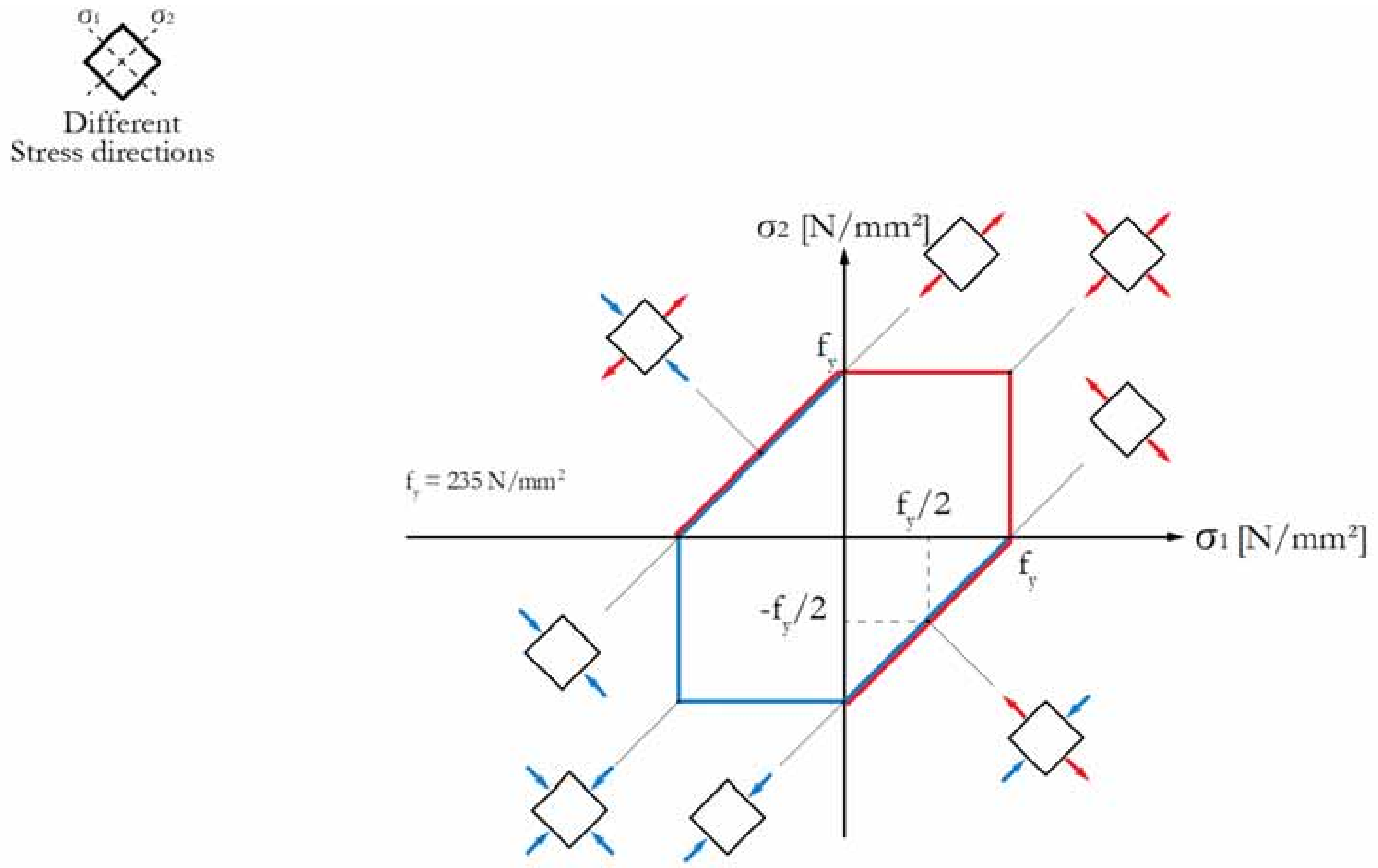


Stahl, Versagenskriterium in 2D

Steel, failure criterion in 2D

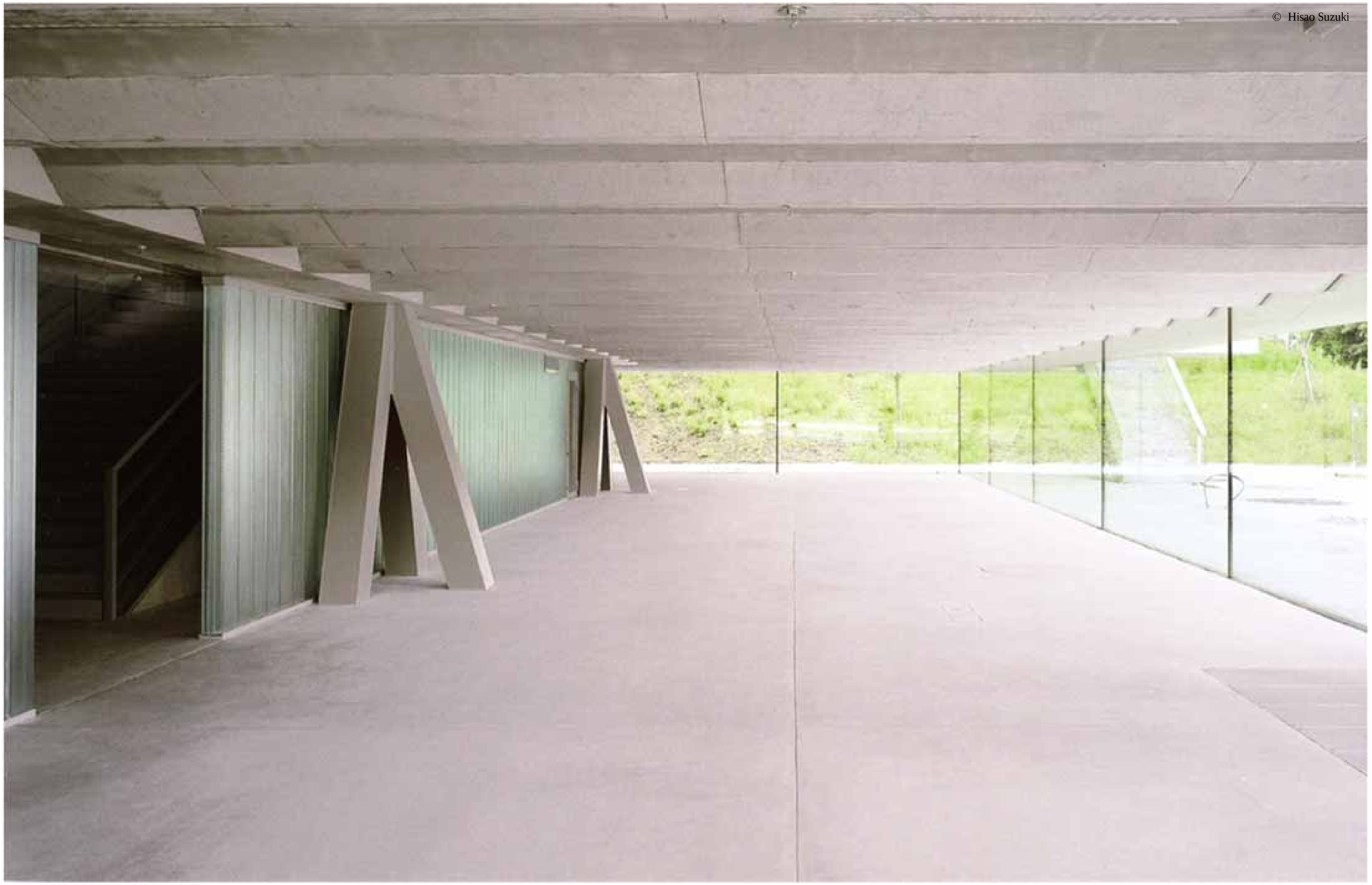
Gebäude im Bau
Building under construction

Gebäude im Bau

Building under construction

Innenansicht

Interior view



Stützen des Gebäudes
Building's supports

Stützen des Gebäudes

Building's supports

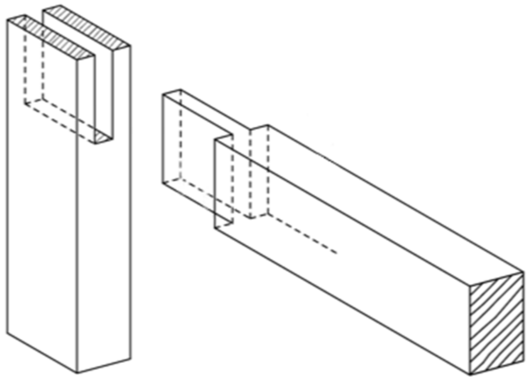
Äußere Ansicht des Gebäudes

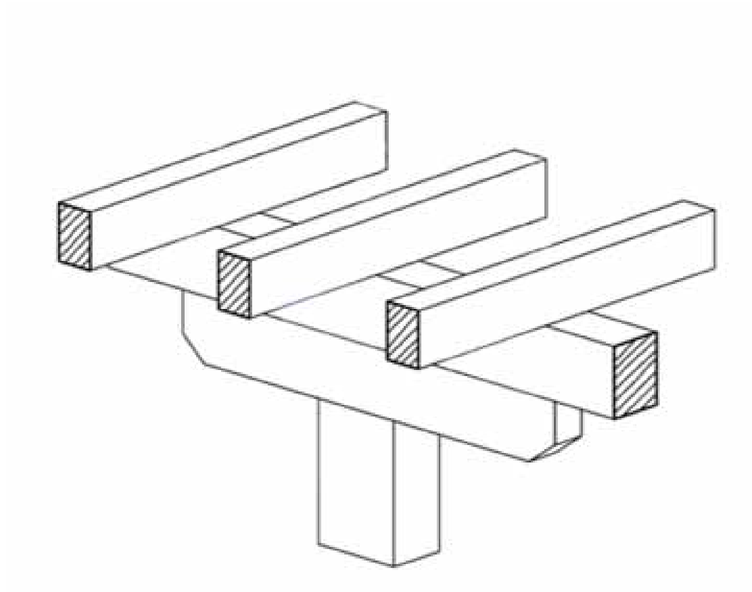
Exterior view of the building

Äußere Ansicht des Gebäudes

Exterior view of the building

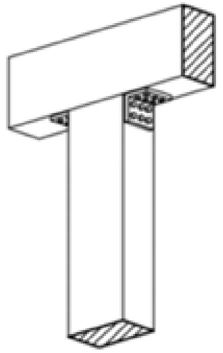
Konstruktionsdetails
Construction details

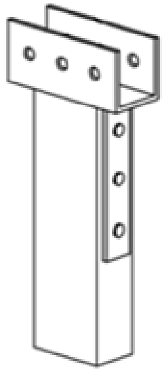




Balken - Holz

Beams – Timber





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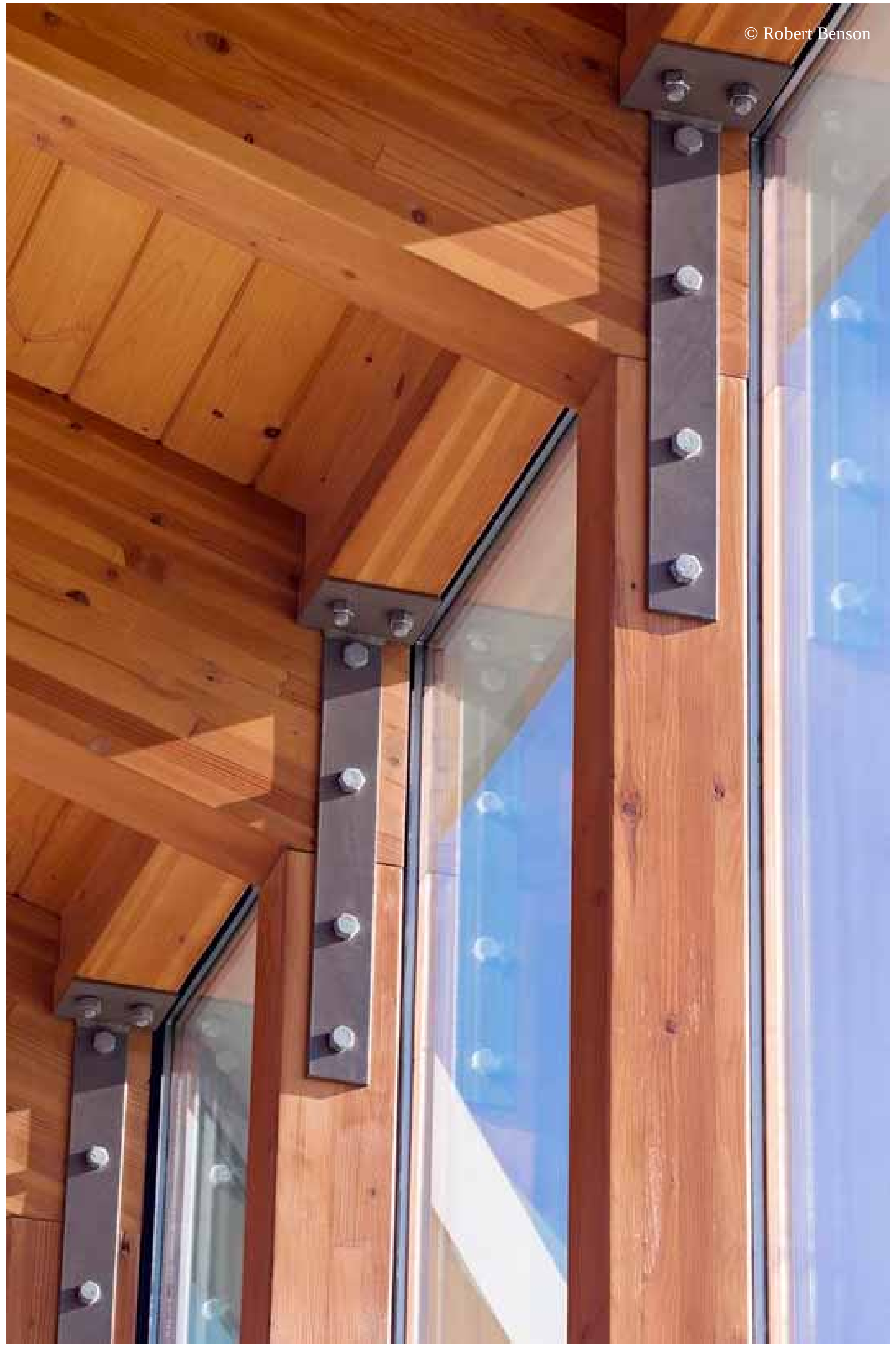

© Robert Benson

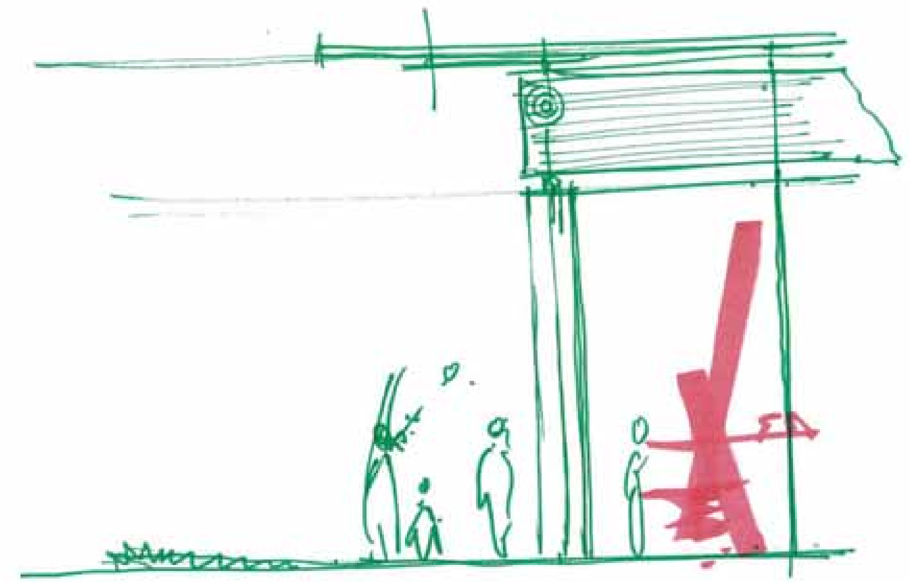
Kimbell Art Museum Expansion

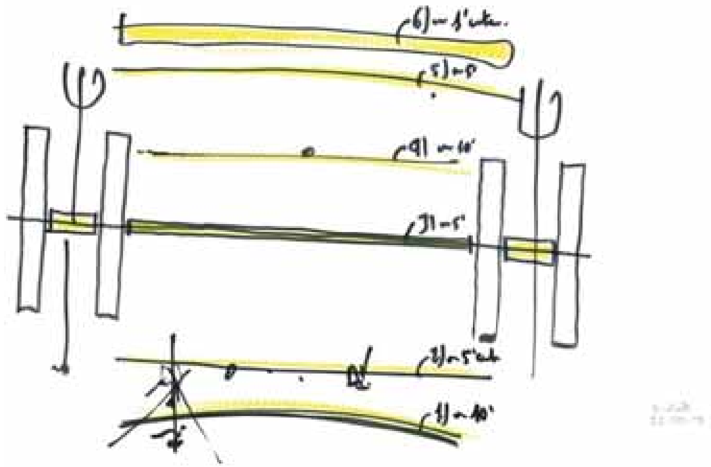
Fort Worth, 2013

Architect: Renzo Piano Building Workshop, Kendall/Heaton Associates

Engineer: Guy Nordenson and Associates

Gesamtansicht des Museums
General view of the museum

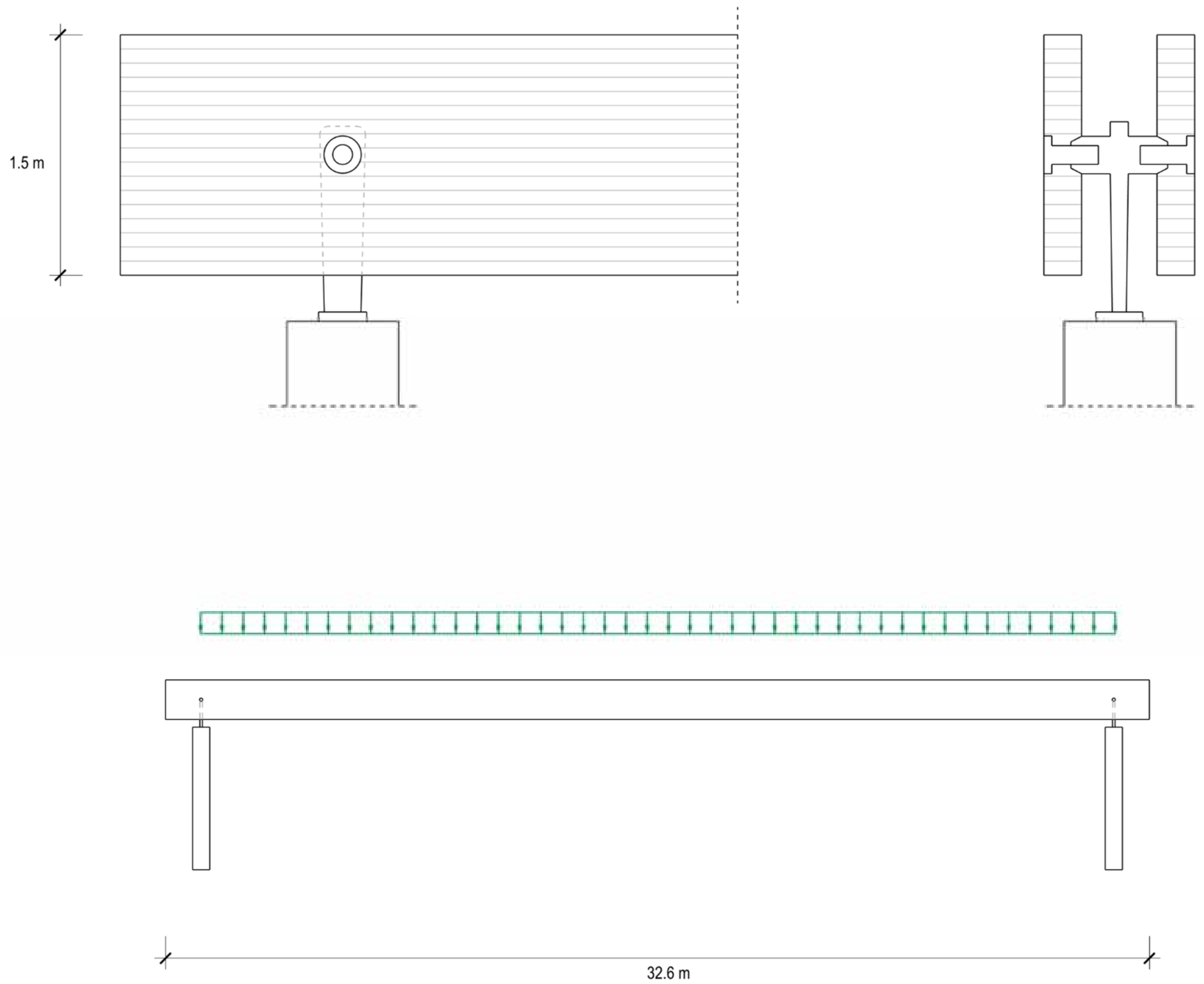




Renzo Pianos Entwurfsskizzen

Renzo Piano's design sketches

Verbindung zwischen den Brettschichtholzträgern und den Betonstützen
Connection between the glue laminated beams and the concrete columns



Verbindung zwischen den Brettschichtholzträgern und den Betonstützen

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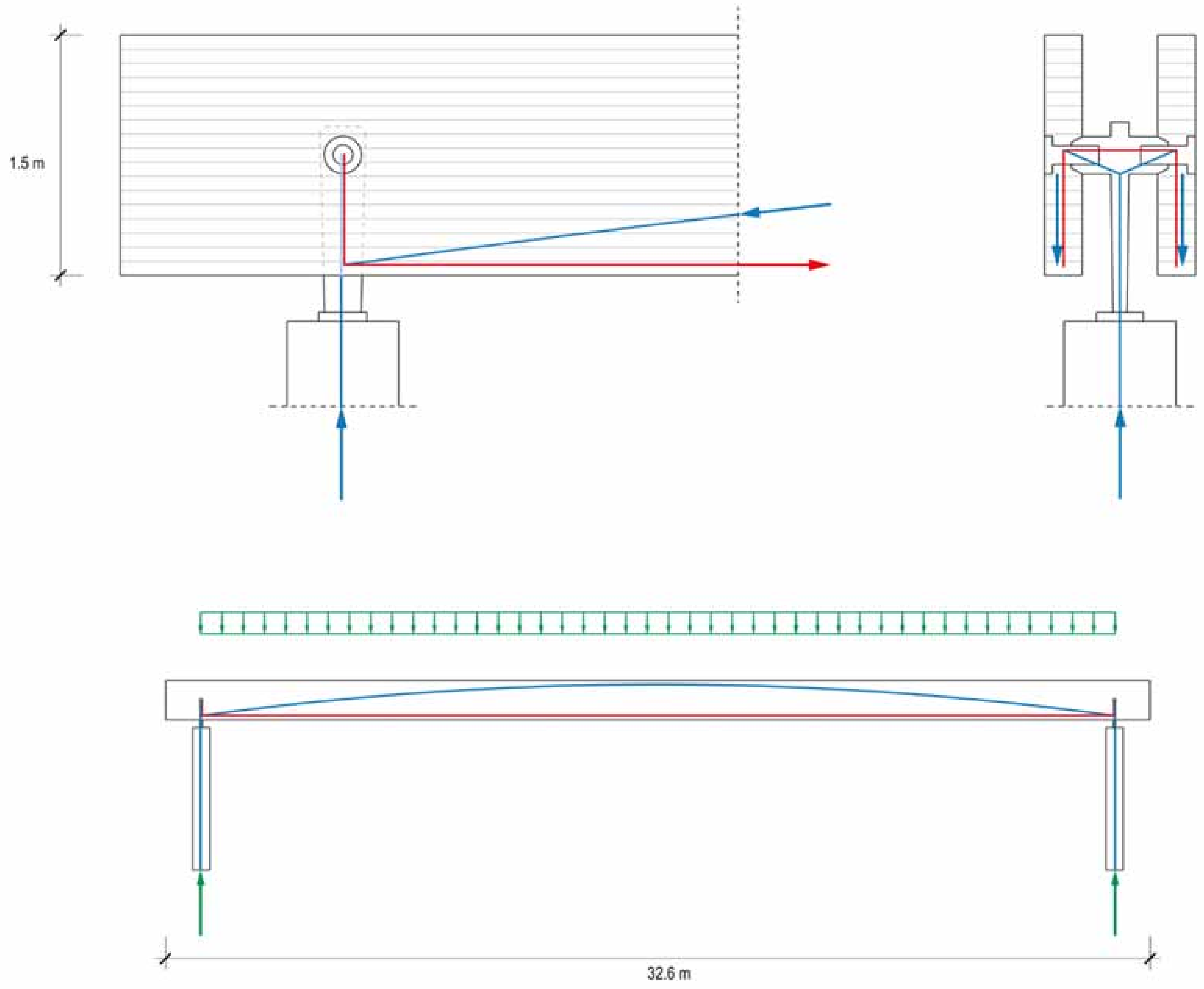

