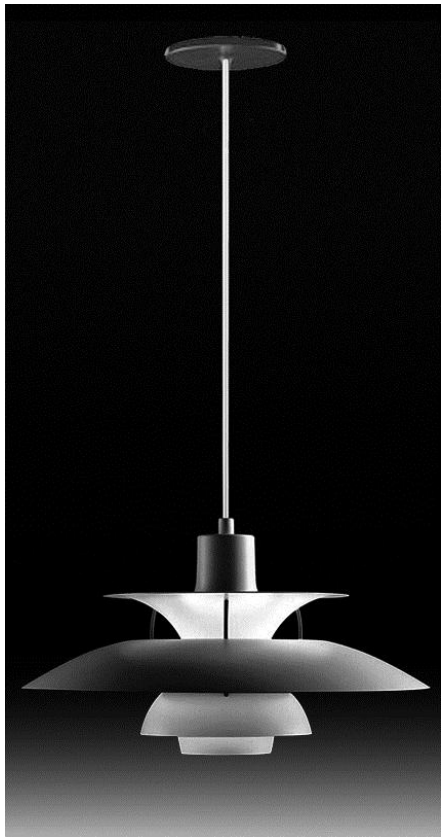
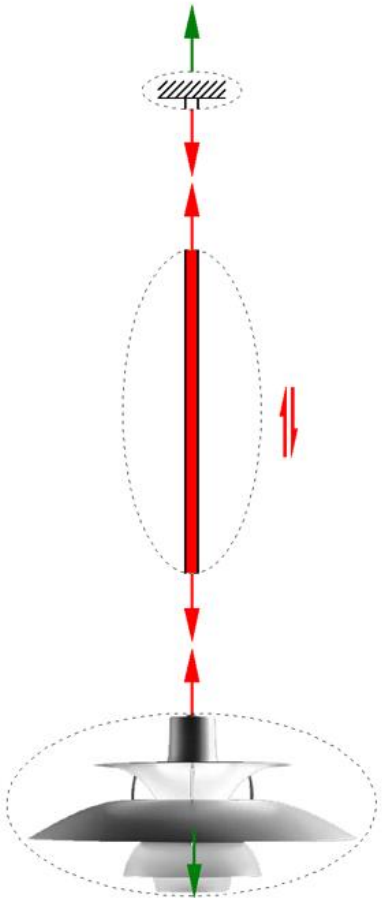
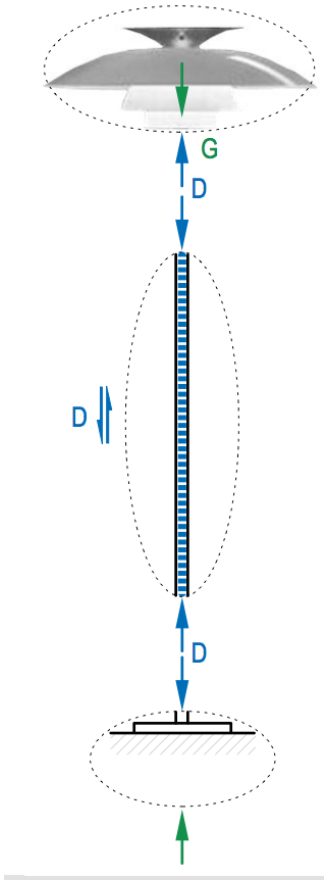
Tragwerksentwurf IV

Einfache Überlegungen zum Kräftefluss ...