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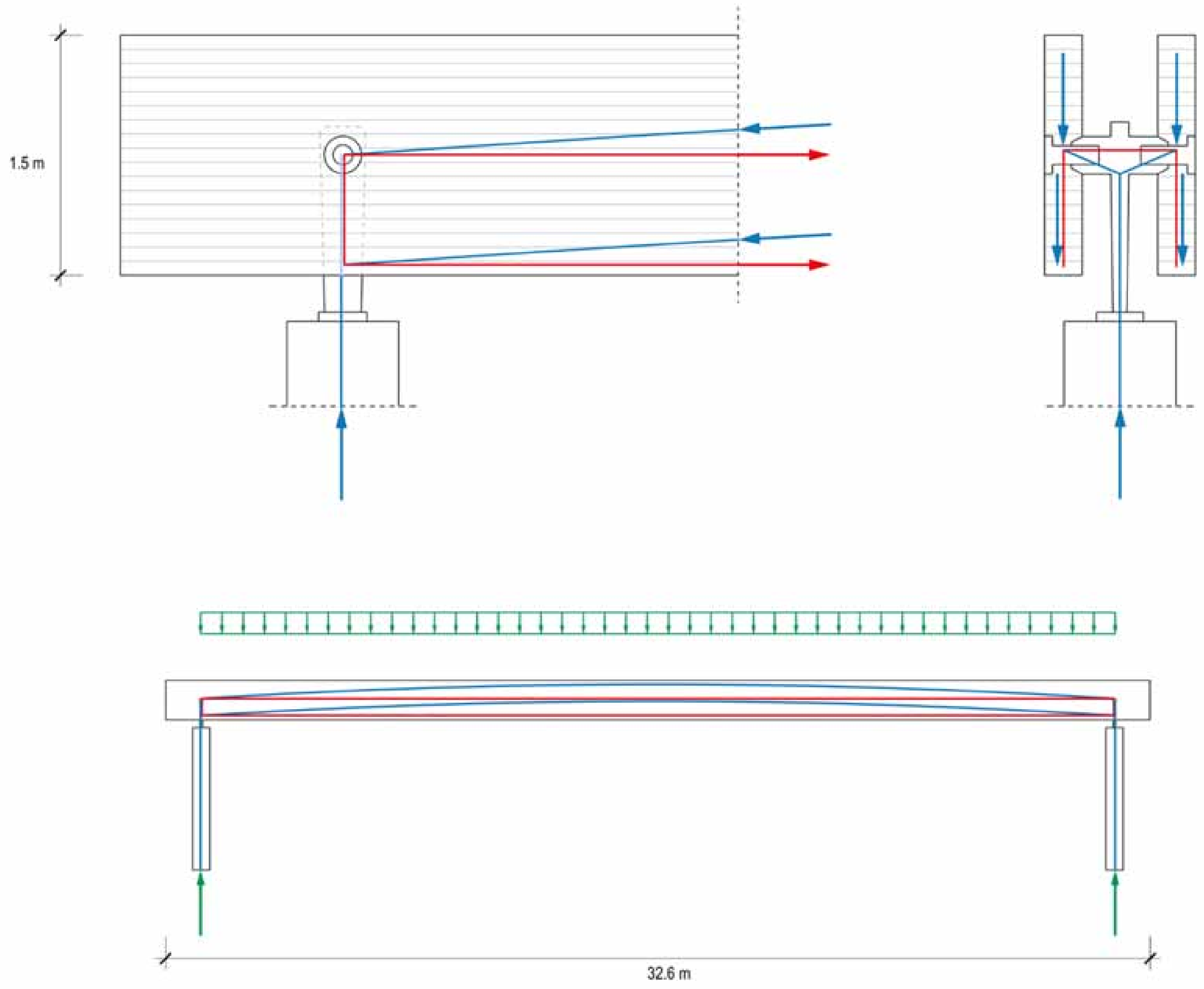

Verbindung zwischen den Brettschichtholzträgern und den Betonstützen
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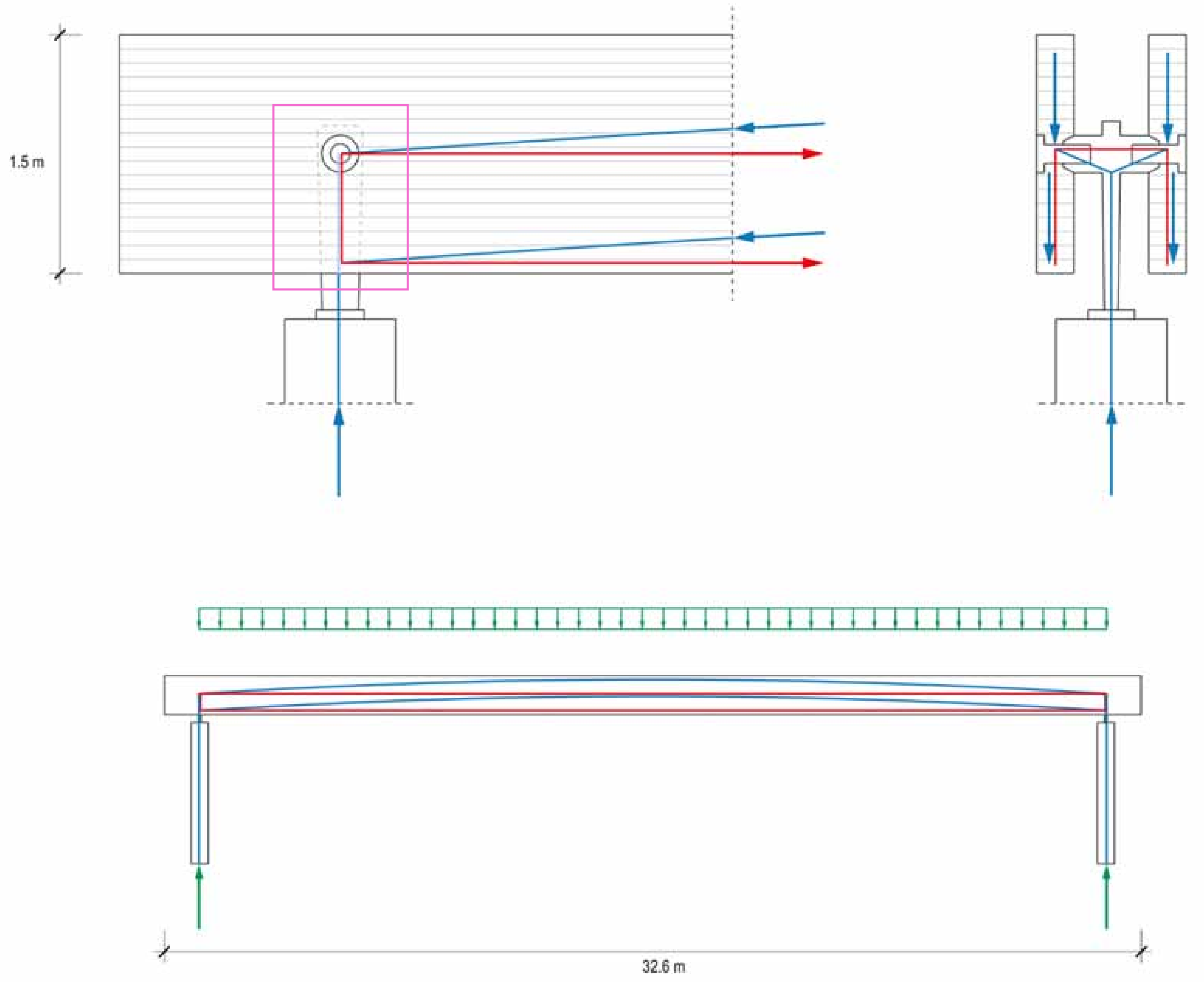

Verbindung zwischen den Brettschichtholzträgern und den Betonstützen

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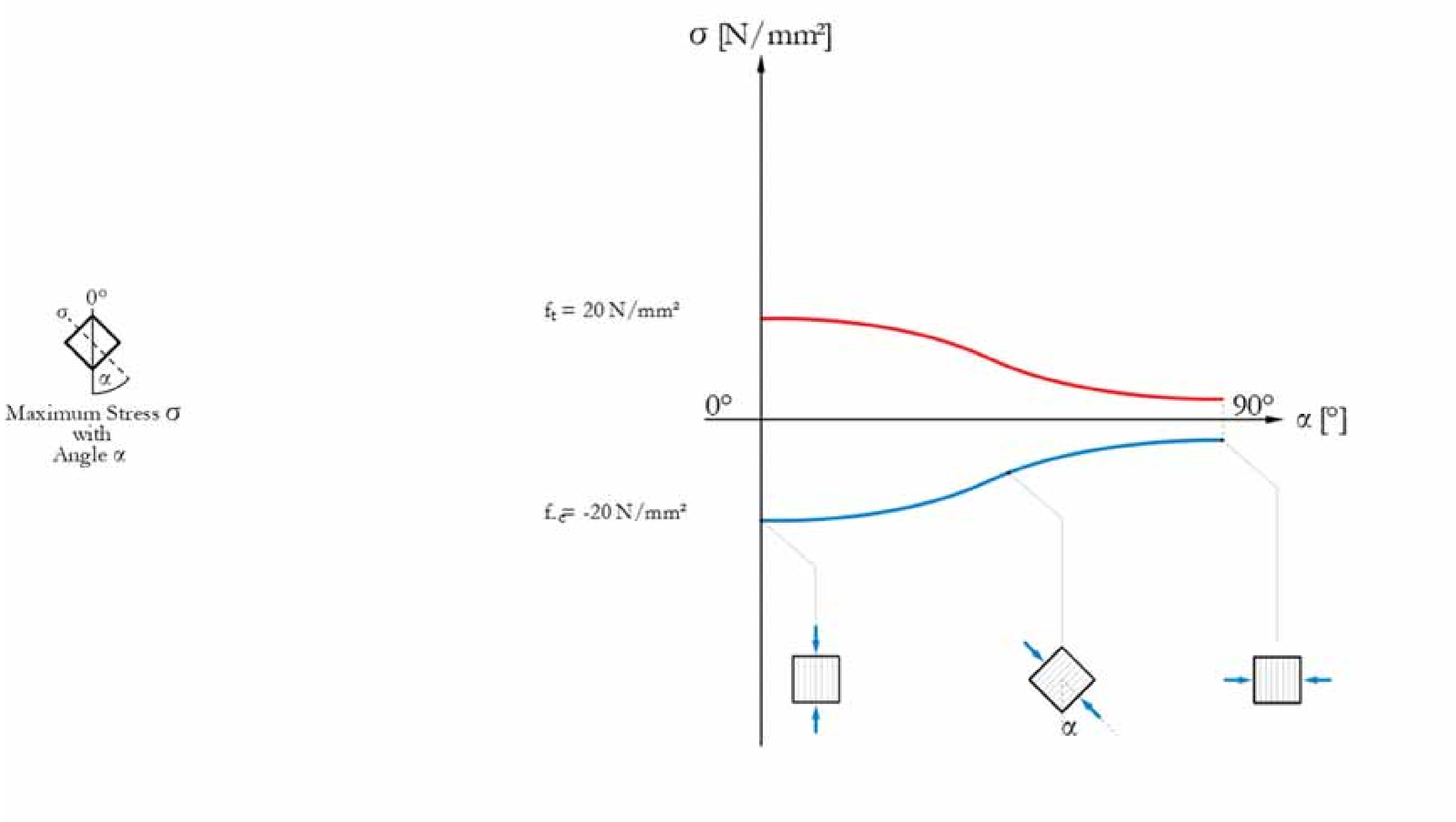
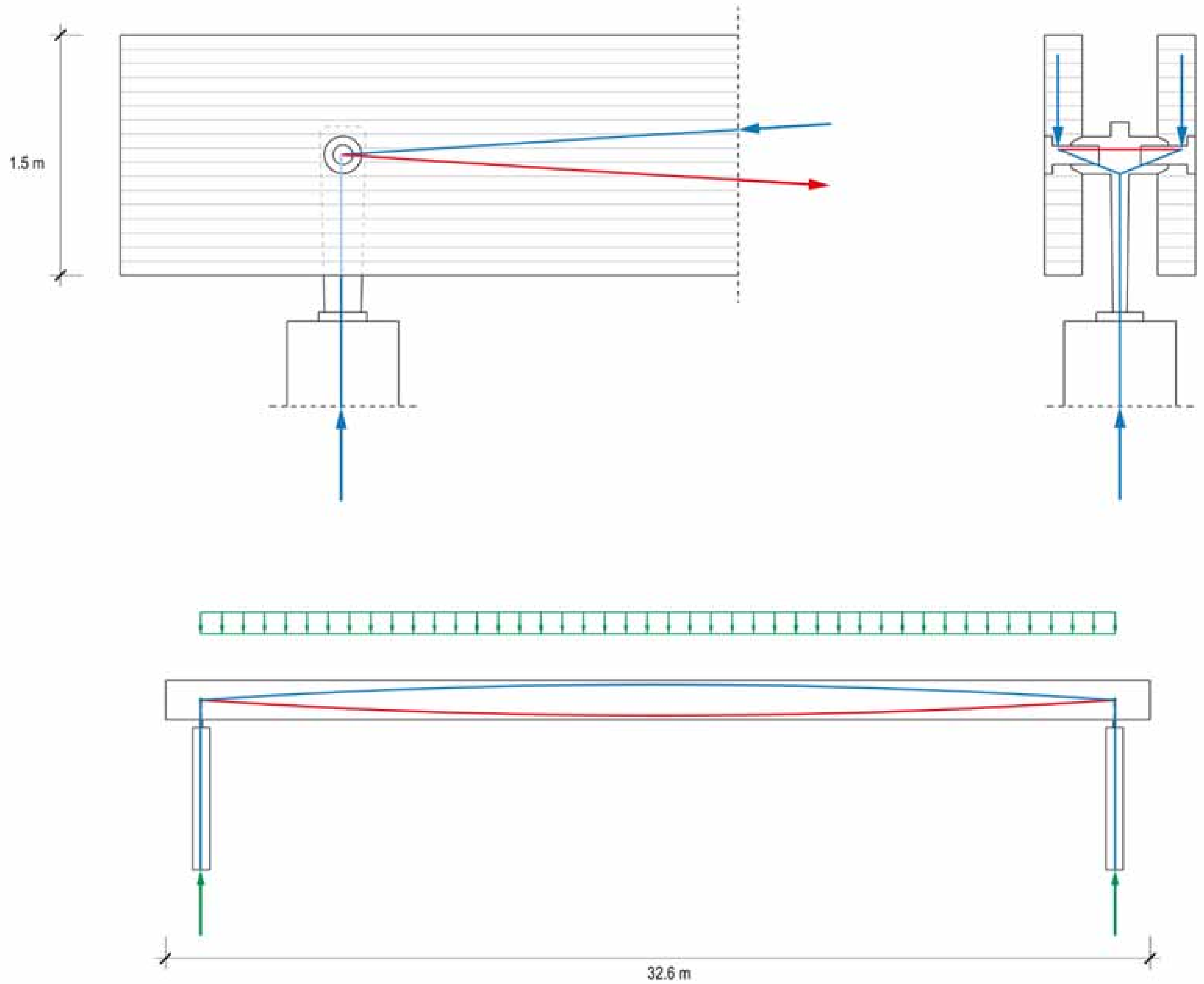
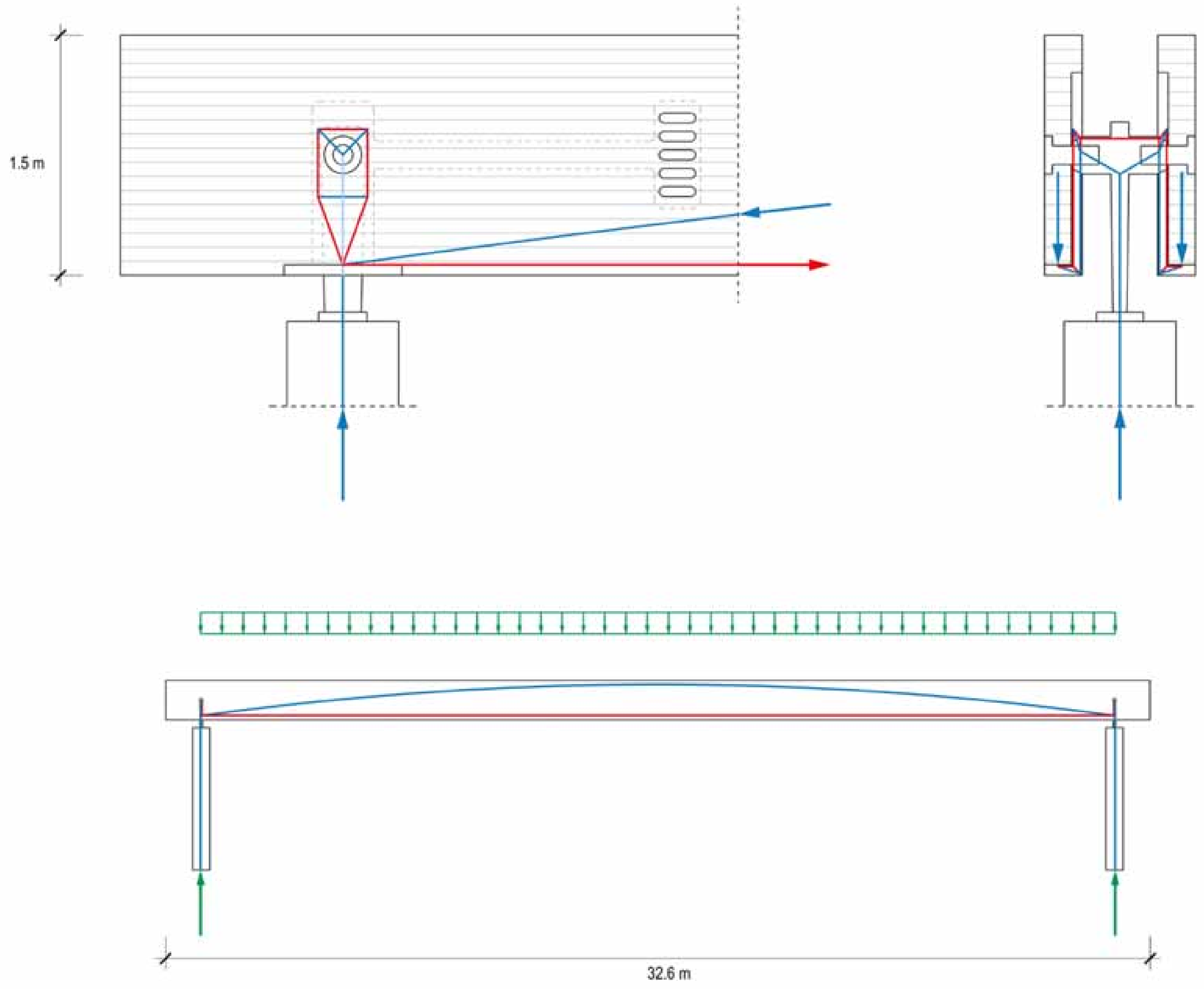


Holz (Tannenholz), Veränderung der Festigkeit in Abhängigkeit des Spannungswinkels
Timber (Fir wood), strength variation according to the stress angle



Verbindung zwischen den Brettschichtholzträgern und den Betonstützen

Connection between the glue laminated beams and the concrete columns



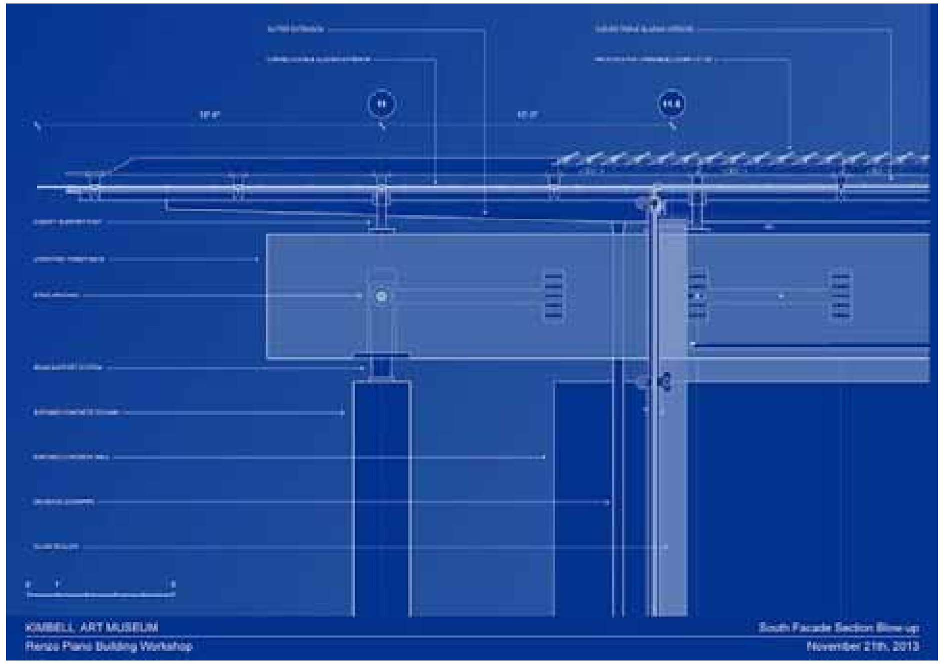
Verbindung zwischen den Brettschichtholzträgern und den Betonstützen

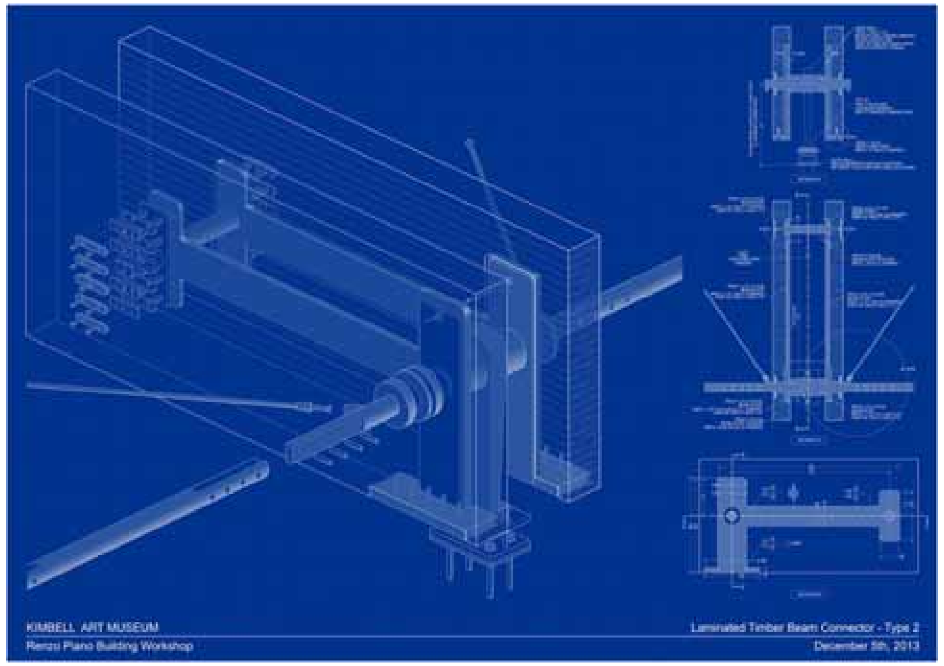
Connection between the glue laminated beams and the concrete columns

Balken aus Brettschichtholz
Glue laminated beams

Balken aus Brettschichtholz

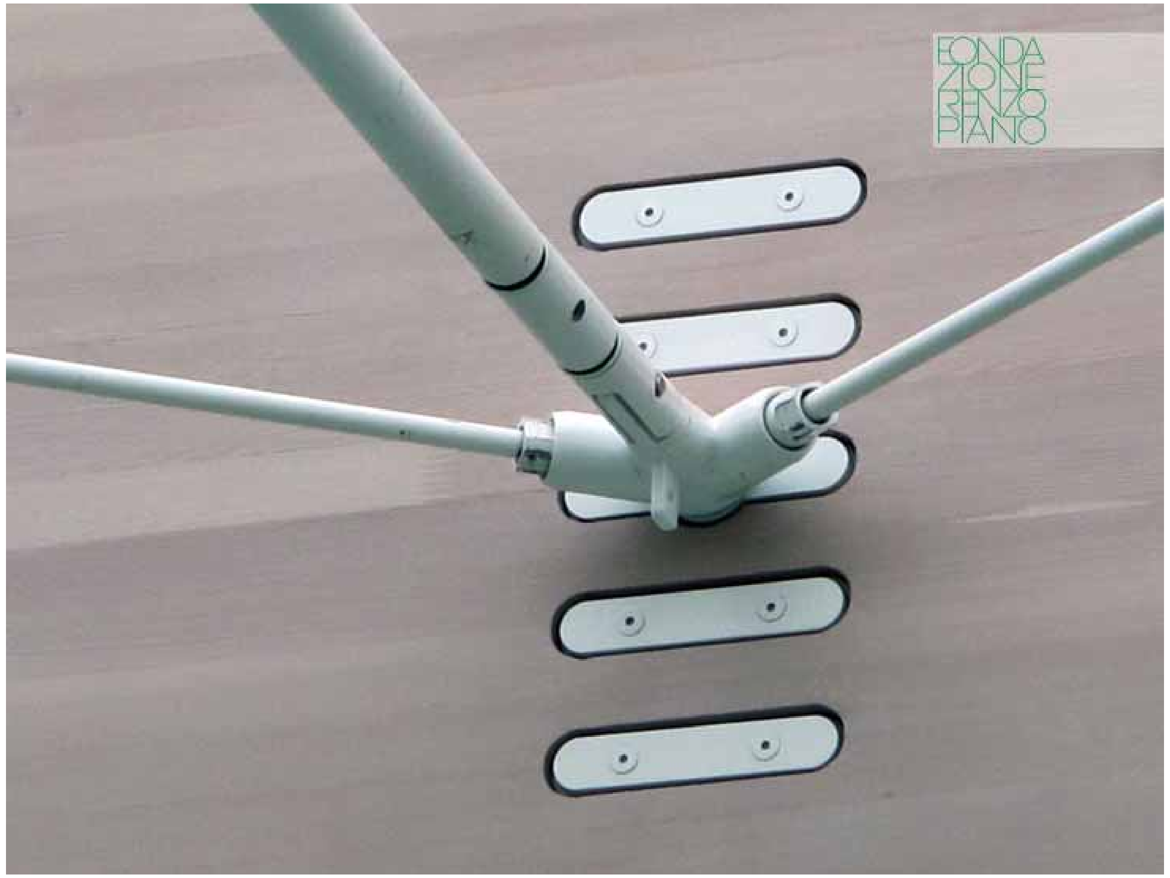
Glue laminated beams





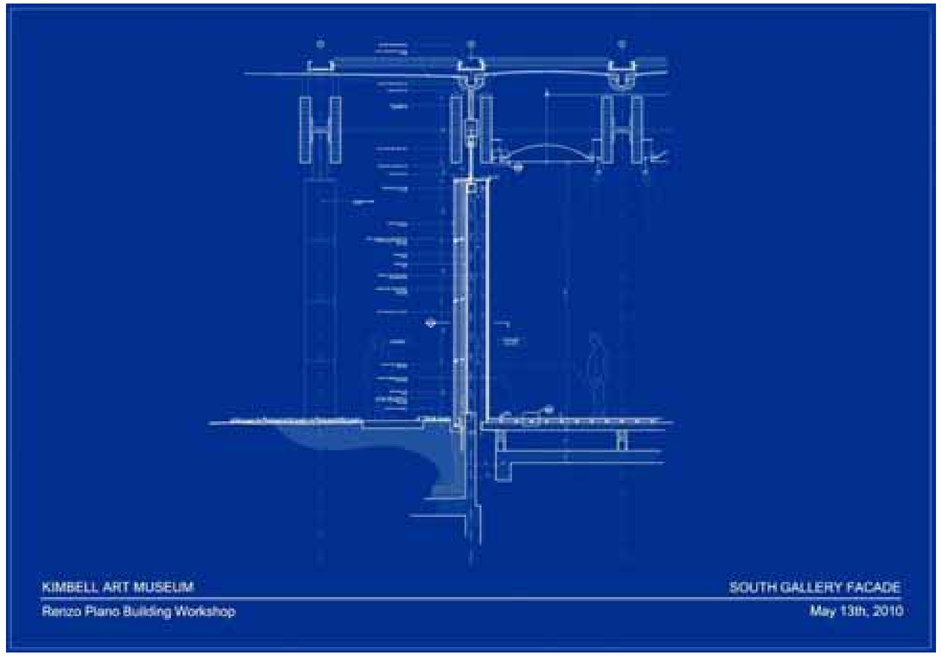
Balken aus Brettschichtholz

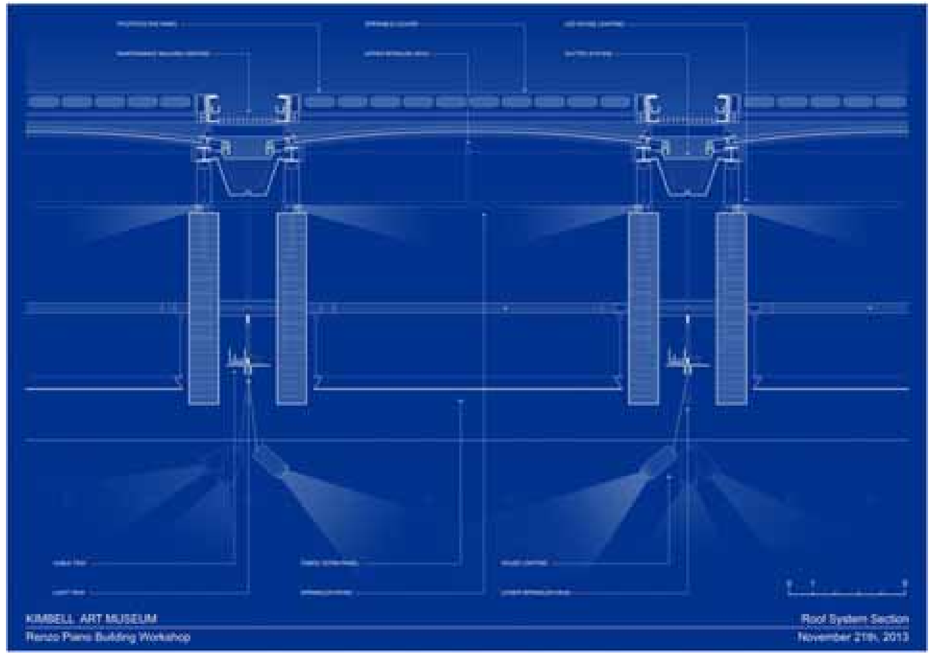
Glue laminated beams



Balken aus Brettschichtholz

Glue laminated beams

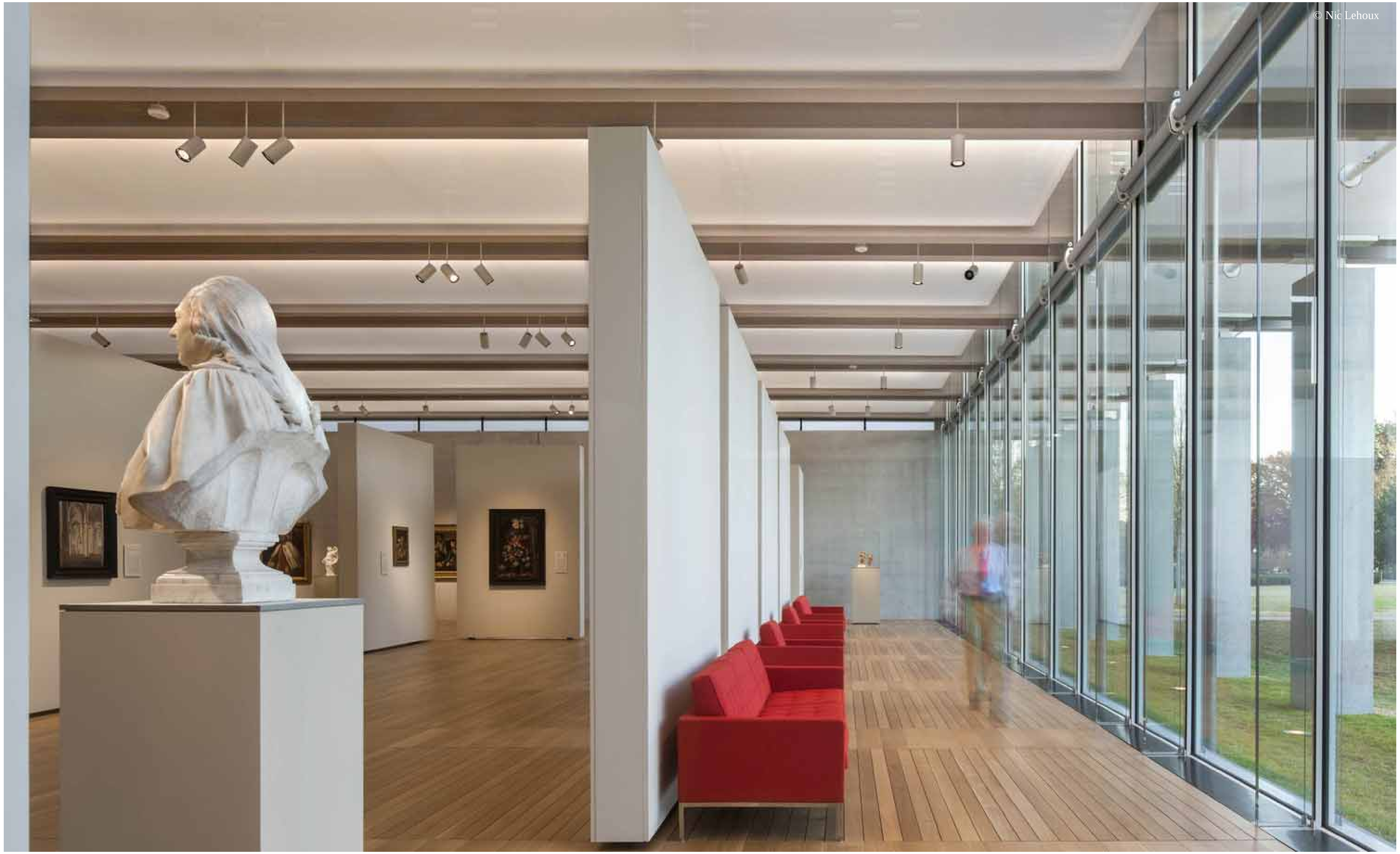




Balken aus Brettschichtholz

Glue laminated beams

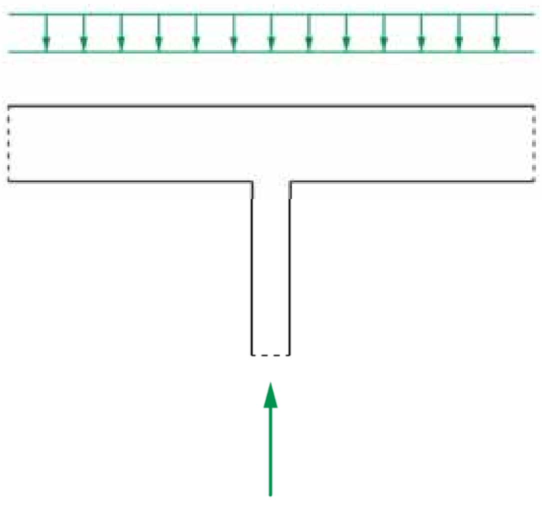
Aussenansicht
Exterior view



Innenansicht

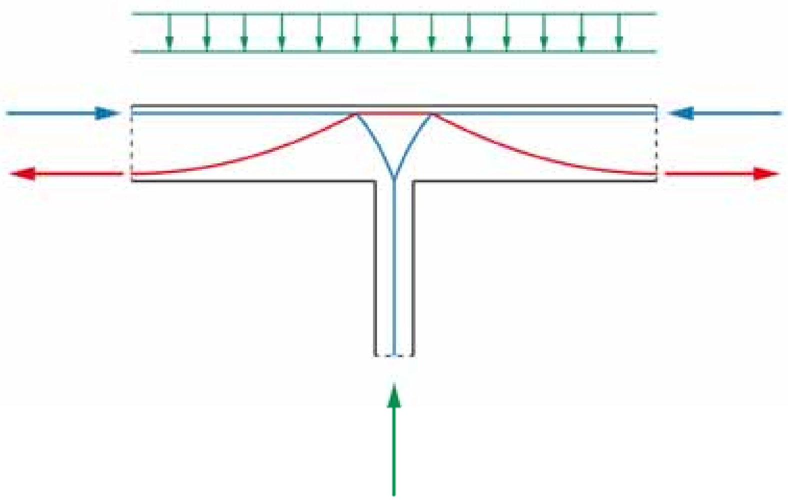
Interior view

Gesamtansicht
General view



Beispiele für Balken- und Stützenverbindungen im Stahlbetonbau

Examples of beams and columns joints in reinforced concrete construction



Beispiele für Balken- und Stützenverbindungen im Stahlbetonbau
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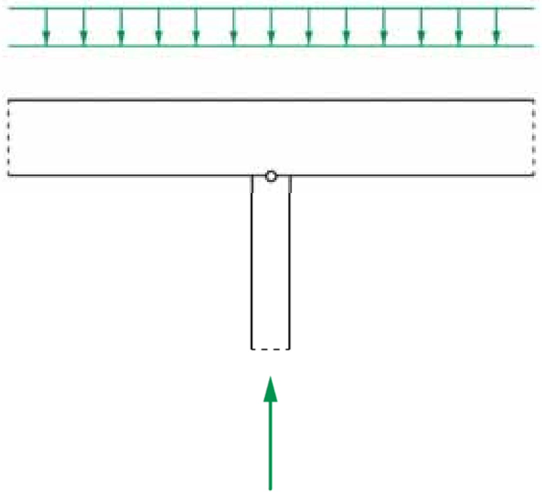

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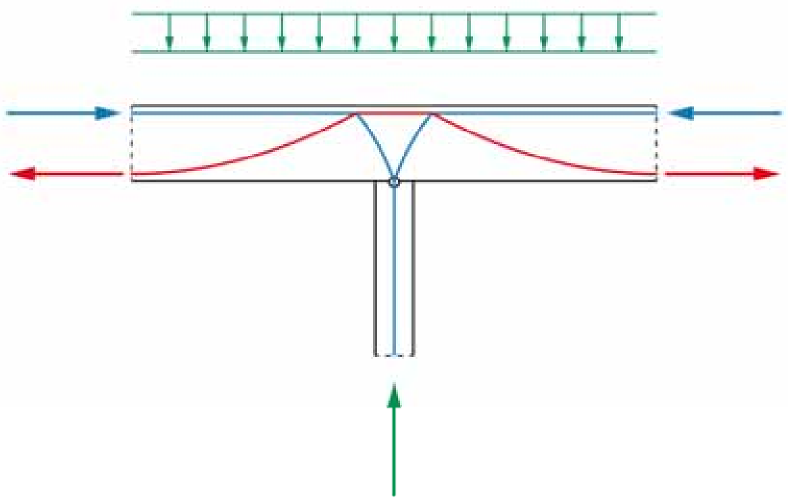

Beispiele für Balken- und Stützenverbindungen im Stahlbetonbau

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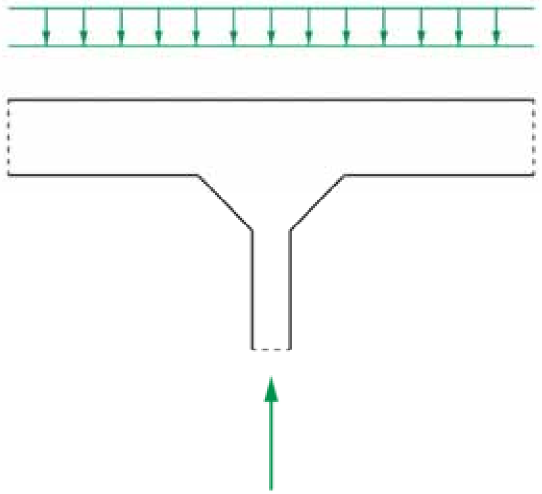

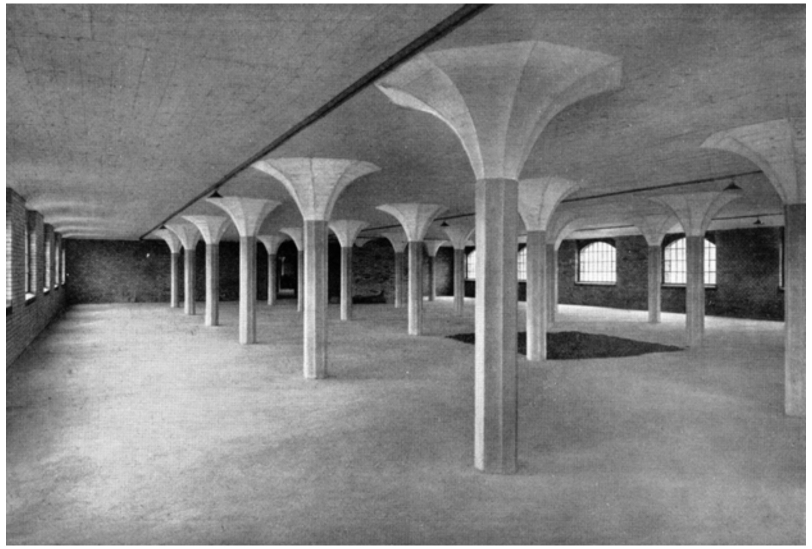

Beispiele für Balken- und Stützenverbindungen im Stahlbetonbau

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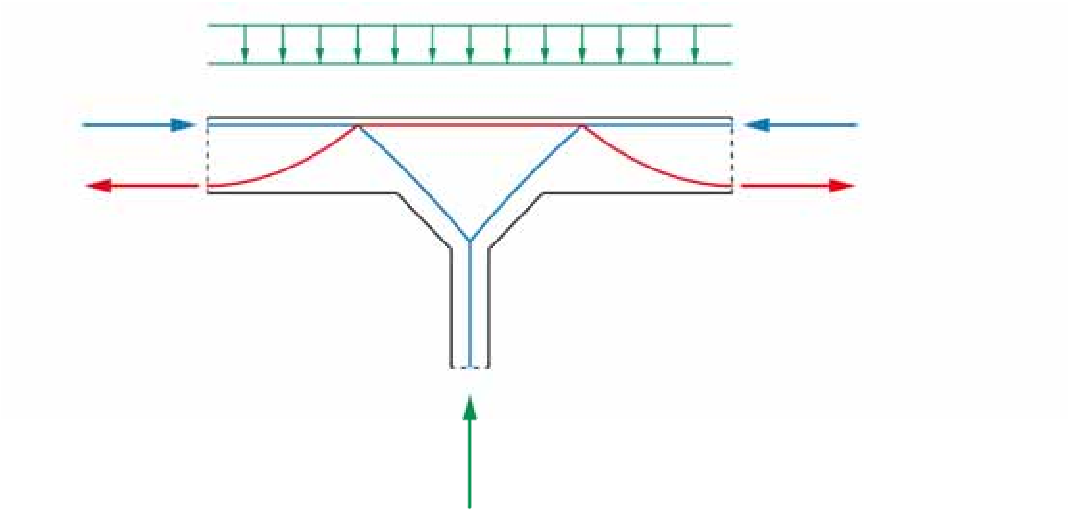

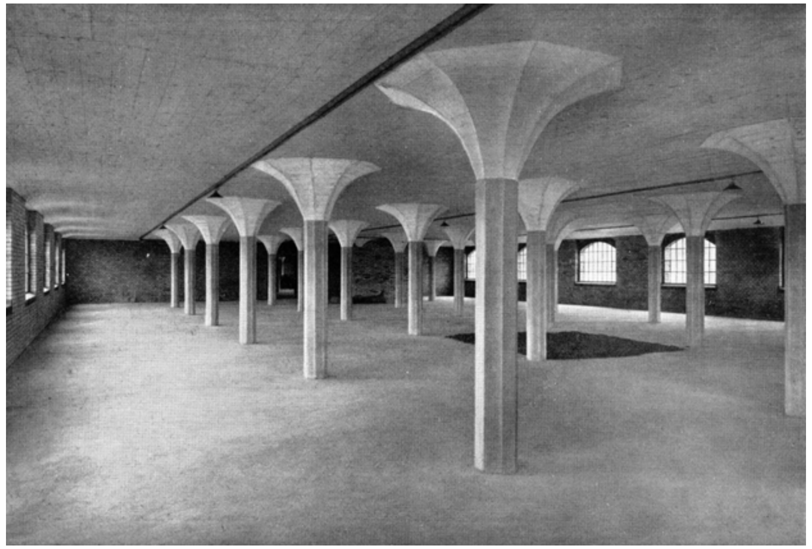

Beispiele für Balken- und Stützenverbindungen im Stahlbetonbau

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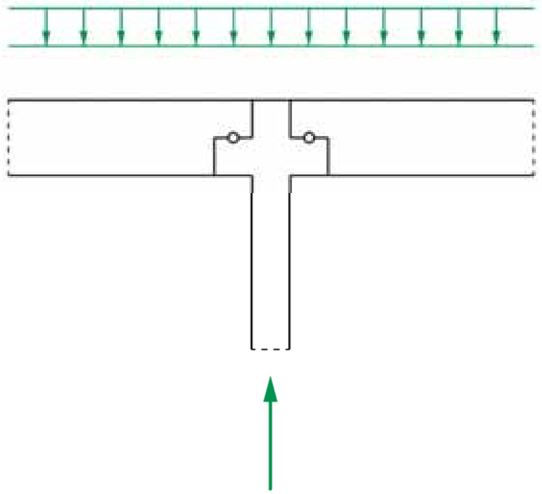
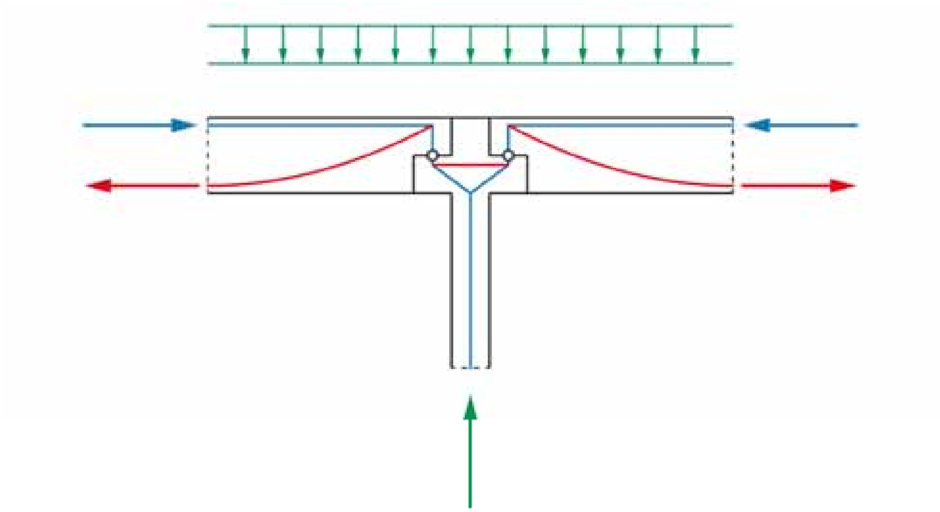
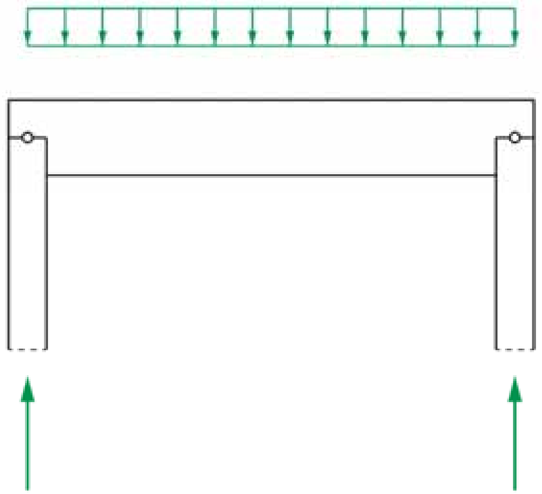
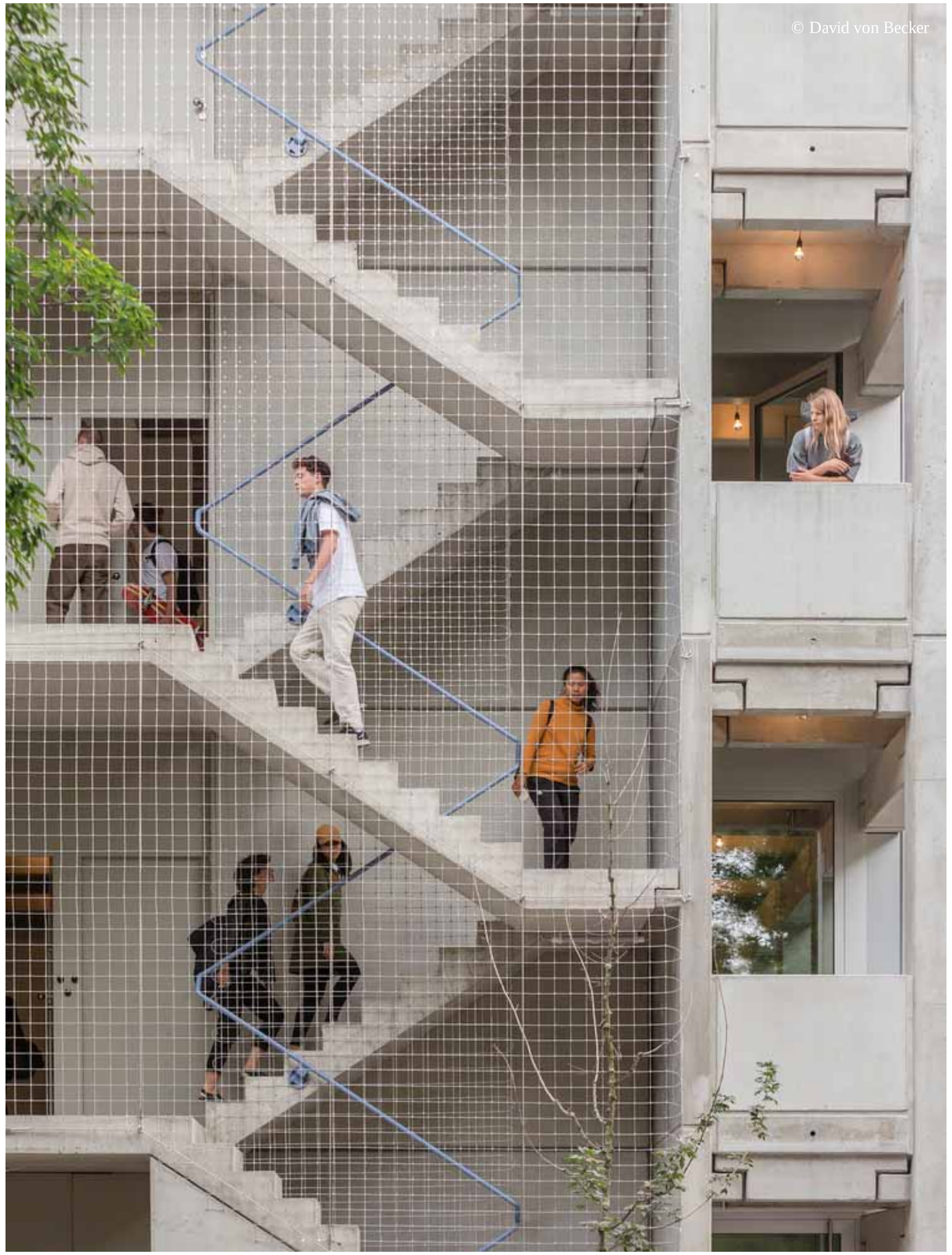


Beispiele für Balken- und Stützenverbindungen im Stahlbetonbau
Examples of beams and columns joints in reinforced concrete construction



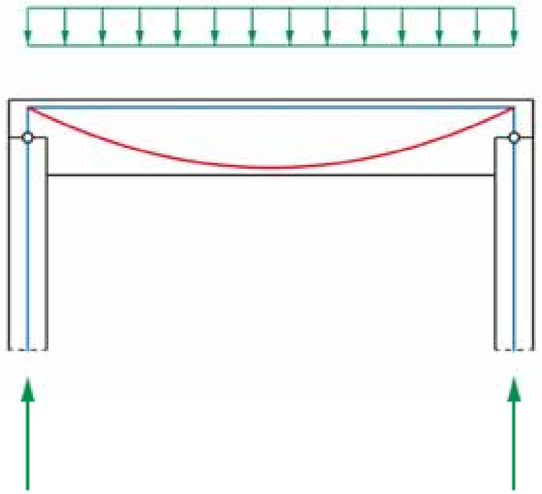
Beispiele für Balken- und Stützenverbindungen im Stahlbetonbau
Examples of beams and columns joints in reinforced concrete construction

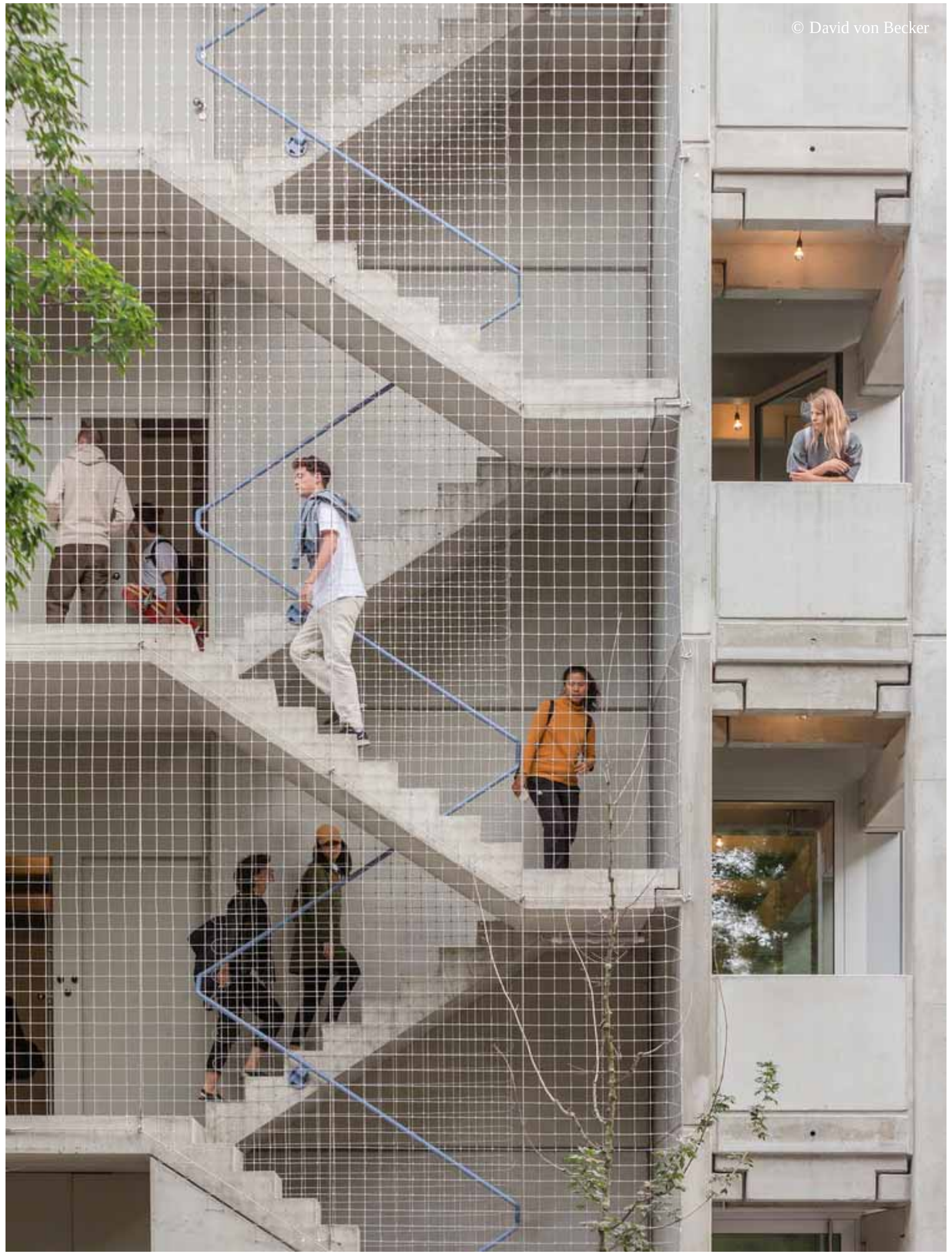




Beispiele für Balken- und Stützenverbindungen im Stahlbetonbau

Examples of beams and columns joints in reinforced concrete construction





Beispiele für Balken- und Stützenverbindungen im Stahlbetonbau

Examples of beams and columns joints in reinforced concrete construction

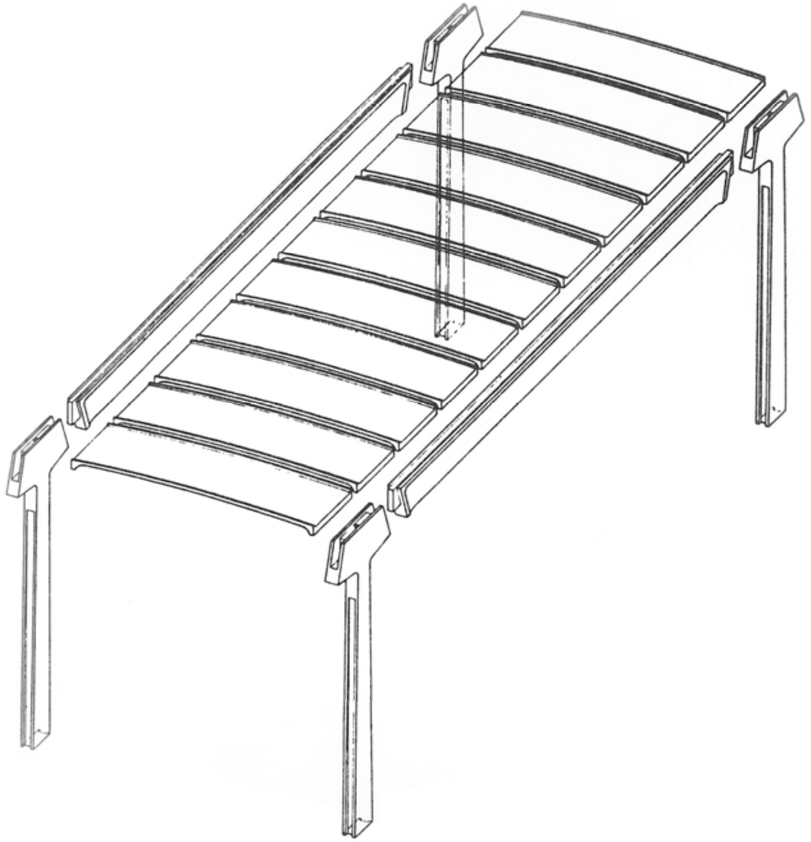
Elmag Factory

Lissone, 1963-66

Architect: Angelo Mangiarotti

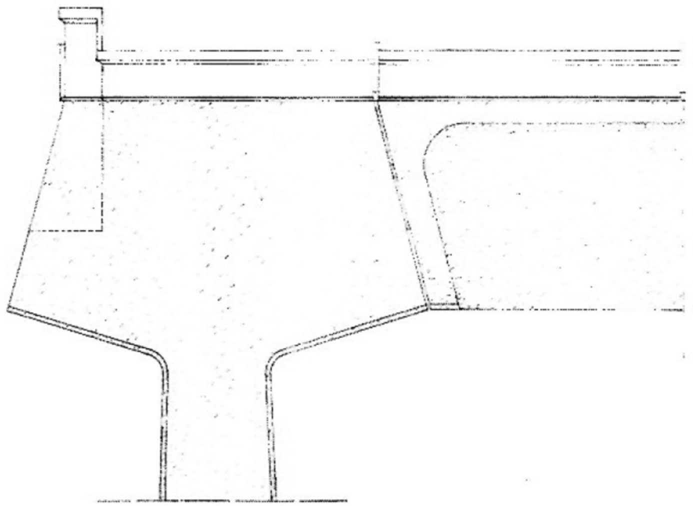
Engineer: Alessandro Sbriscia Fioretti

Gesamtansicht der Fabrik
General view of the factory



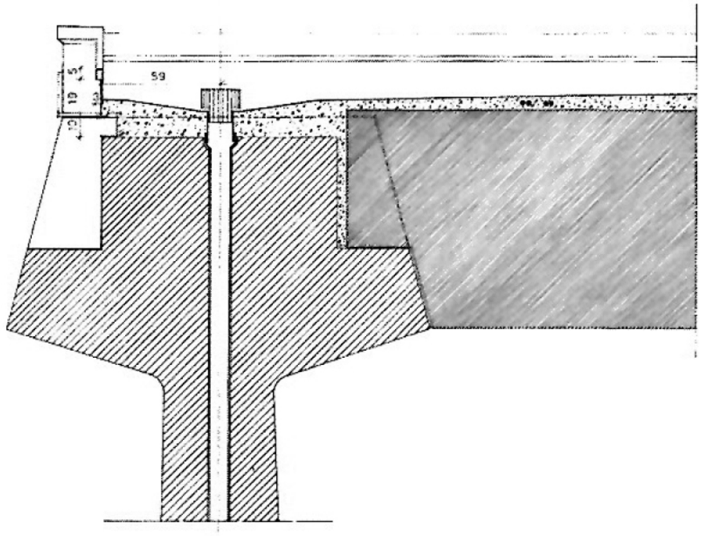
Vorgefertigtes System von Trägern und Stützen

Prefabricated system of beams and columns



Verbindung von Trägern und Stützen

Beams and columns connection



Verbindung von Trägern und Stützen

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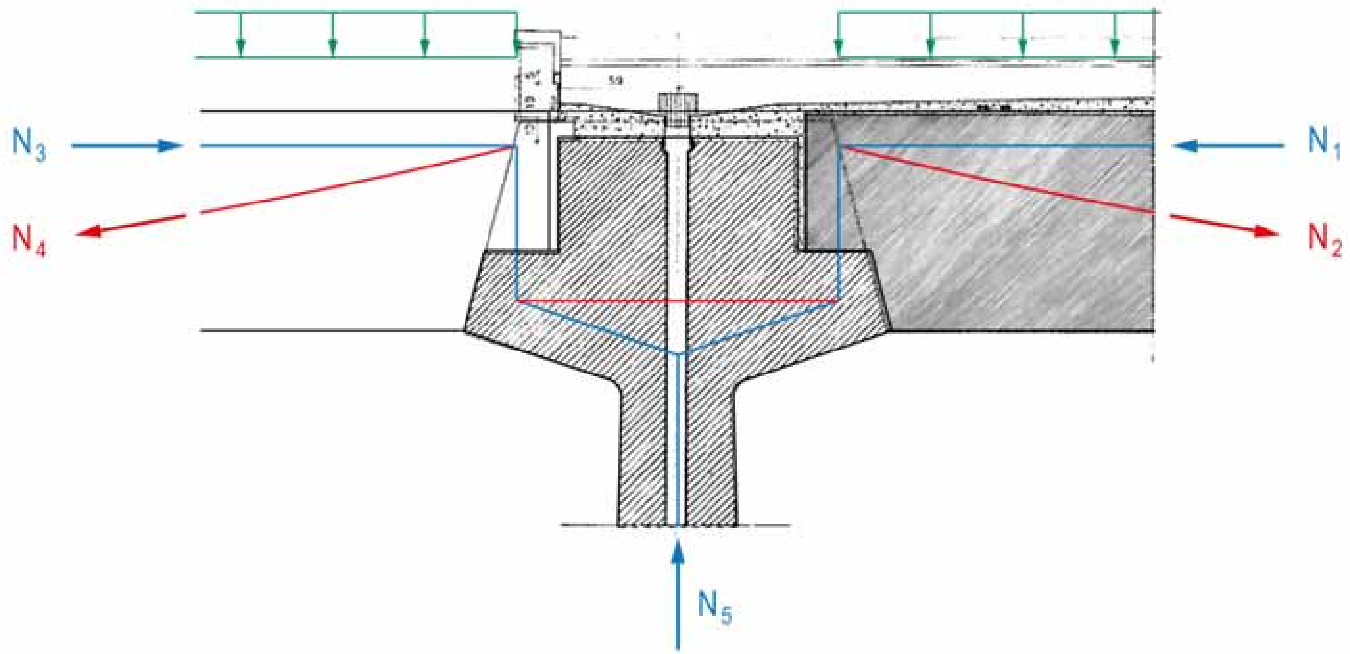
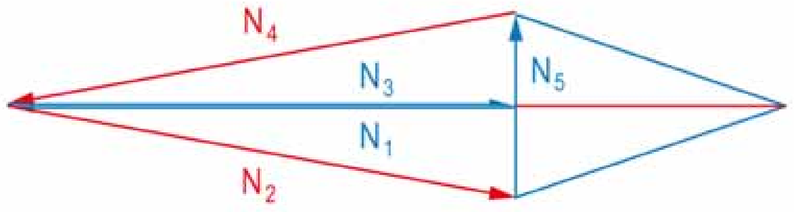
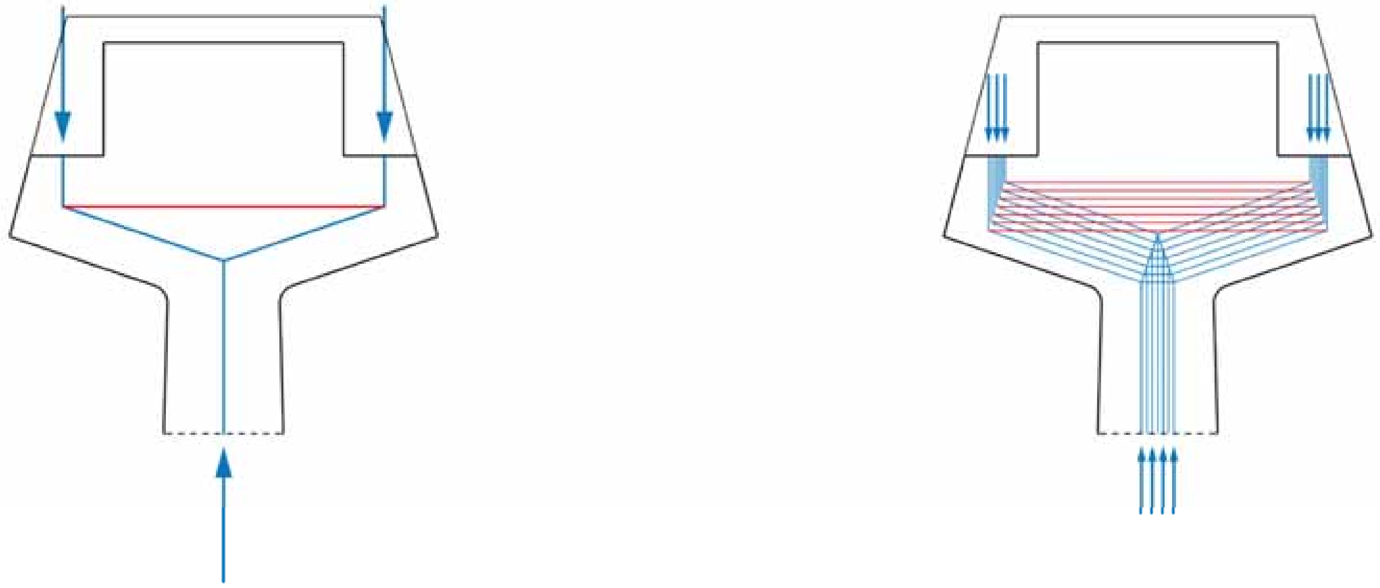
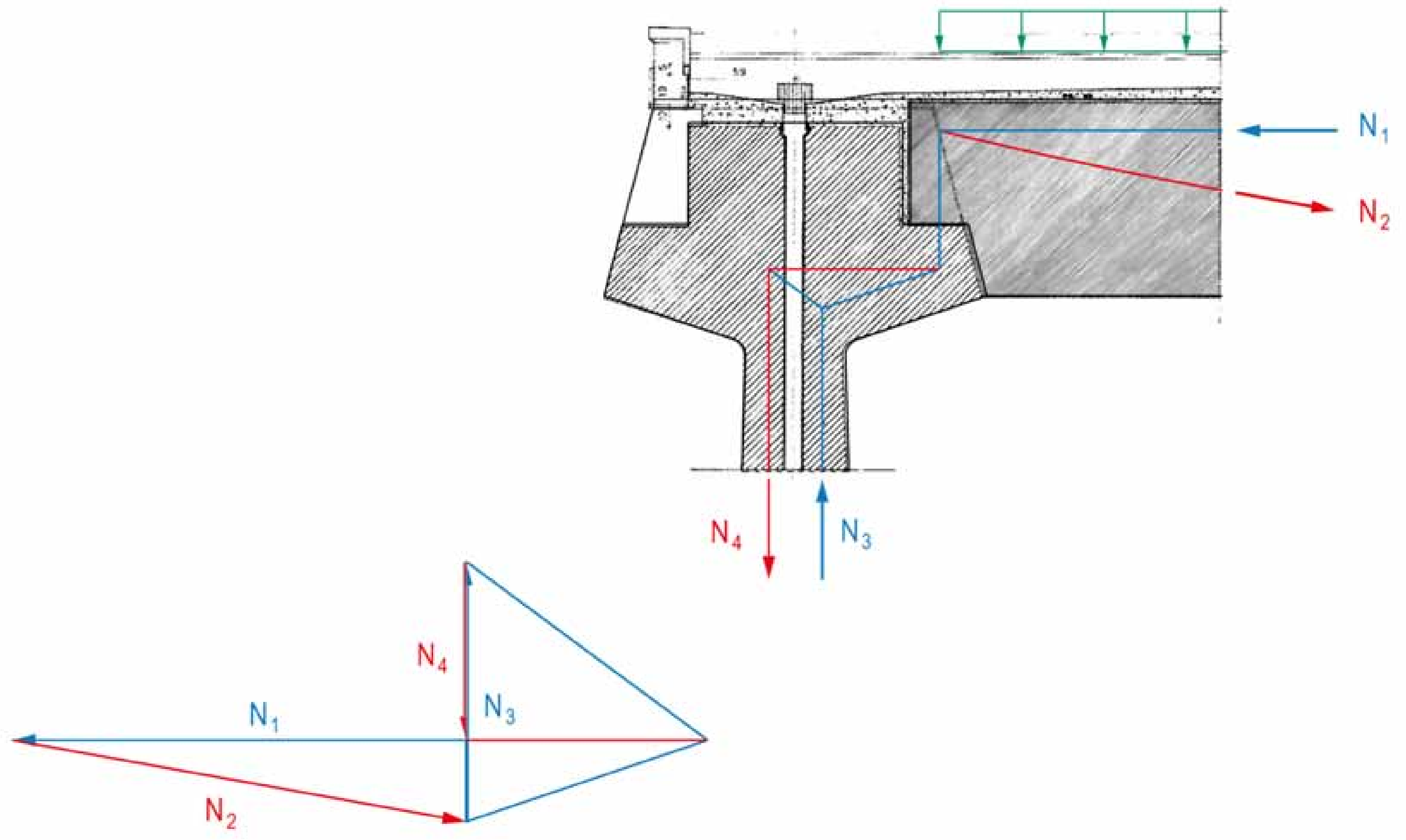




Verbindung von Trägern und Stützen
Beams and columns connection

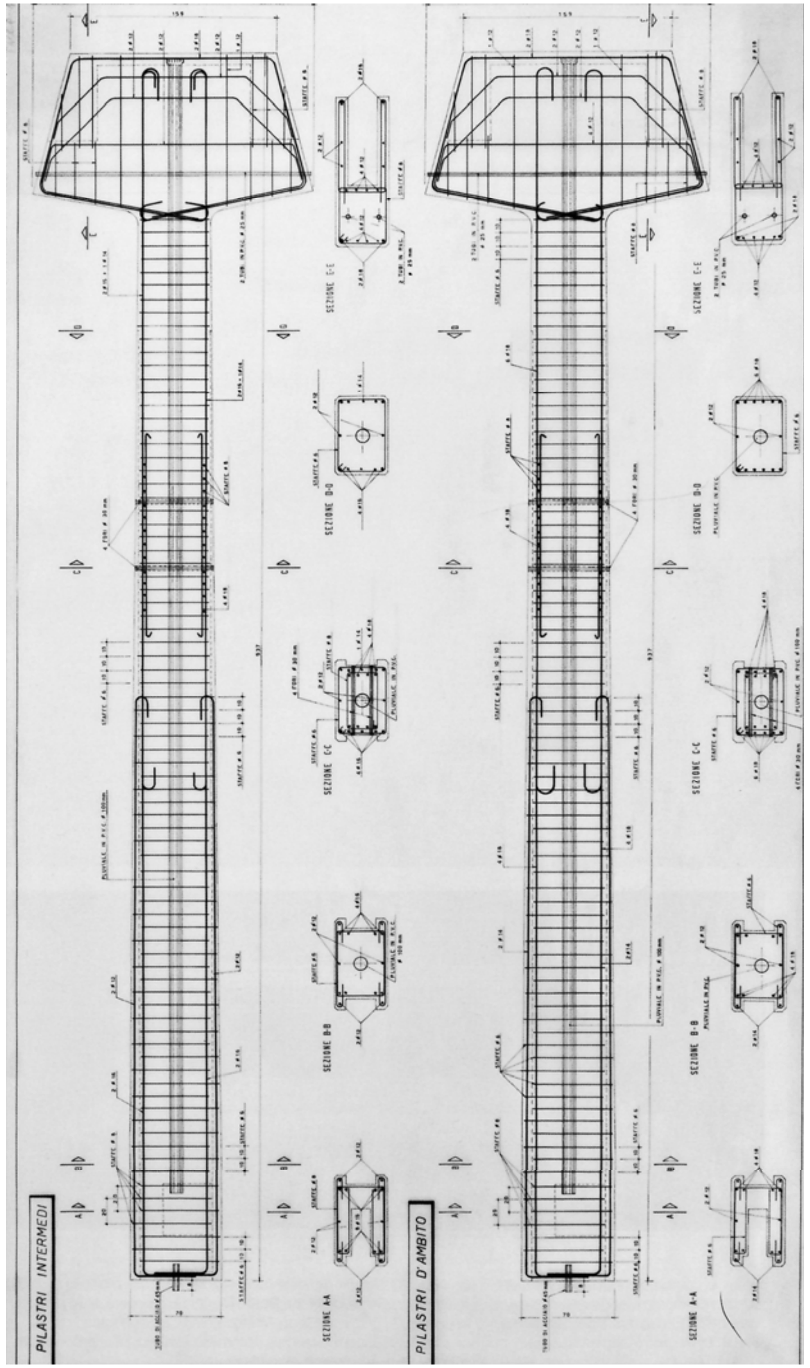


Verbindung von Trägern und Stützen
Beams and columns connection



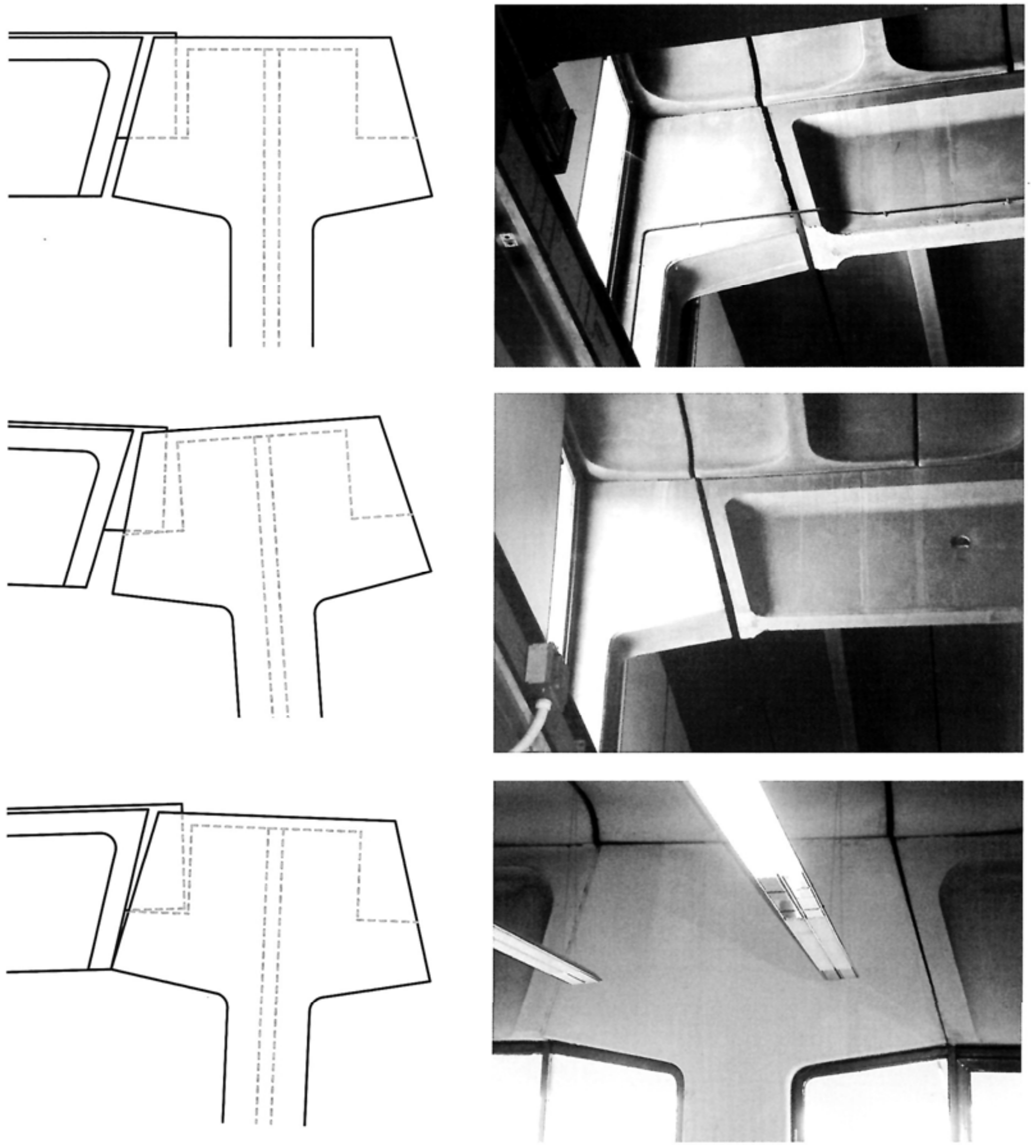
Verbindung von Trägern und Stützen

Beams and columns connection



Anordnung der Bewehrungsstäbe in den Stützen

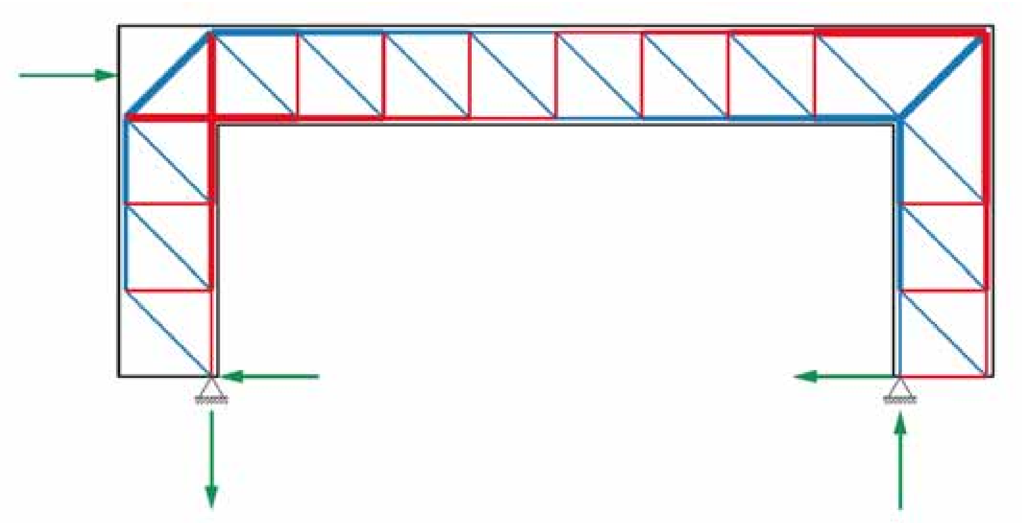
Layout of the reinforcement bars in the columns



Verhalten der Gelenke

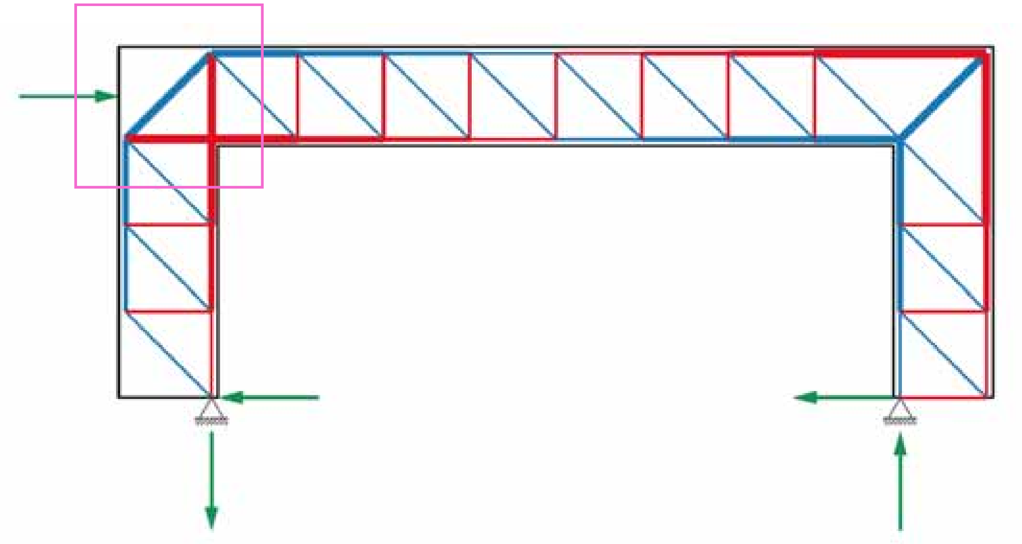
Hinge behaviour

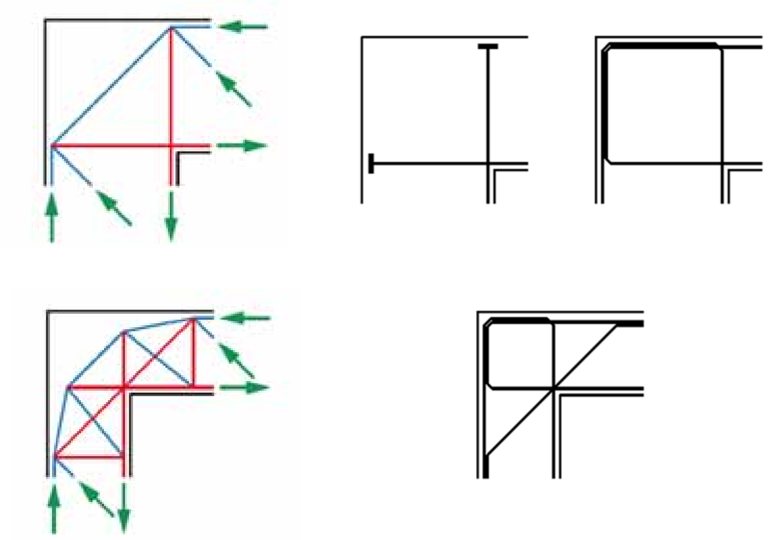
Konstruktionsdetails
Construction details



Rahmen - Stahlbeton

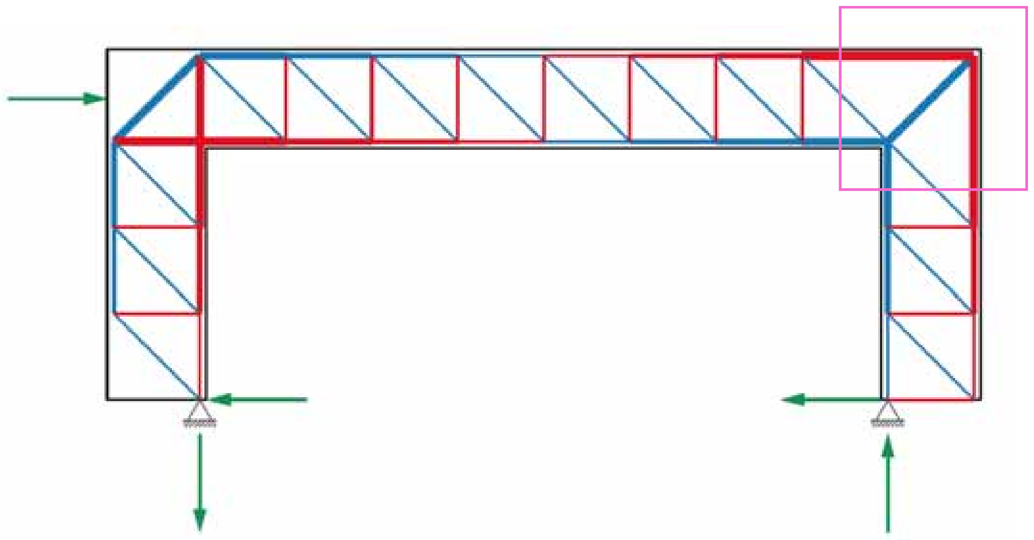
Frames – Reinforced Concrete

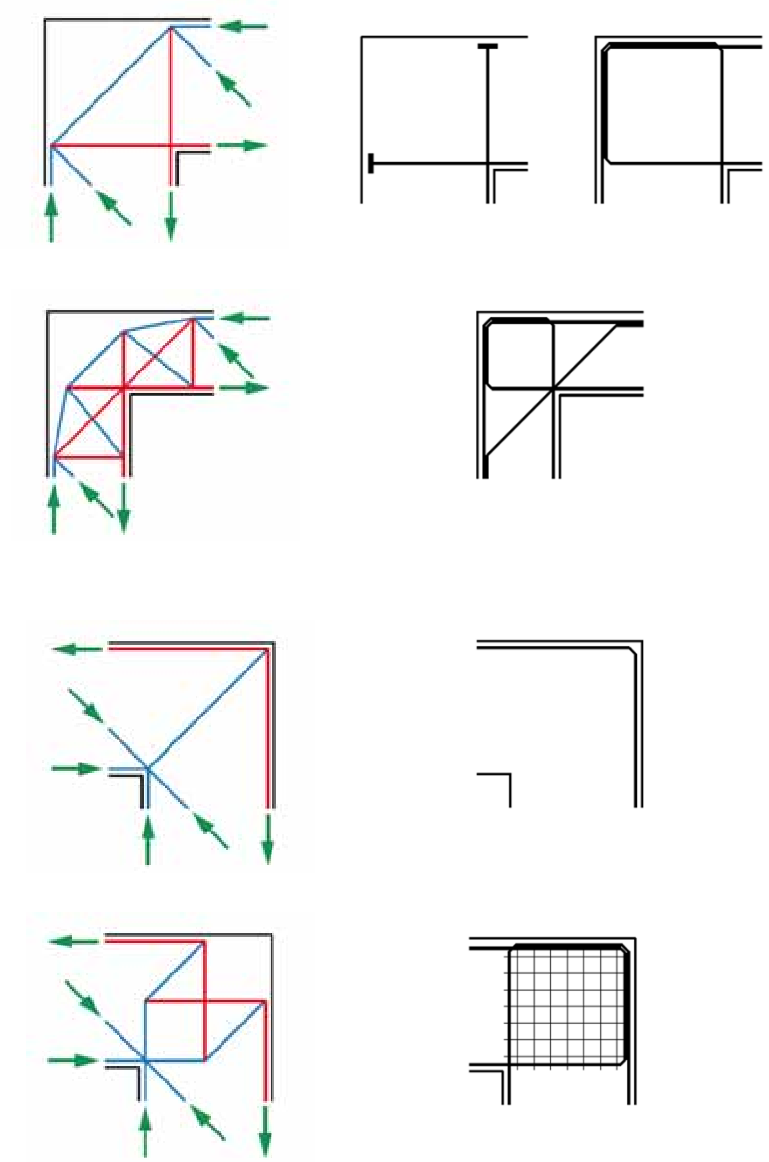




Rahmen - Stahlbeton

Frames – Reinforced Concrete





Rahmen - Stahlbeton

Frames – Reinforced Concrete

Museum of Modern Art

Rio de Janeiro, 1954

Architect: Affonso Edourdo Reidy

Engineer: Emílio Baumgart

Gesamtansicht

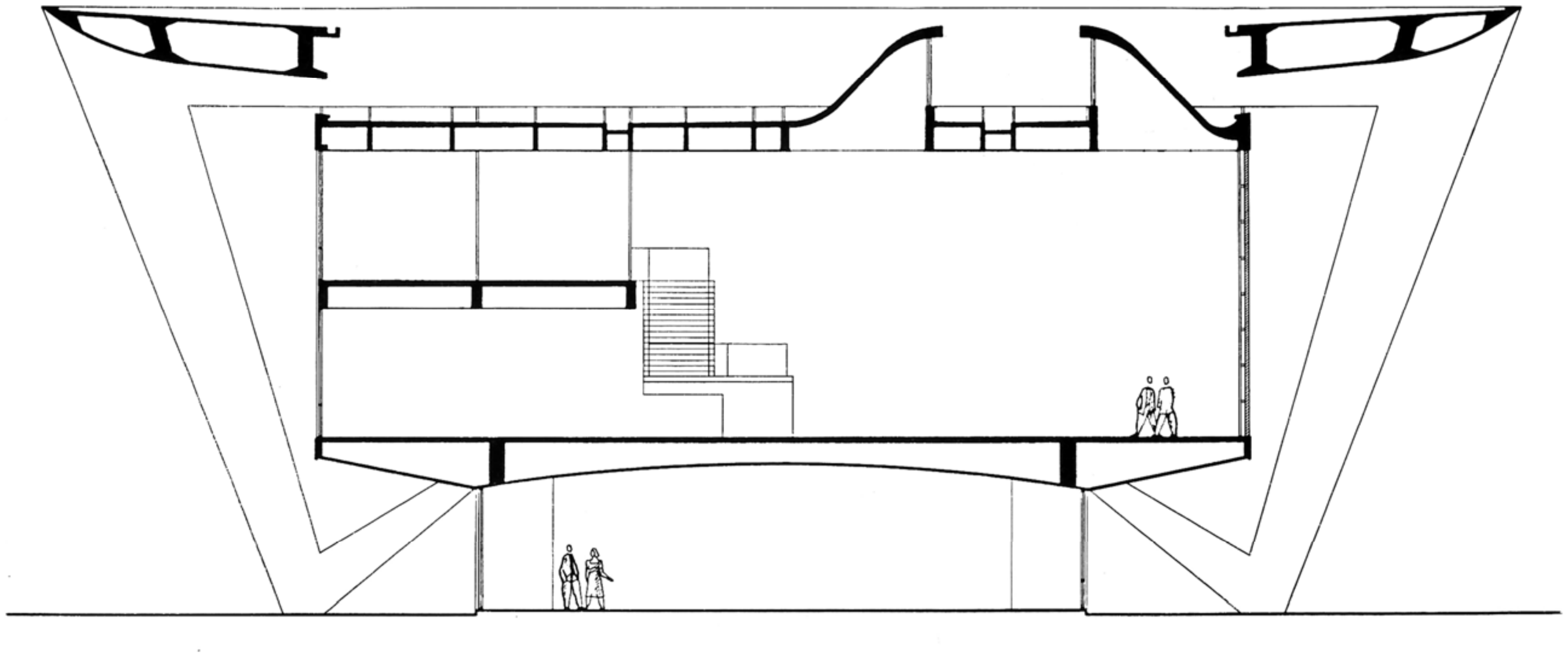
General view

Gesamtansicht

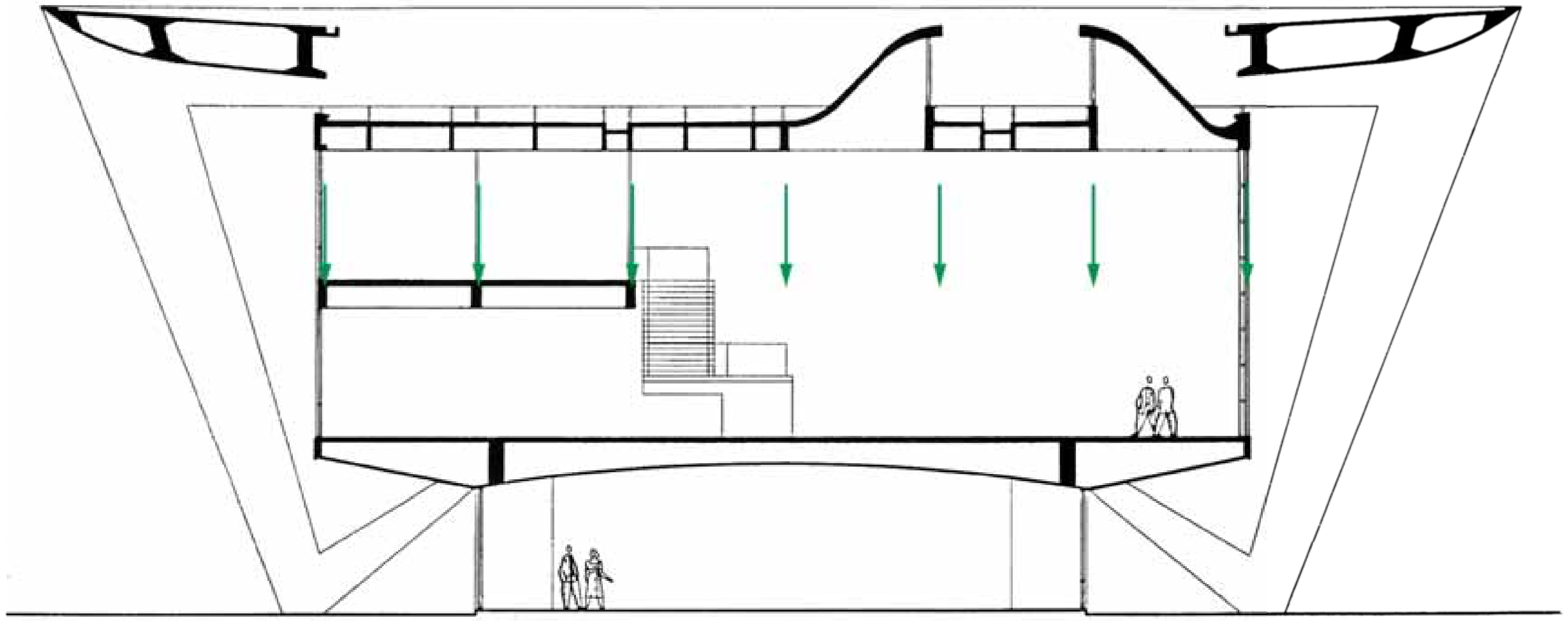
General view

Struktur des Gebäudes

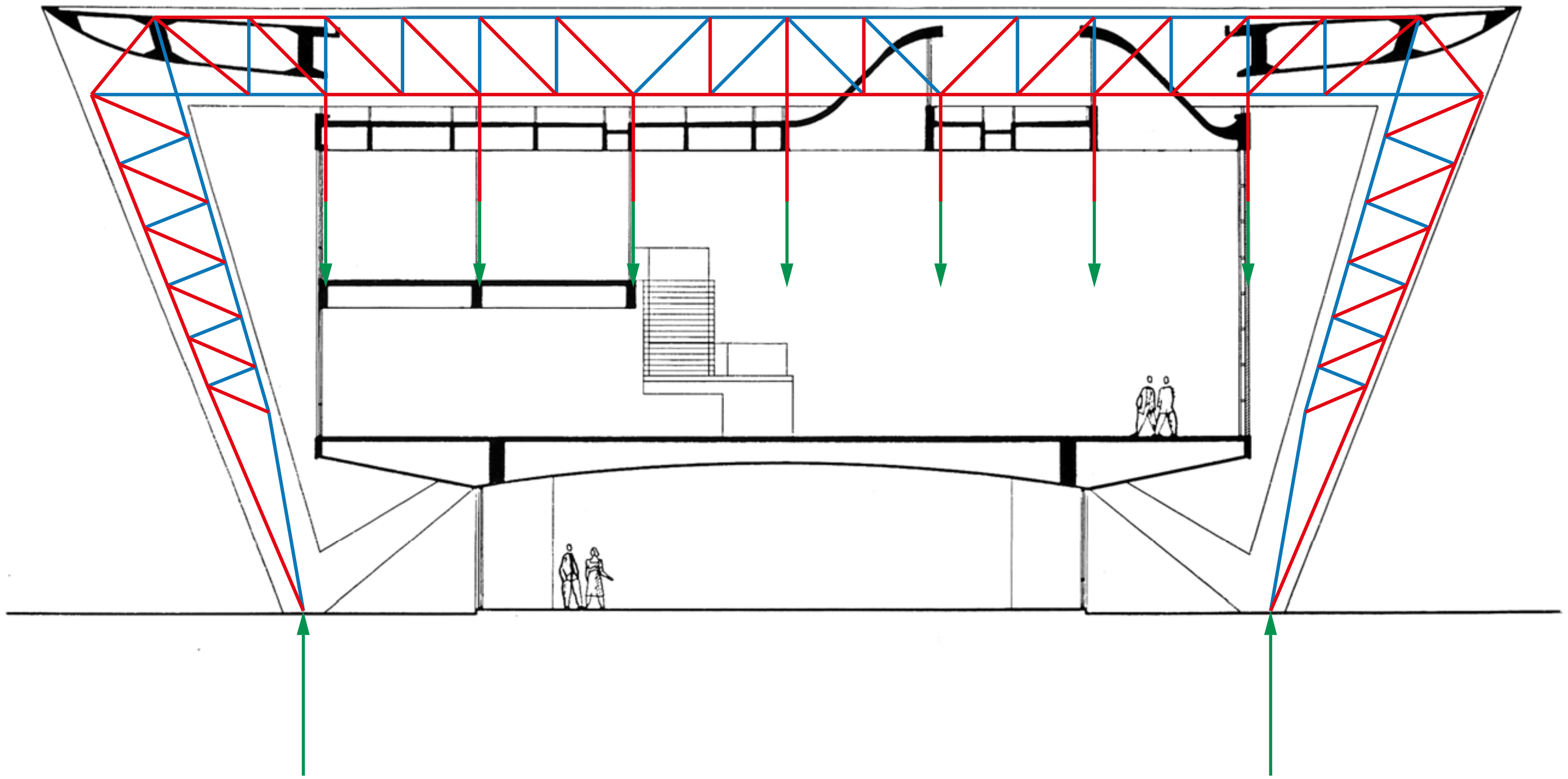
Building’s structure



Schnitt
Section

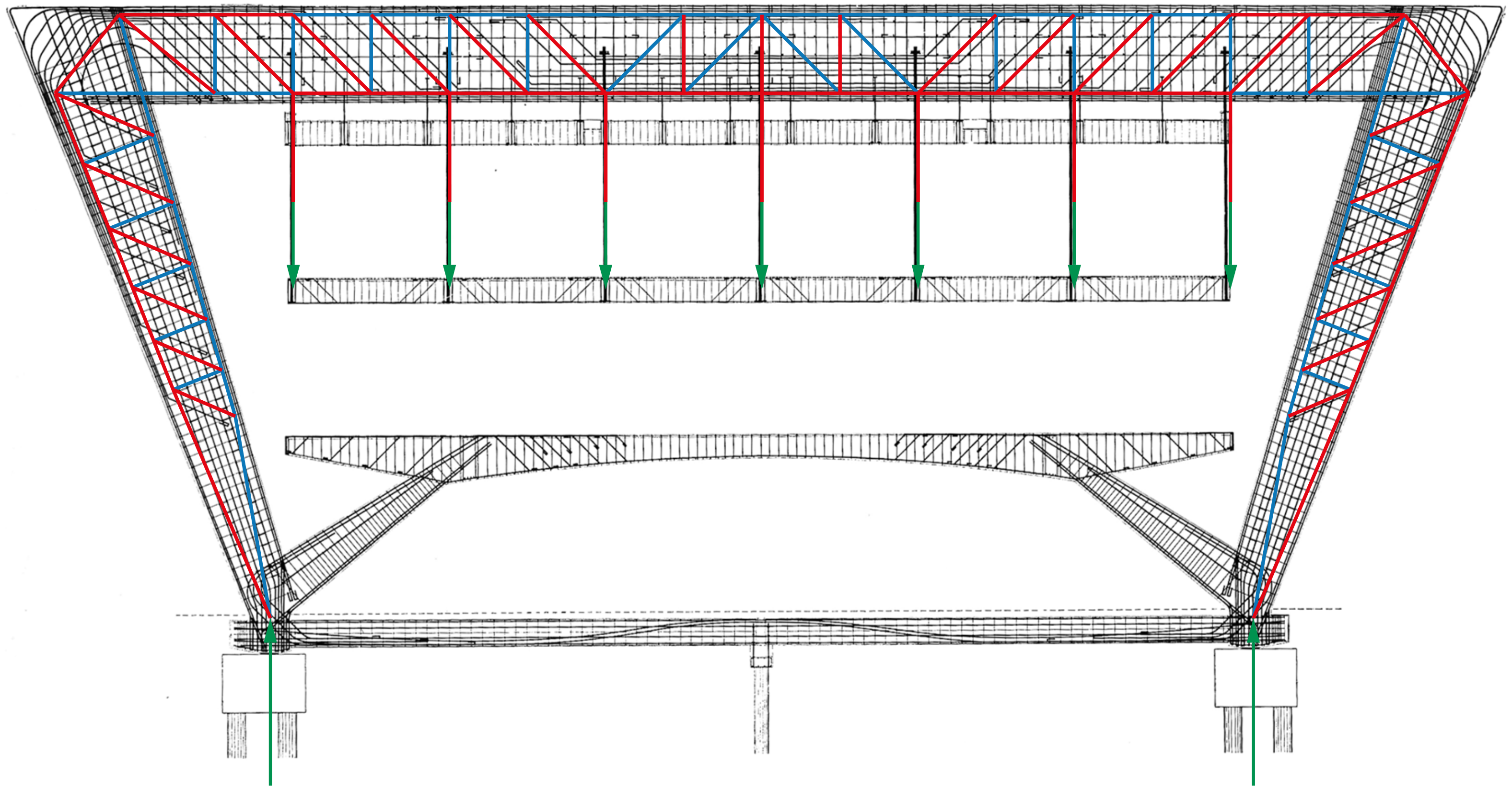


Statisches Gleichgewicht
Static equilibrium

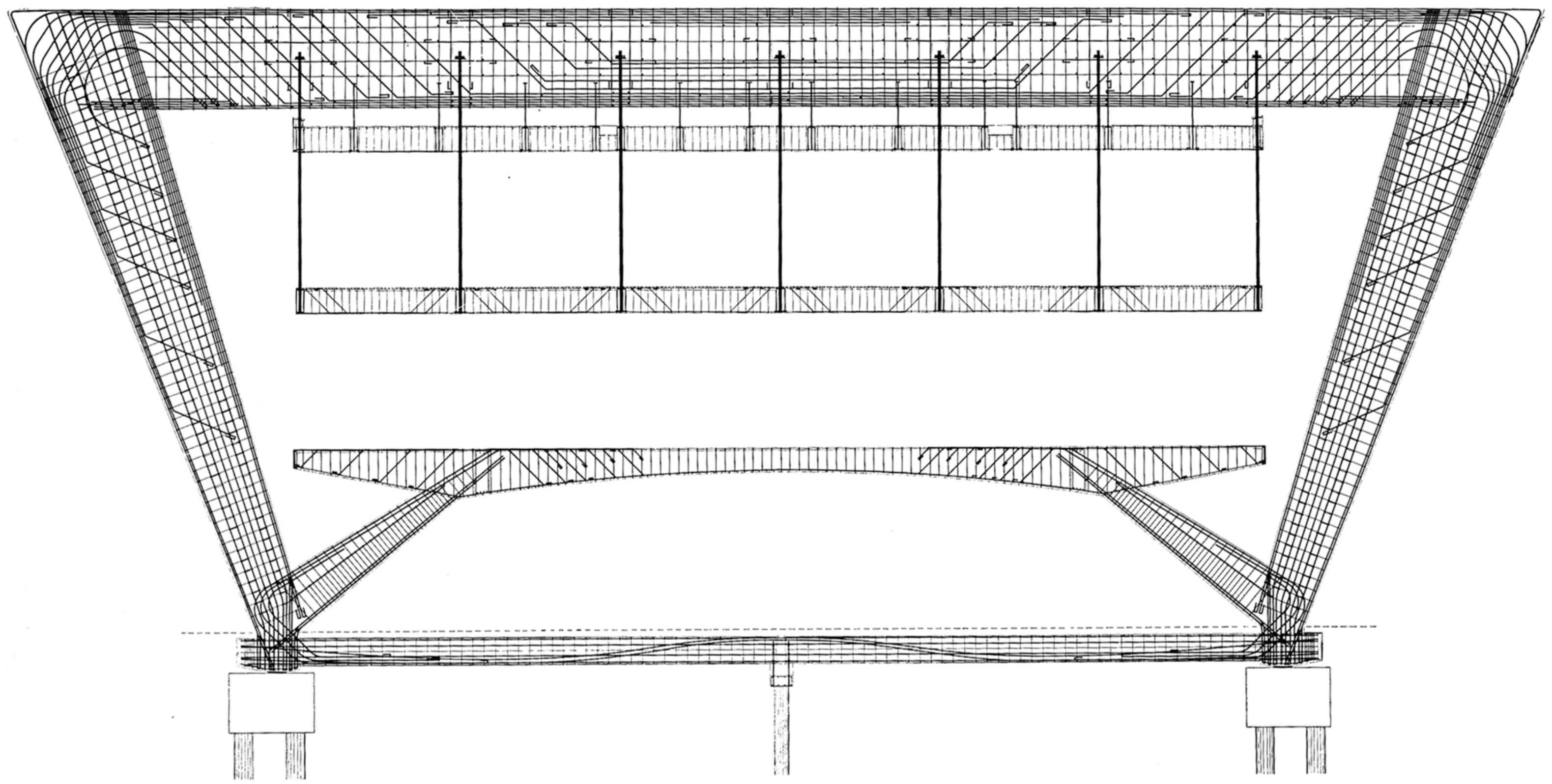


Statisches Gleichgewicht

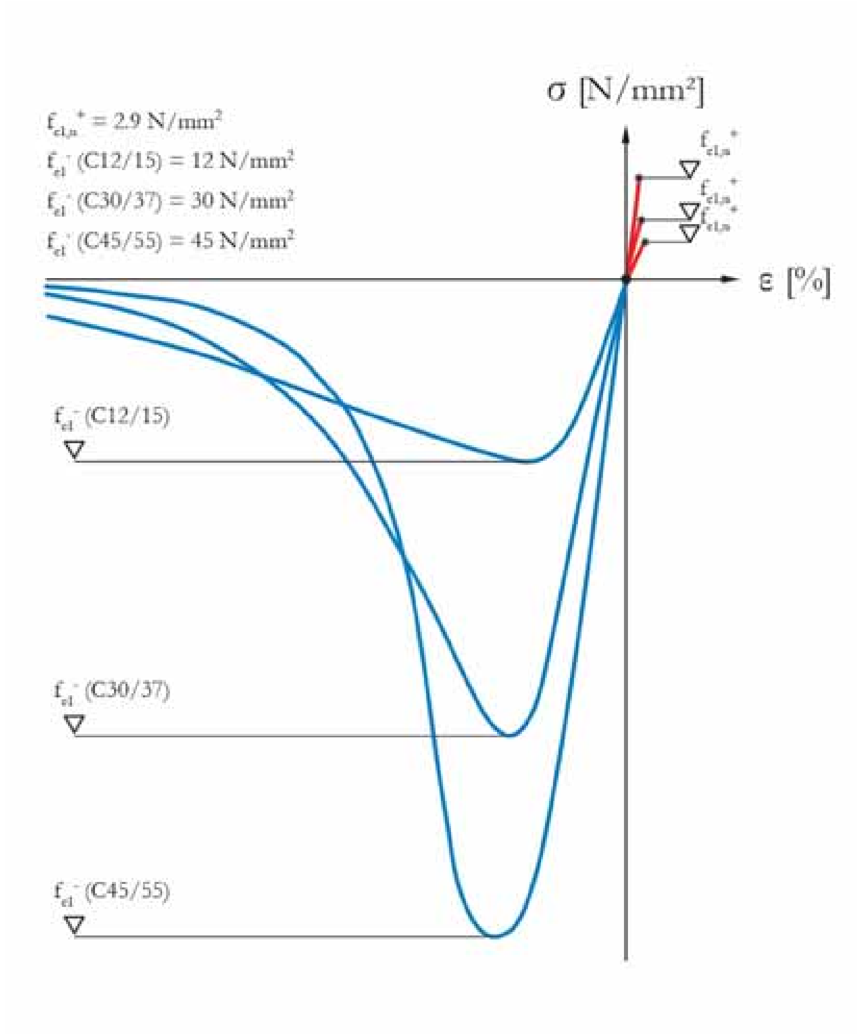
Static equilibrium



Anordnung der Bewehrungsstäbe
Layout of the reinforcement bars

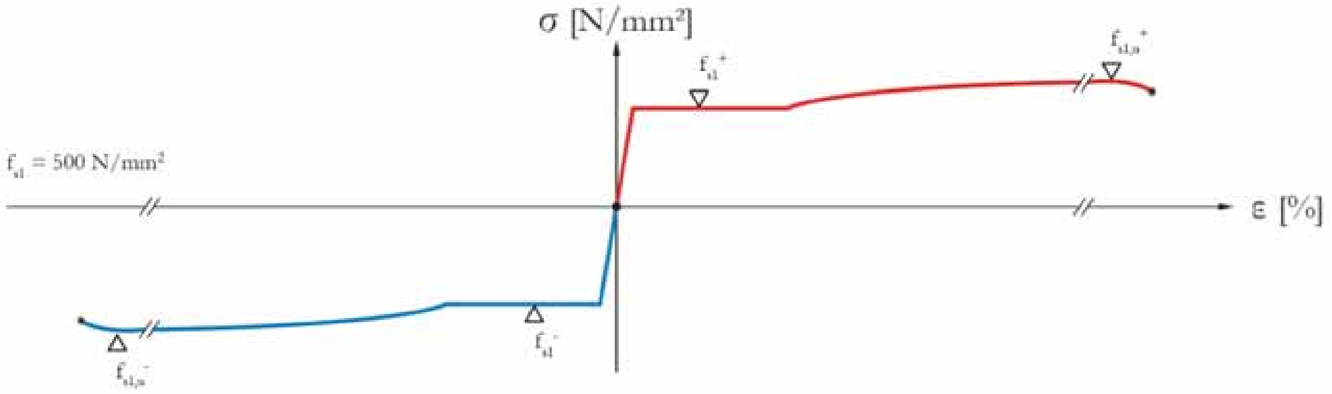


Anordnung der Bewehrungsstäbe
Layout of the reinforcement bars



Beton, Spannungs-Dehnungs-Diagramm

Concrete, stress-strain diagram



Stahl, Spannungs-Dehnungs-Diagramm

Steel, stress-strain diagram


© Michel Aertsens


© Filippo Poli

Anordnung der Bewehrungsstäbe

Layout of the reinforcement bars

Vidy-Lausanne Theater

Lausanne, 2017

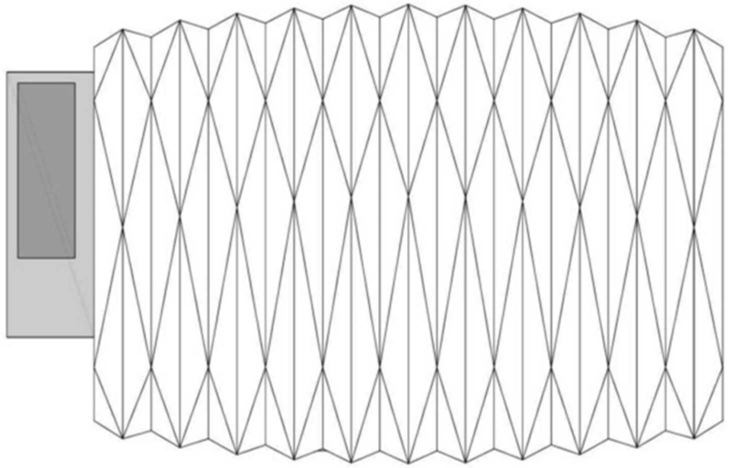
Architect: Yves Weinand, Atelier Cube

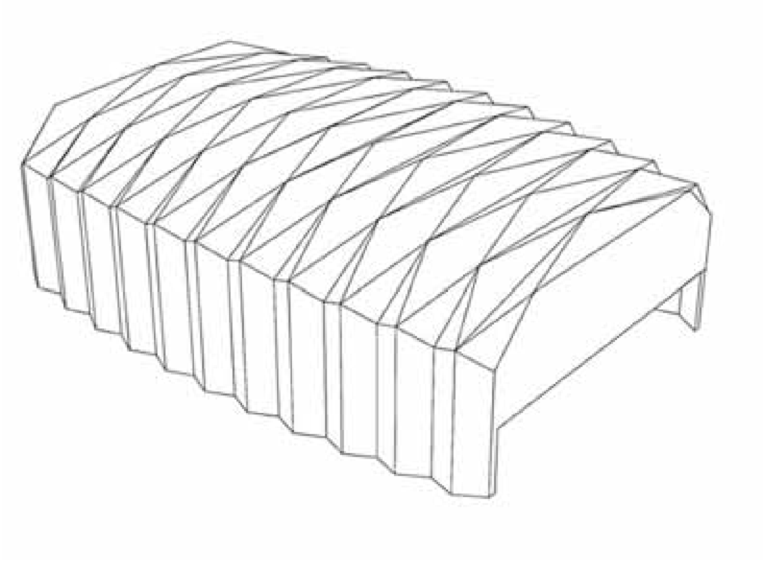
Engineer: Bureau d’études Weinand

Gesamtansicht
General view

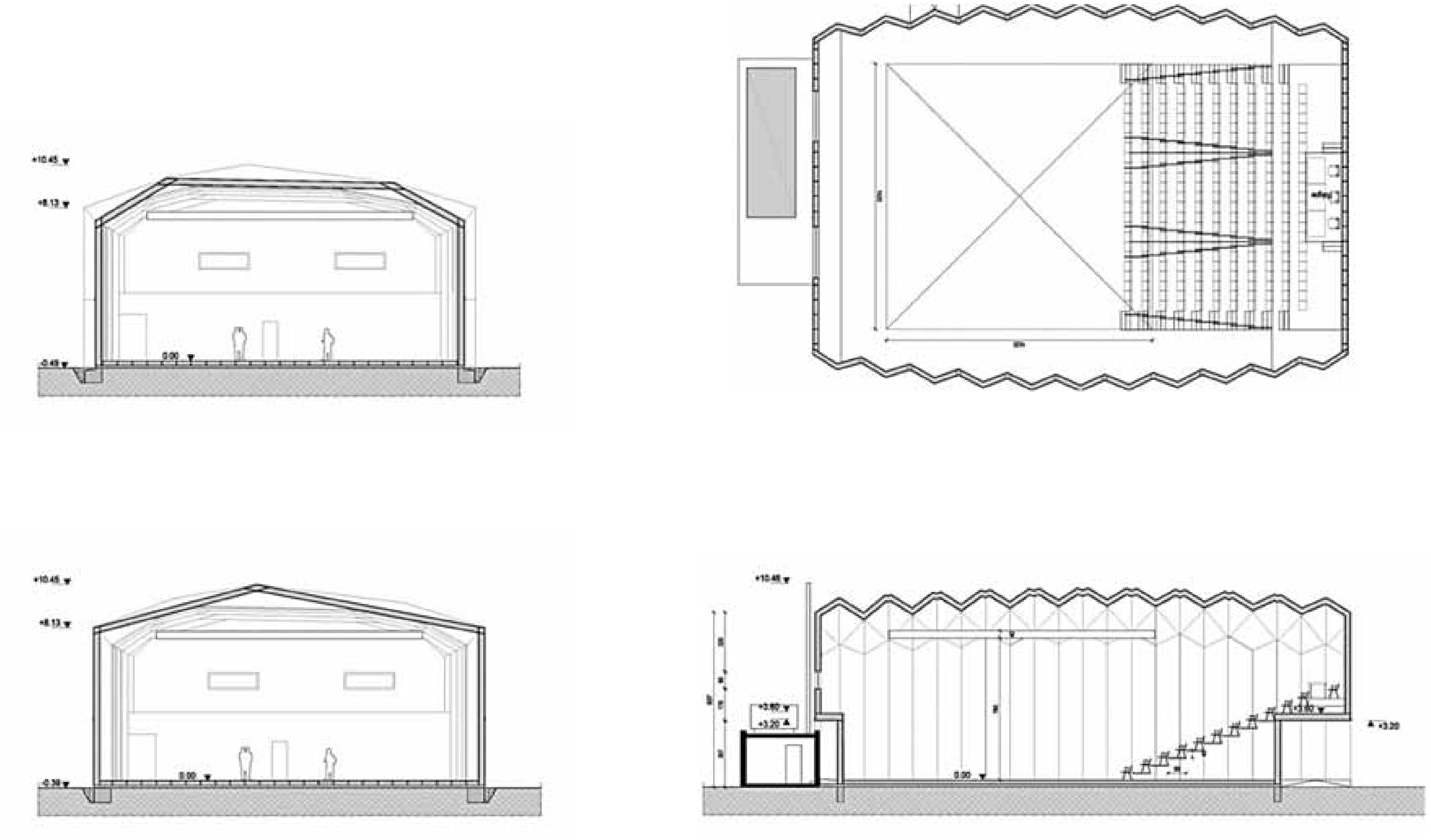
Ansicht von der Seite

View from the side





Erdgeschoss und Schnitte
Ground floor and sections



Erdgeschoss und Schnitte

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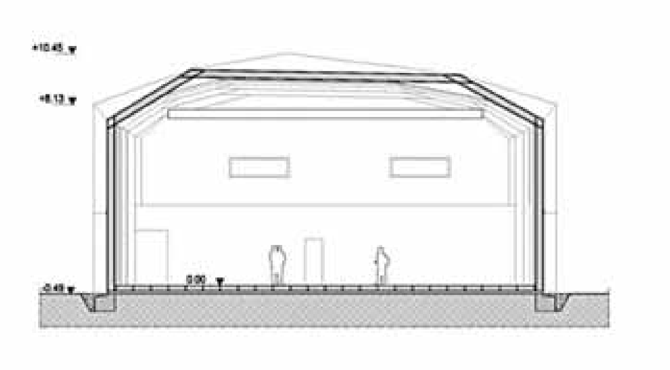
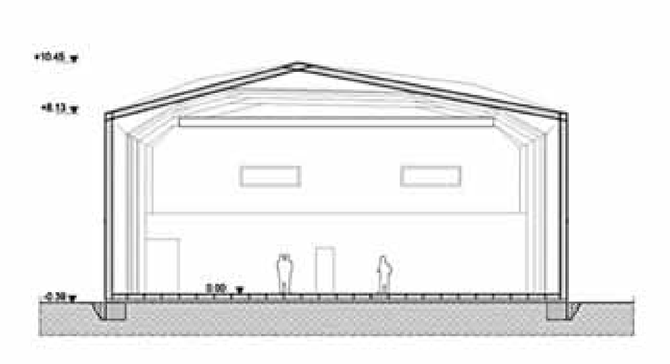
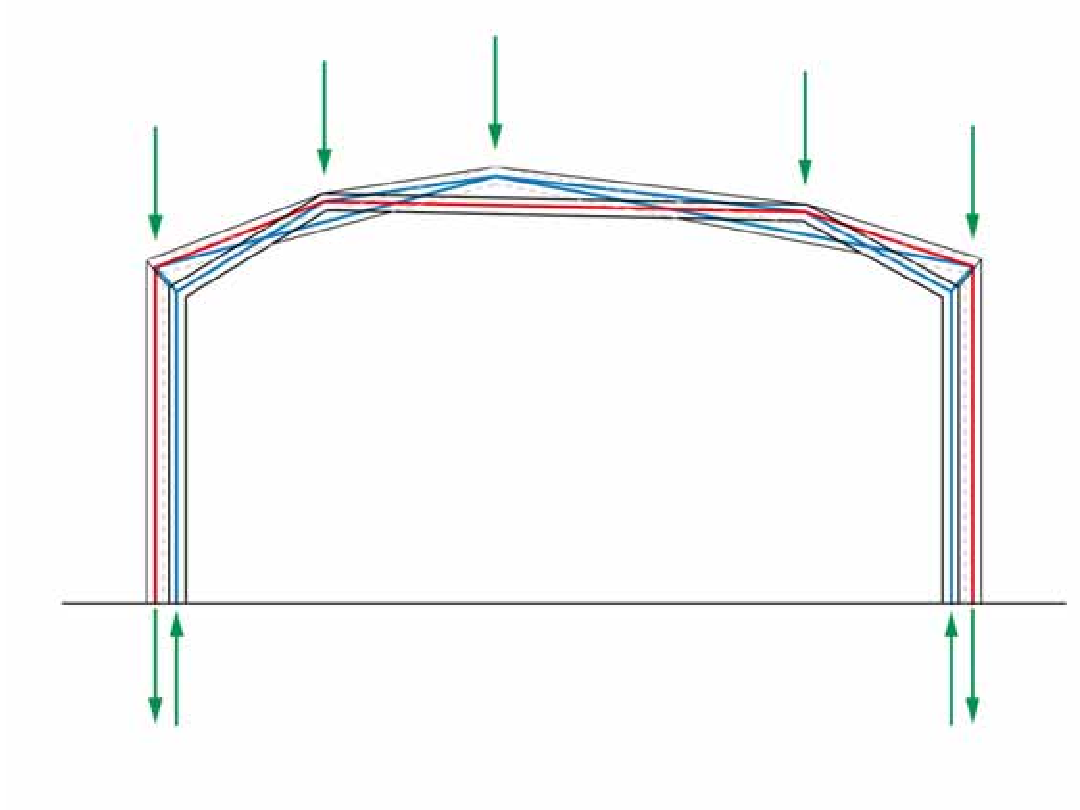
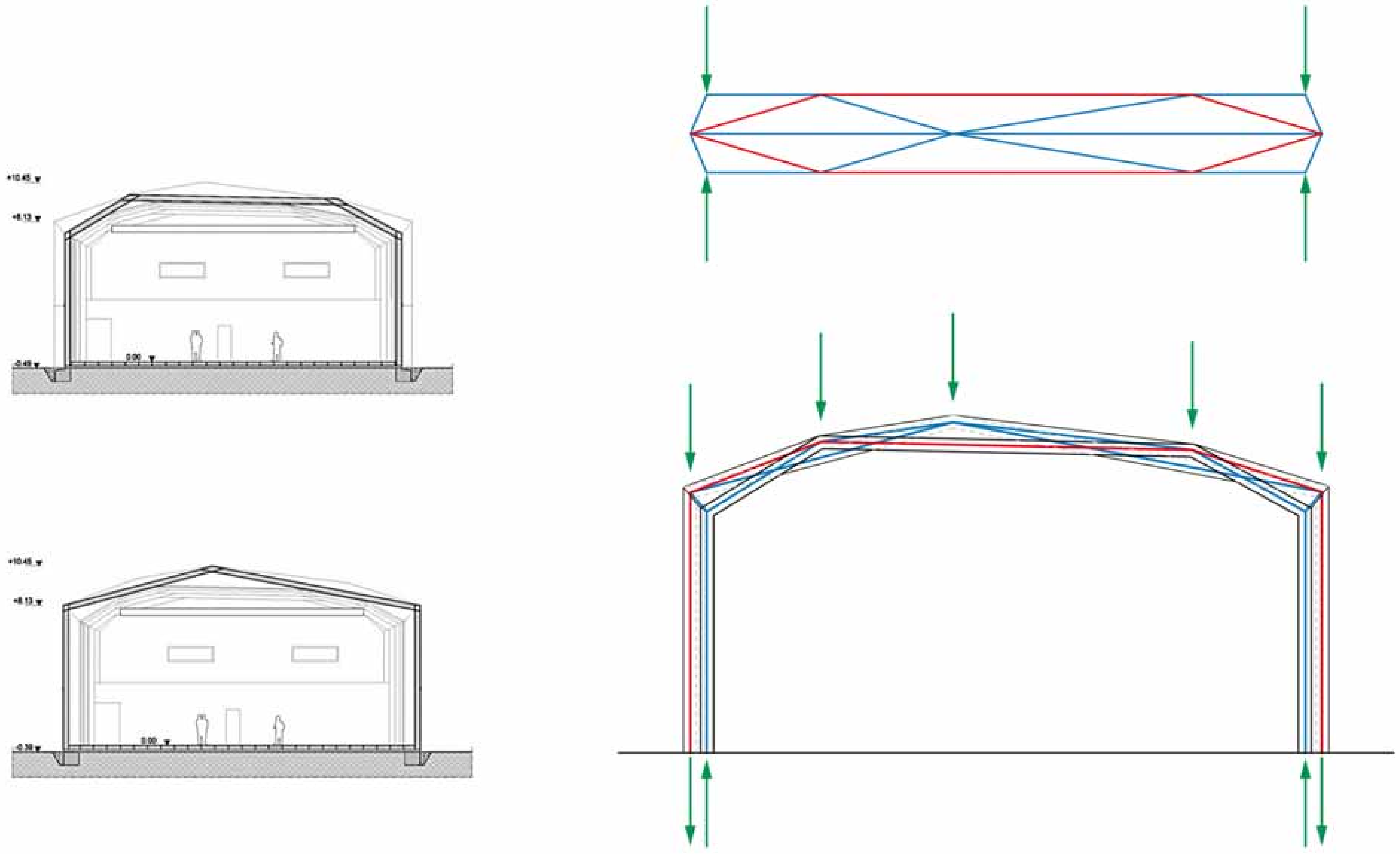






Statisches Gleichgewicht der gefalteten Plattenstruktur

Static equilibrium of the folded plate structure



Statisches Gleichgewicht der gefalteten Plattenstruktur

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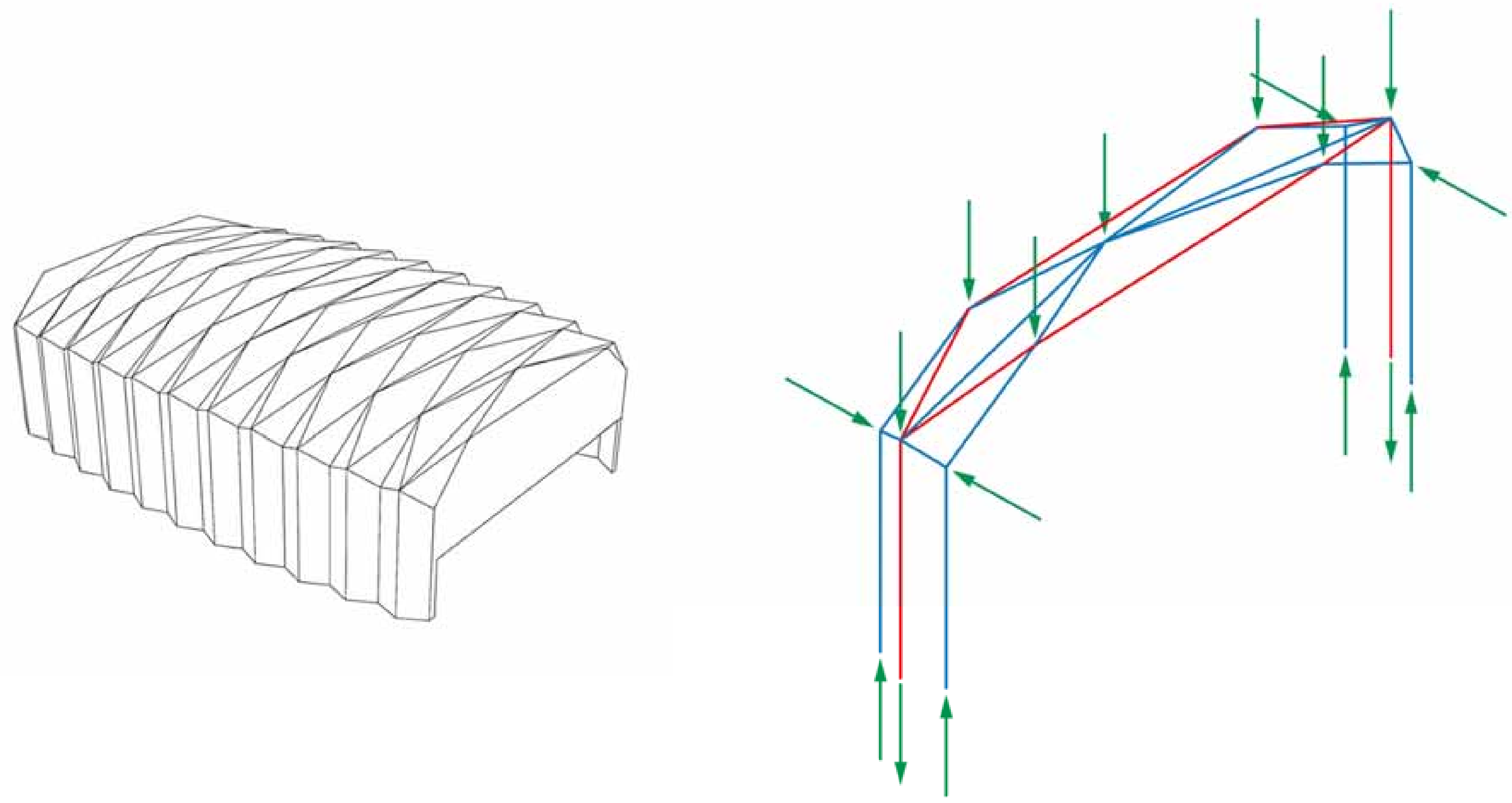


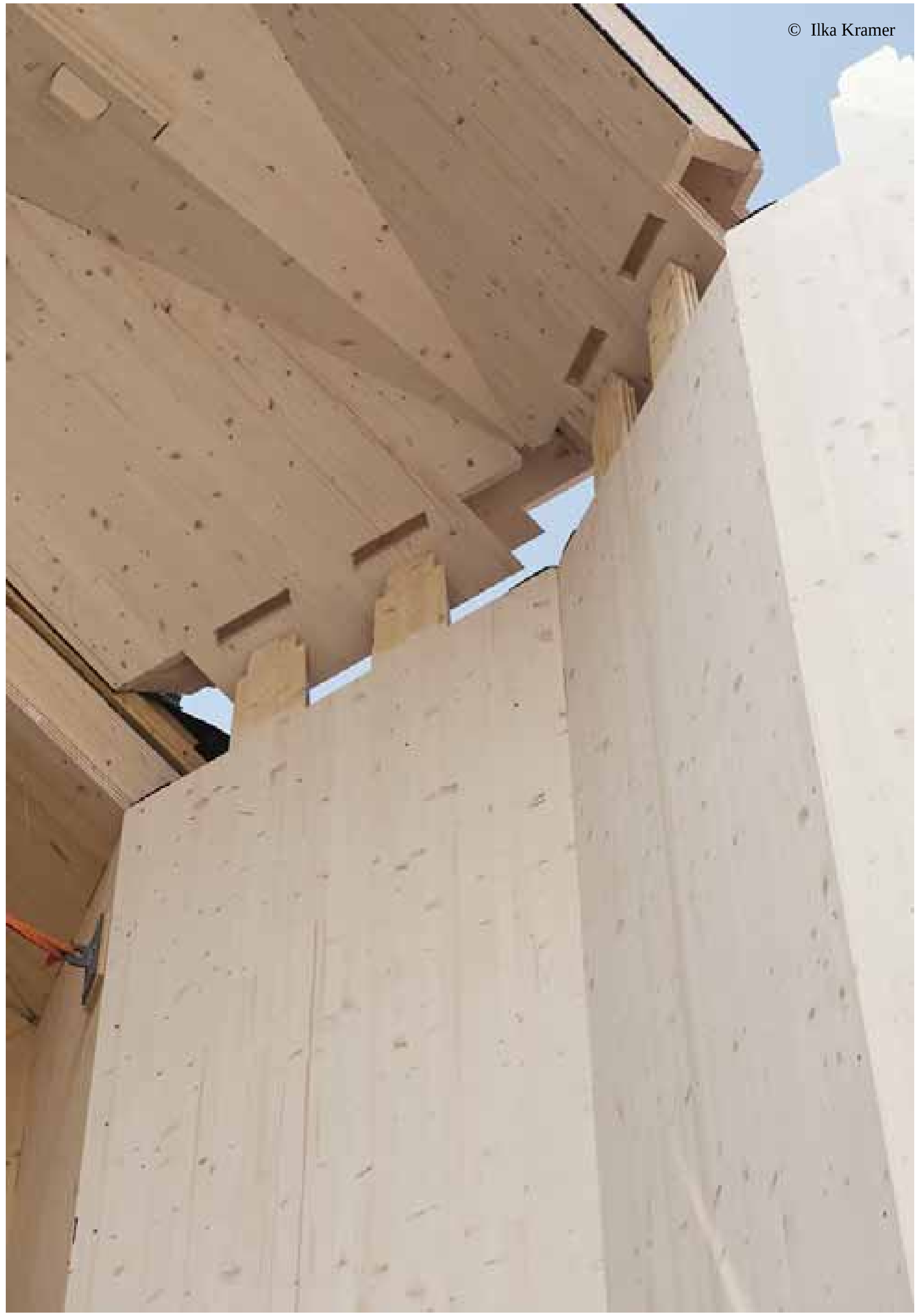
Statisches Gleichgewicht der gefalteten Plattenstruktur
Static equilibrium of the folded plate structure

Theater im Bau

Theater under construction

Theater im Bau
Theater under construction

Details der gefalteten Plattenstruktur
Details of the folded plate structure



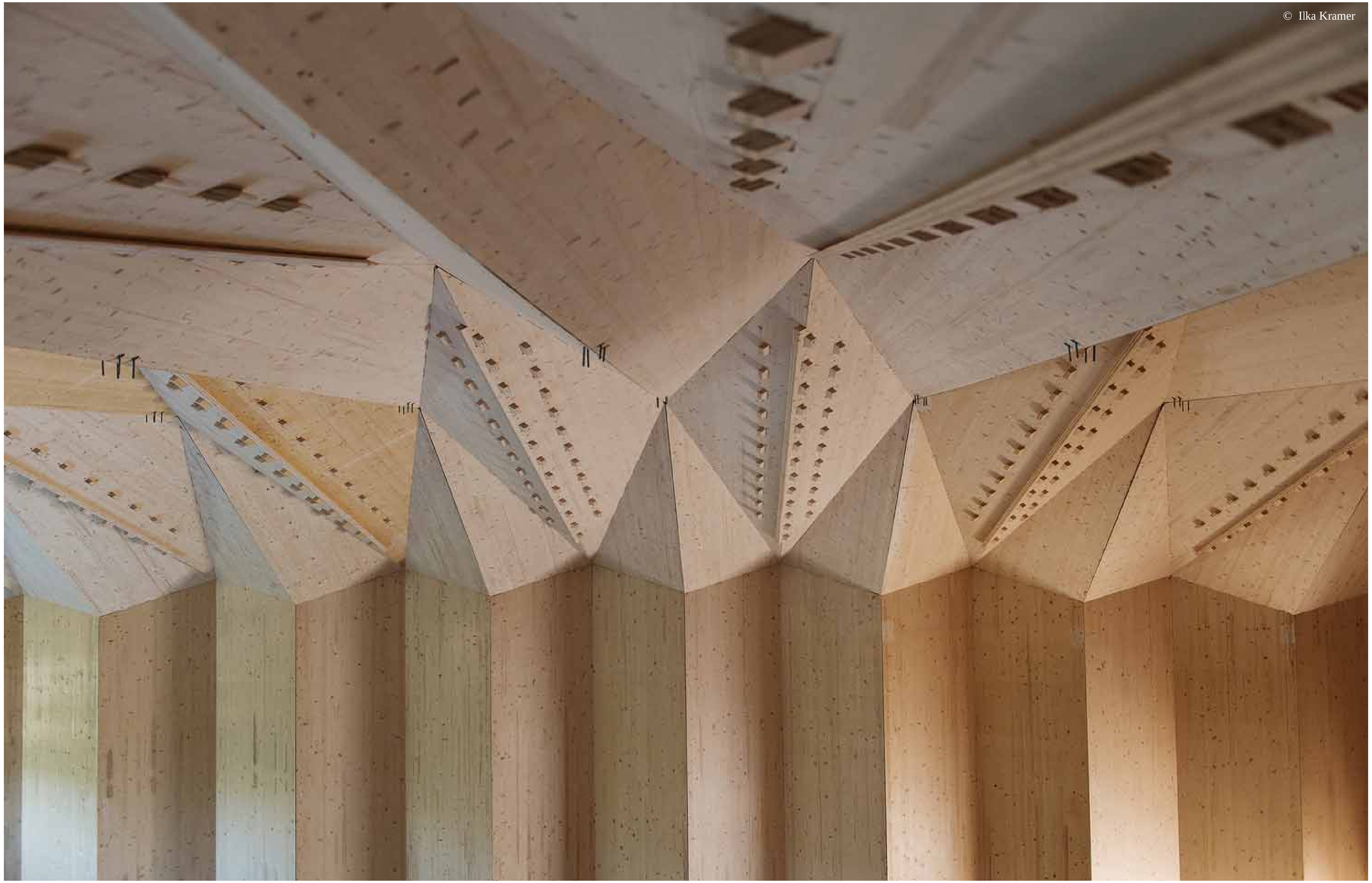
Details der gefalteten Plattenstruktur
Details of the folded plate structure

Struktur aus gefalteten Platten im Bau

Folded plate structure under construction

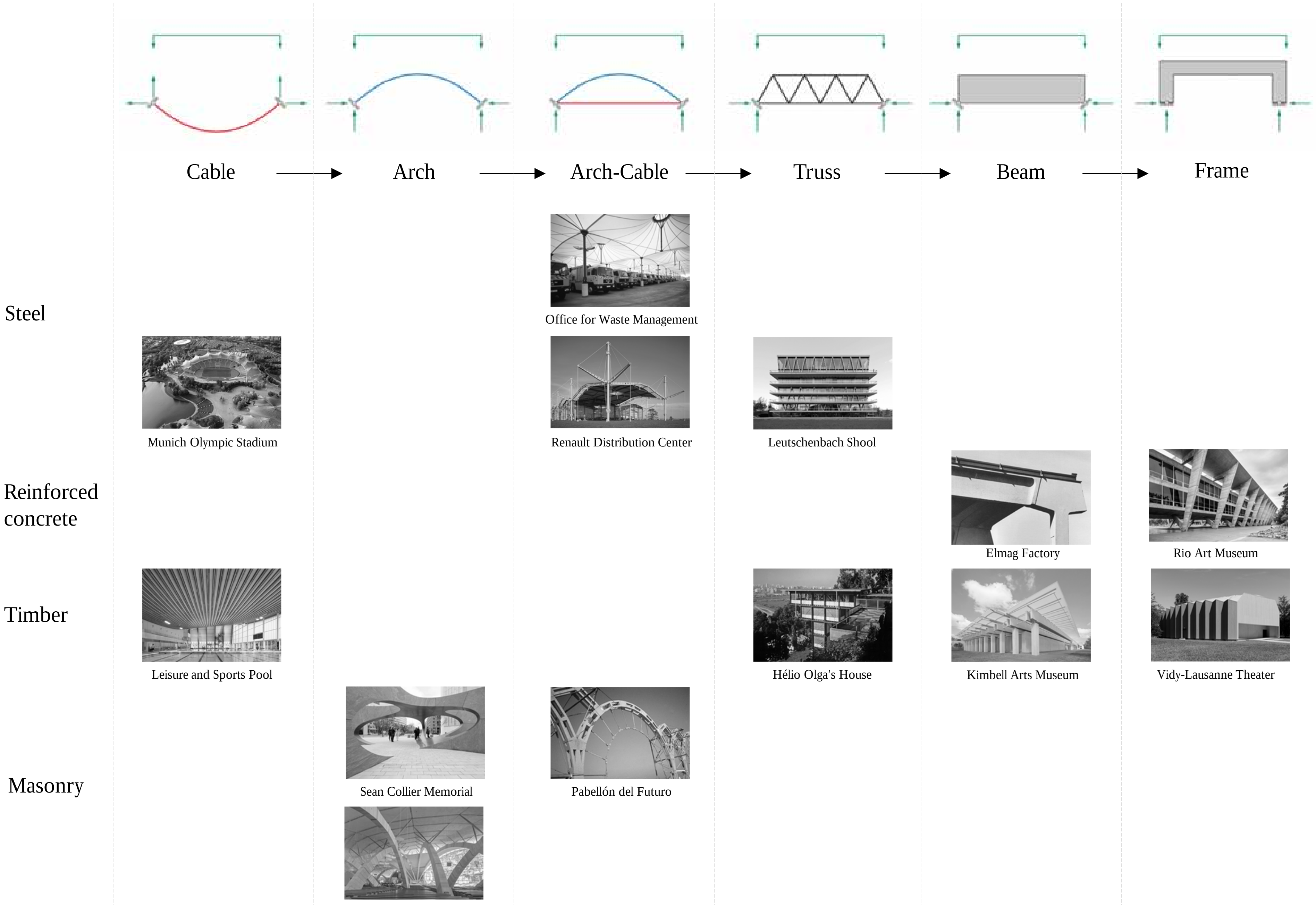
Herstellung und Montage der Holz-Faltplattenkonstruktion

Manufacturing and assembly of the timber folded plate structure



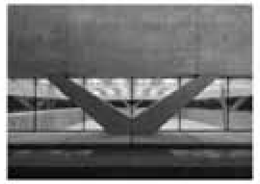
Innenansicht
Interior view

Innenansicht
Interior view


Cable
Arch
Arch-Cable
Truss
Beam
Frame
Steel
Reinforced concrete
Timber
Masonry
Office for Waste Management
Munich Olympic Stadium
Renault Distribution Center
Leutschenbach Shool
Elmag Factory
Rio Art Museum
Leisure and Sports Pool
Hélio Olga's House
Kimbell Arts Museum
Vidy-Lausanne Theater
Sean Collier Memorial
Pabellón del Futuro

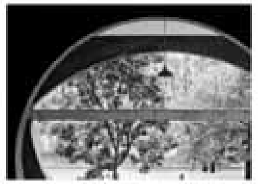
Introduction to 3D equilibrium

1. Steel

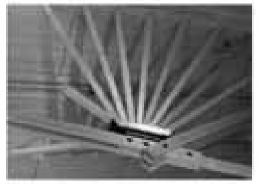


2. Reinforced Concrete

3. Timber



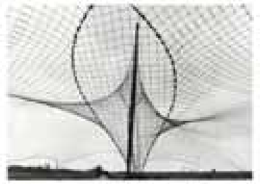
4. Masonry



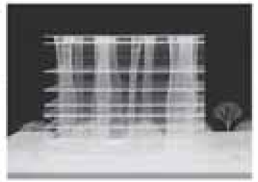
5. Construction Details

Structural Design III

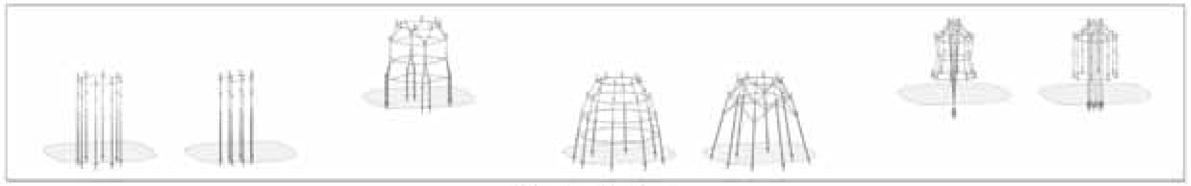
Structural Design IV



1. From 2D to 3D



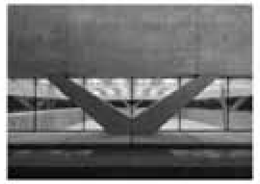
2. Architecture and Structure



Design Project

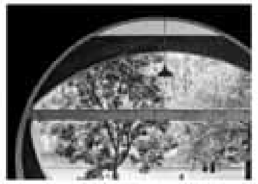
Introduction to
3D equilibrium

1. Steel

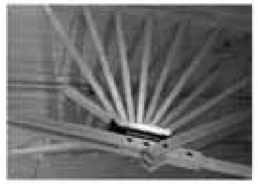


2. Reinforced
Concrete

3. Timber



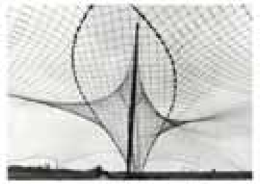
4. Masonry



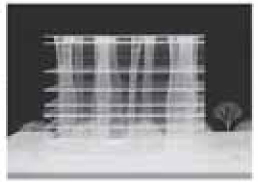
5. Construction Details

Structural Design III

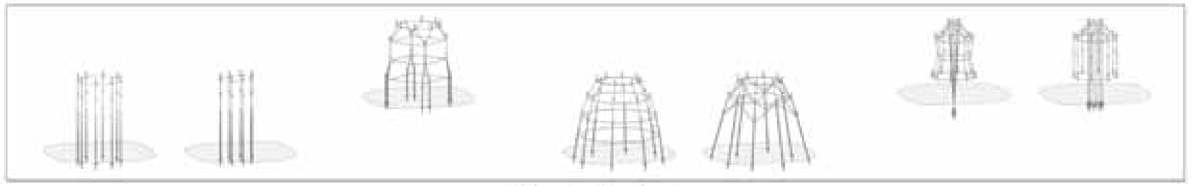
Structural Design IV



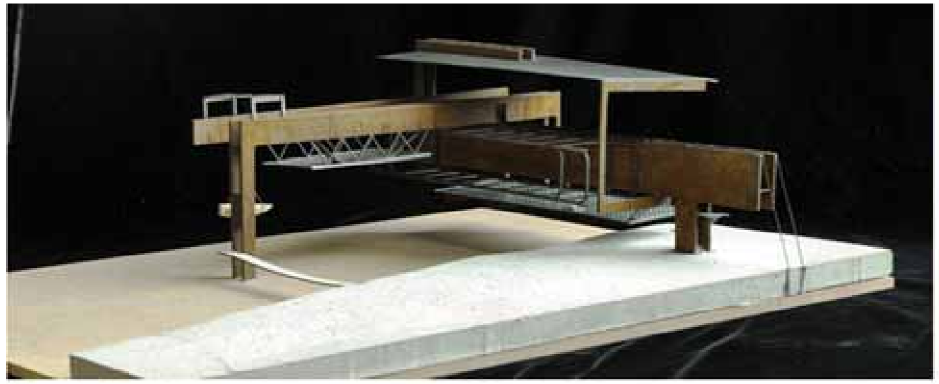
1. From 2D to 3D

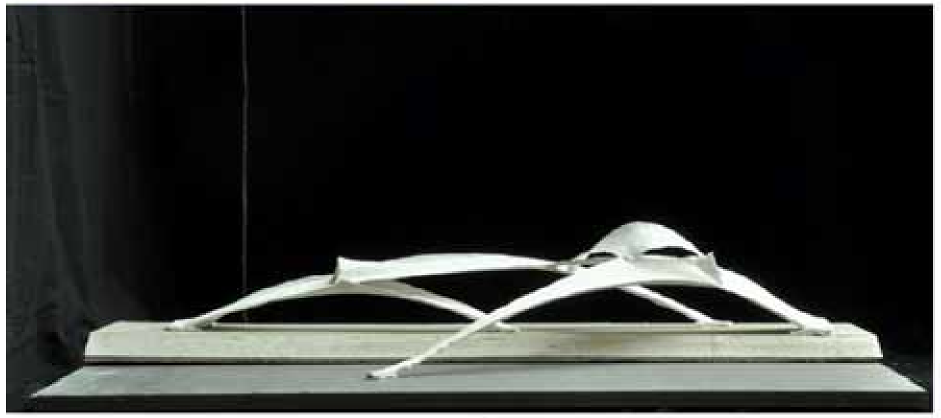
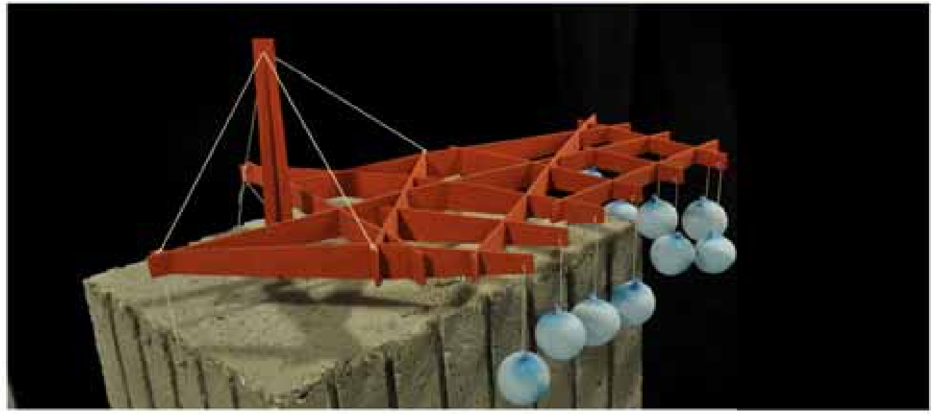
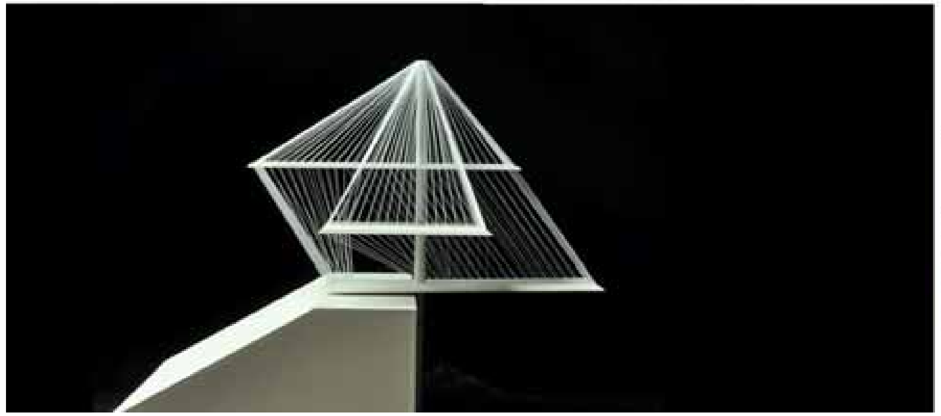
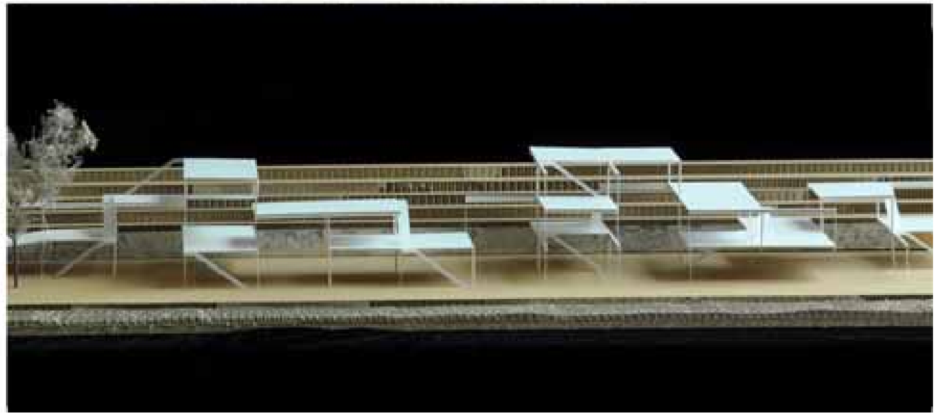


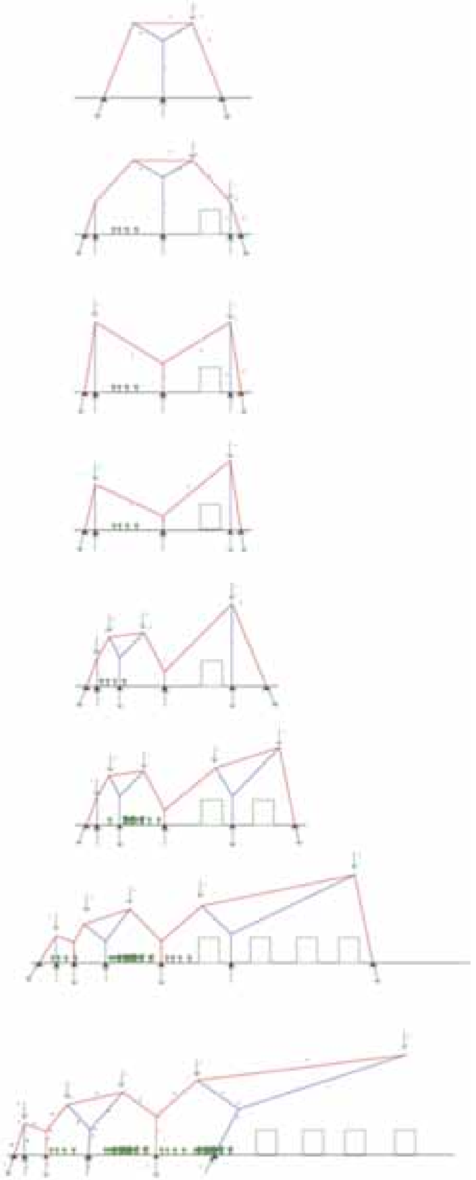
2. Architecture
and Structure

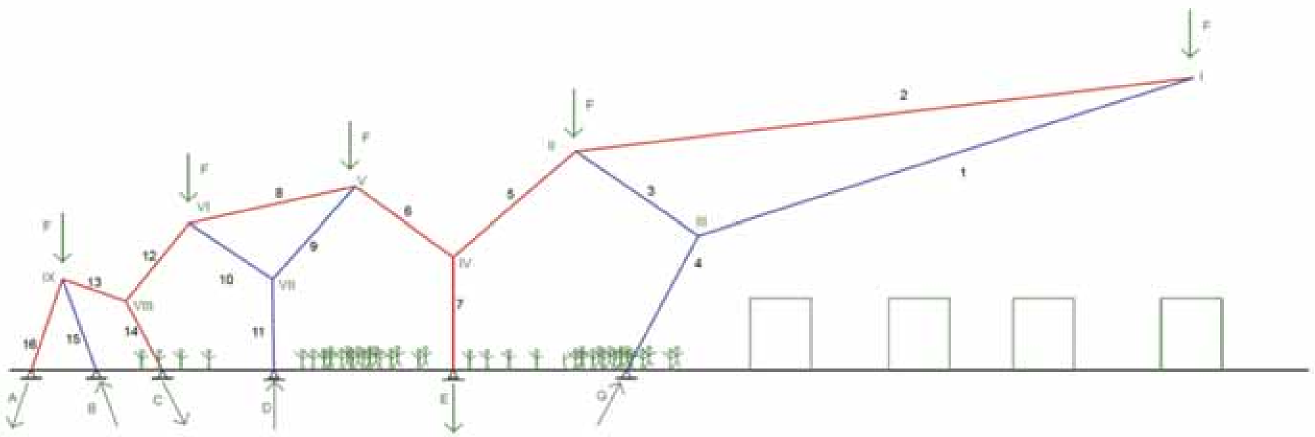


Design Project







Studenten: Halima Hassan, Stephanie Nünlist, Besjana Ramadani, Joanna Rubin

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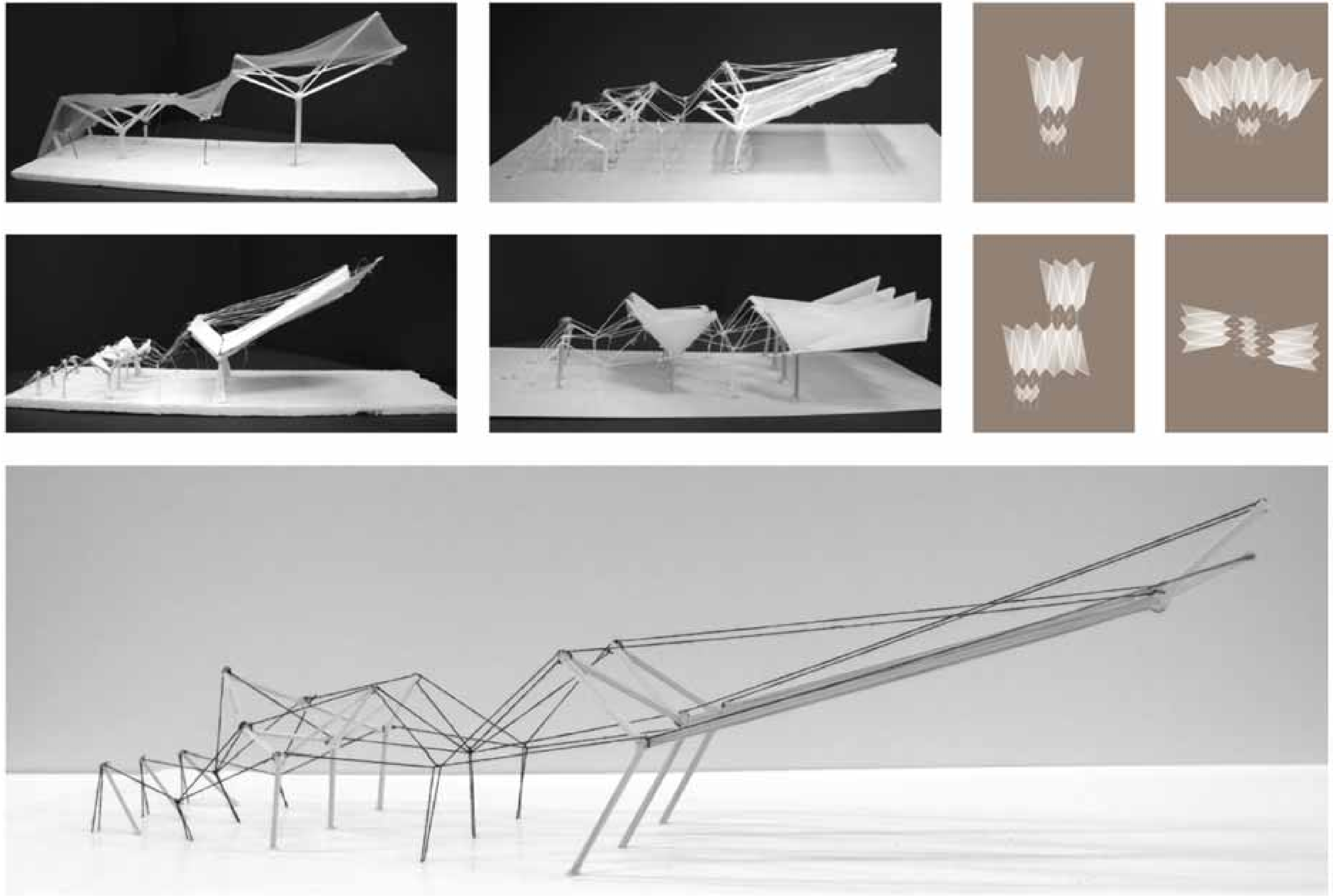

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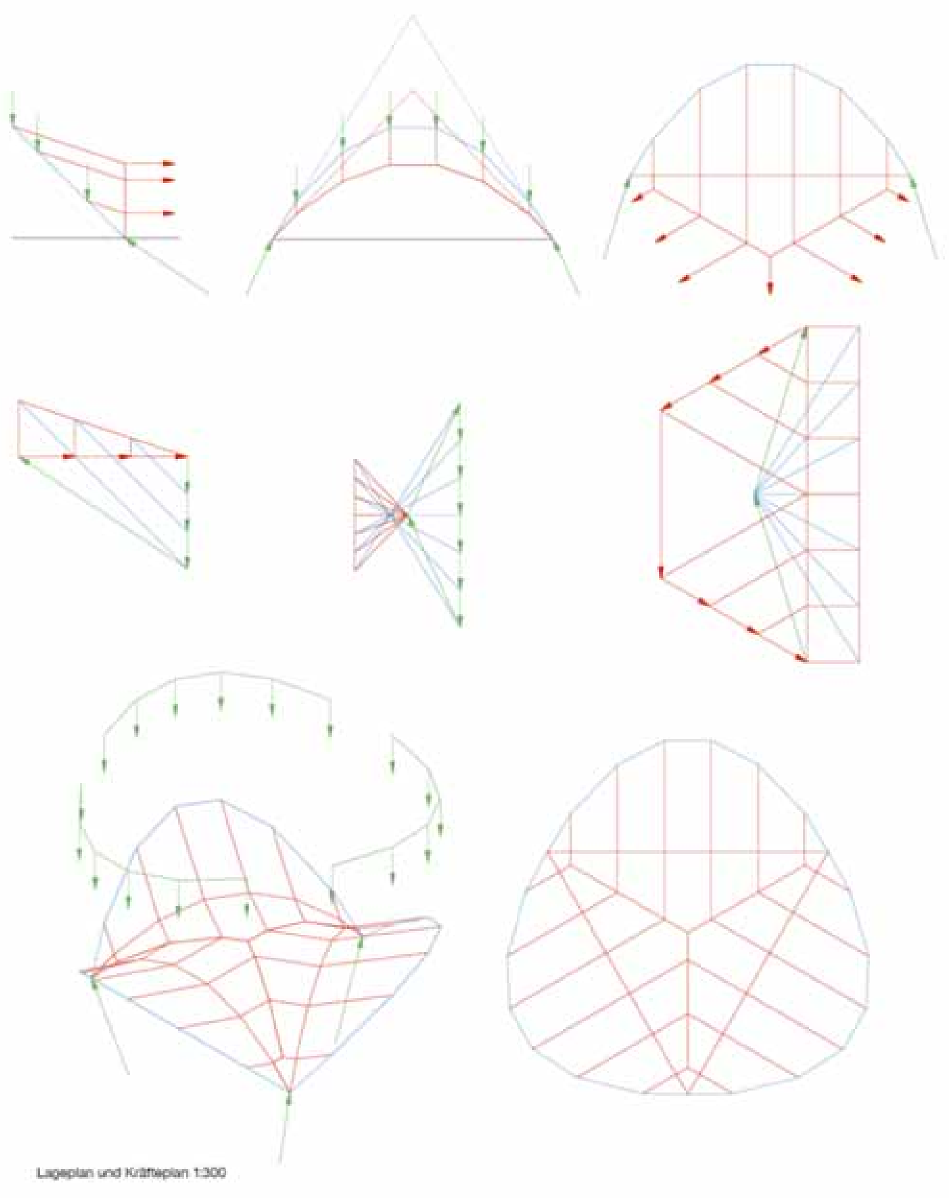

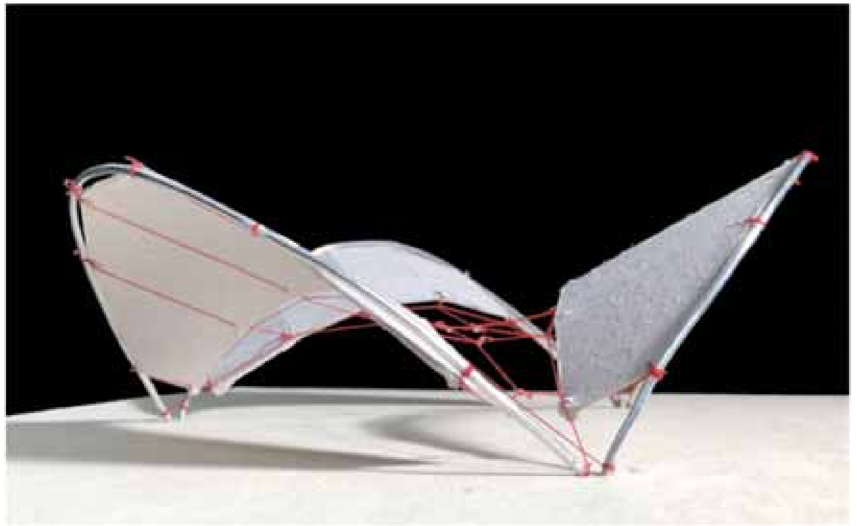

Studenten: Xingyu He, Yaxin Hou, Fei Li, Zhaoye Li

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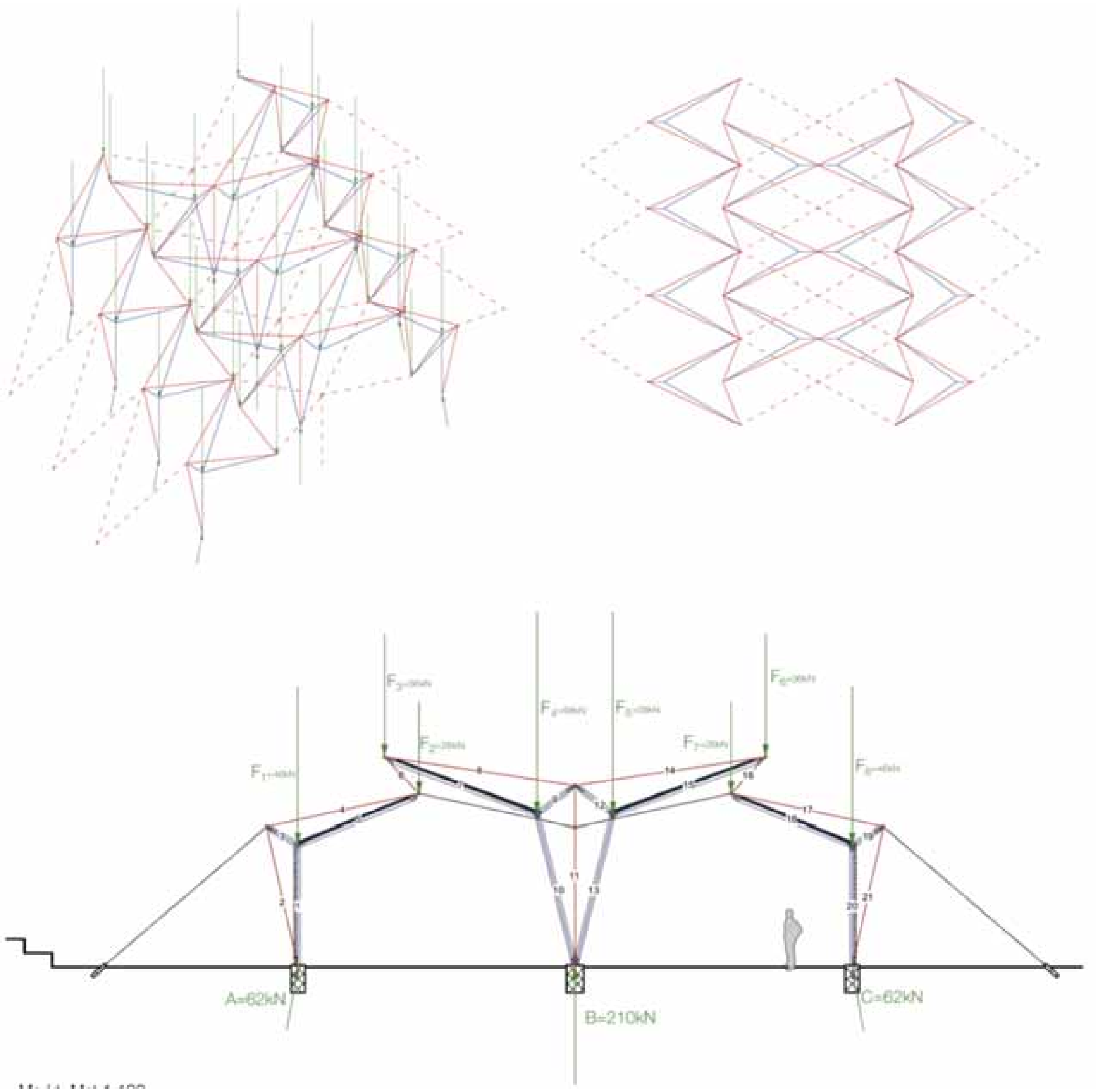

Studenten: Nicole Alder, Carole Allenbach, Salome Roggensinger, Cara Steiner

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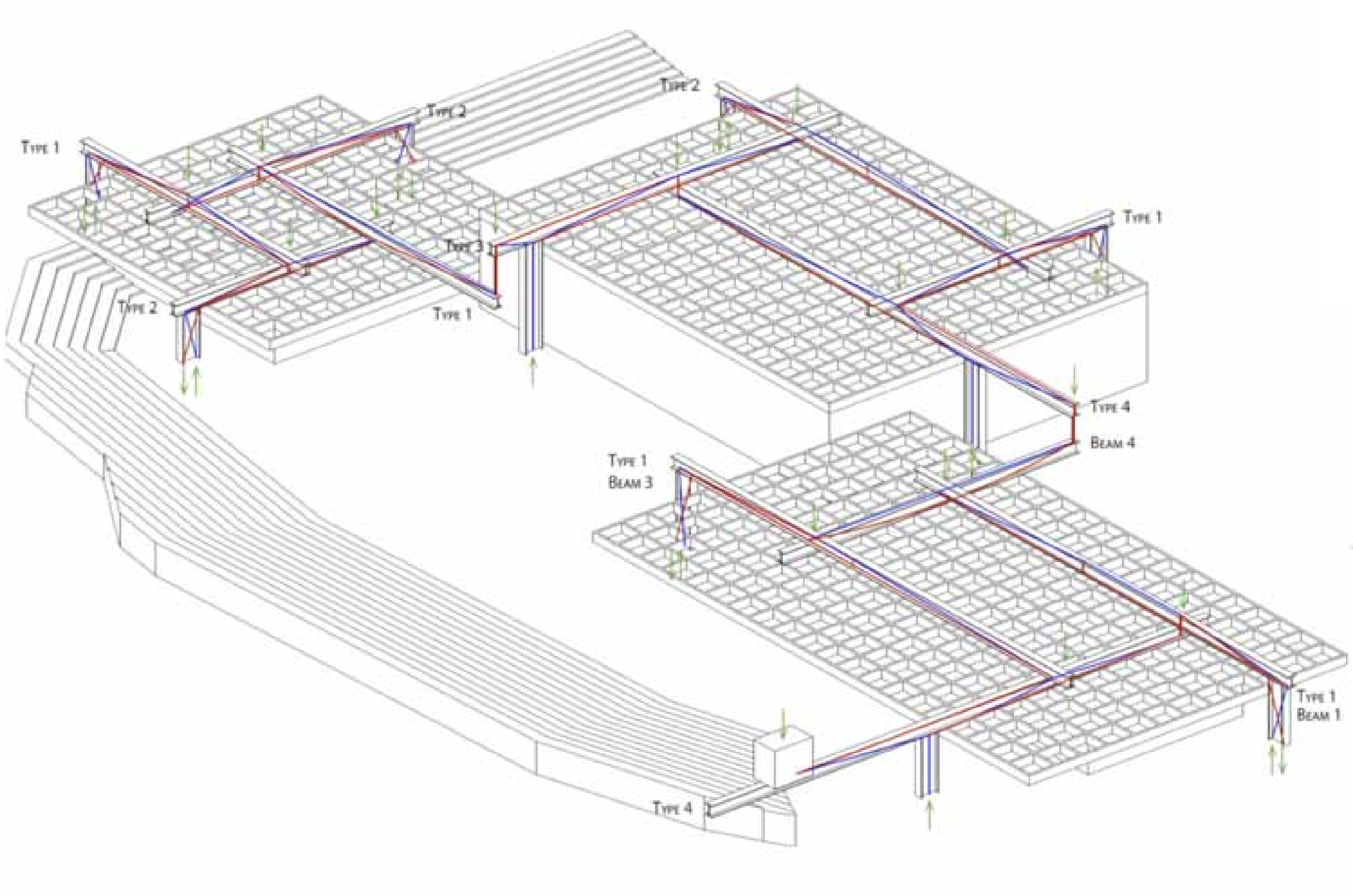

Studenten: Leonce Gruber, Natalie Klak, Abigail Vogel, Chantal Winiger

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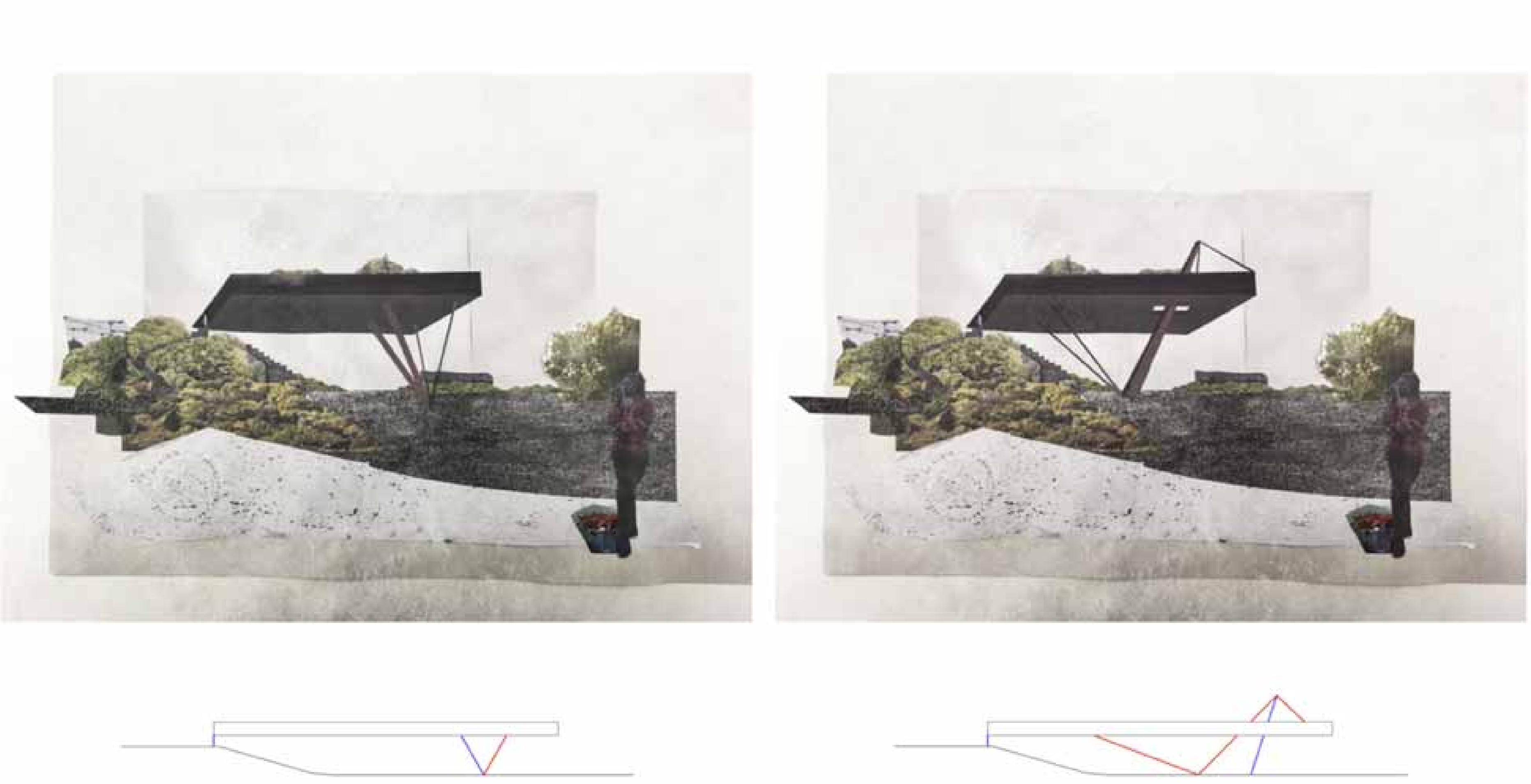

Studenten: Cynthia Baumann, Alex Nagel, Leonard Schmidt, Philip Stöckler

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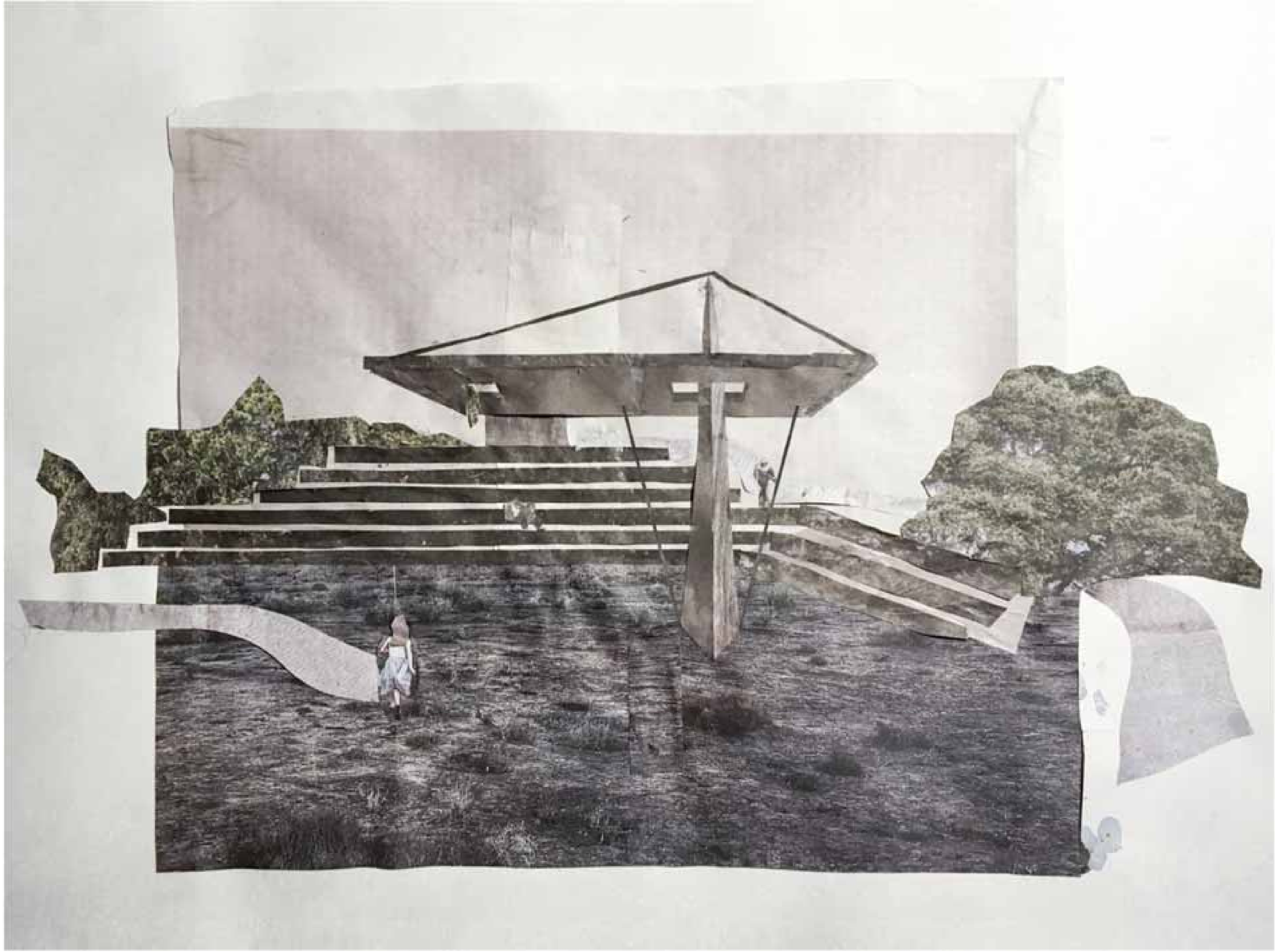

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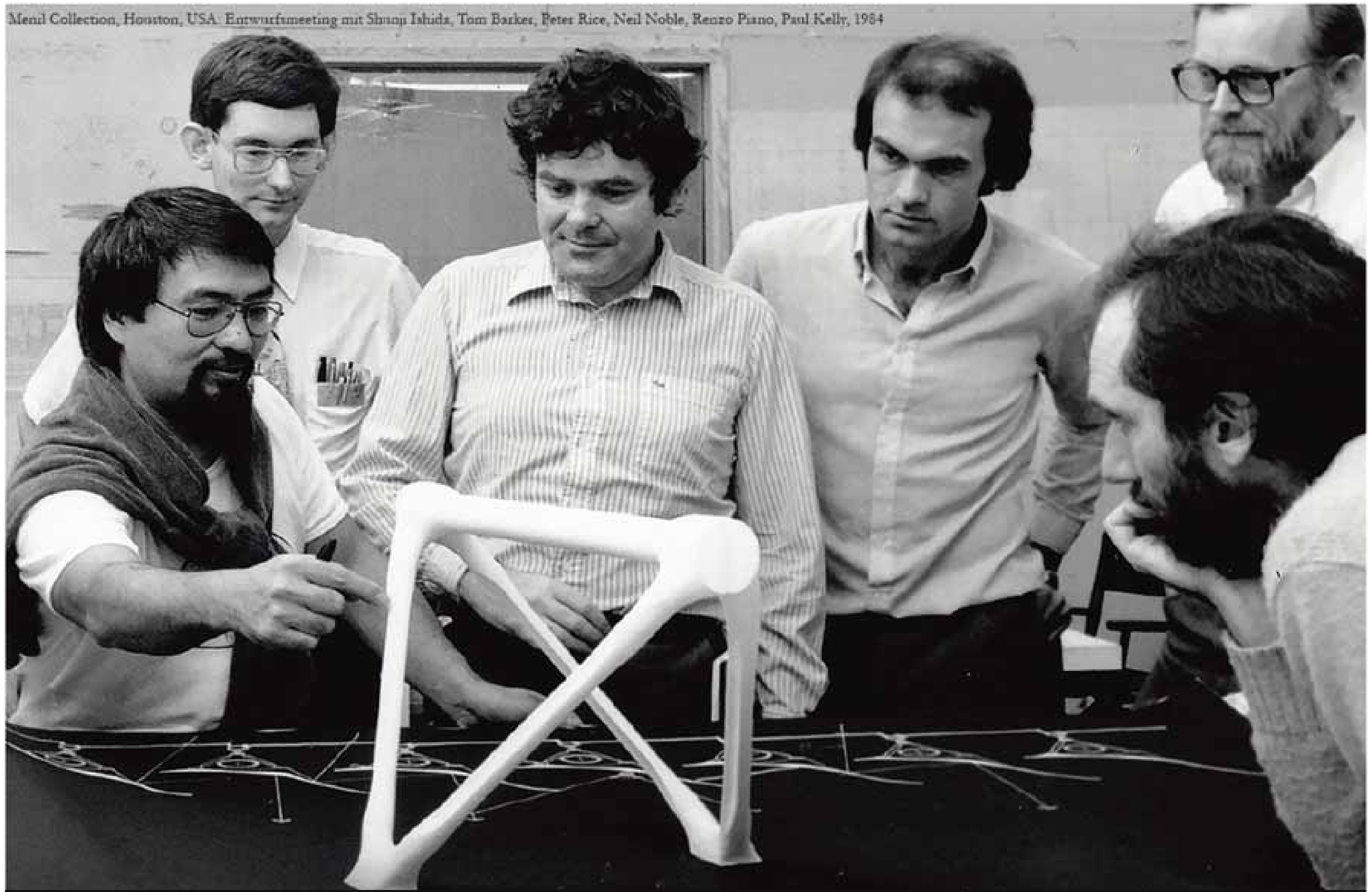
Menil Collection, Houston, USA: Entwurfsmeeting mit Shunji Ishida, Tom Barker, Peter Rice, Neil Noble, Renzo Piano, Paul Kelly, 1984
FÜR ARCHITEKTUR UND
BAUINGENIEUR STUDIERENDE



Menil Collection, Houston, USA: Entwurfsmeeting mit Shunji Ishida, Tom Barker, Peter Rice, Neil Noble, Renzo Piano, Paul Kelly, 1984

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