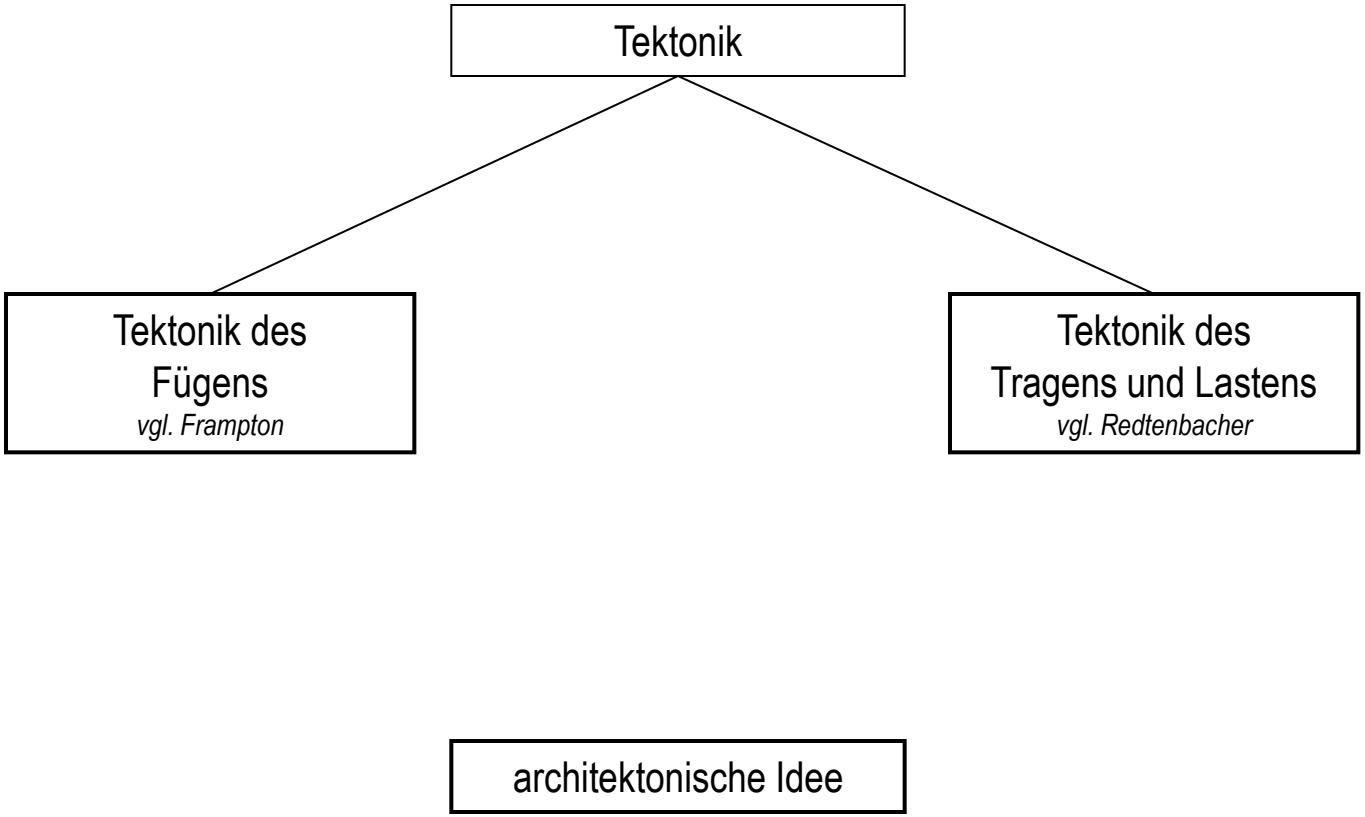


... als Ausgangspunkt für die Frage nach
physikalischer Notwendigkeit und gestalterischer Freiheit

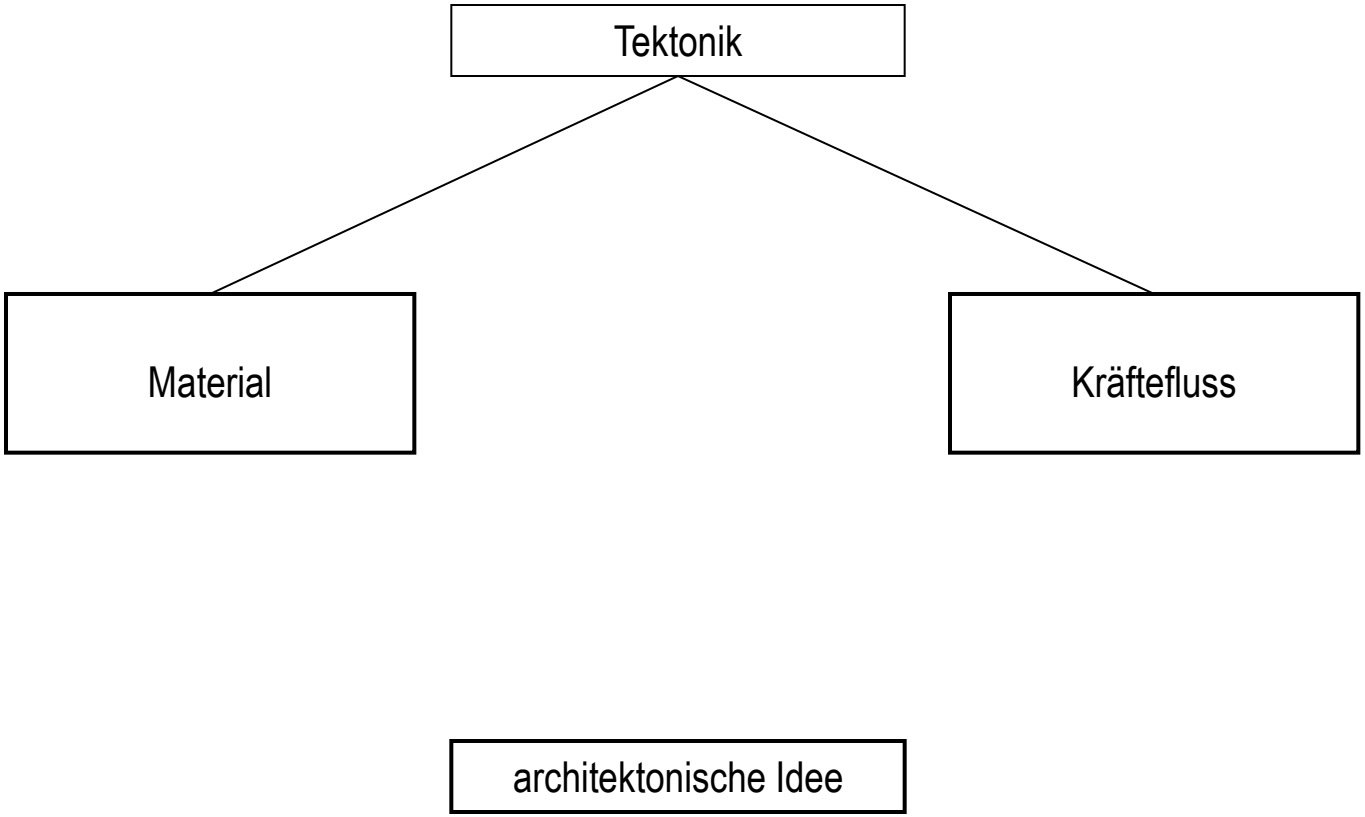
Ponte dei Salti, Lavertezzo, 18. Jhd; Brücke der Jurazementwerke, Wildegg, 1890; Brücke bei der Fondazione Querini Stampalia, Venedig, Arch.: Carlo Scarpa, 1963.

Tragkonstruktion
(Tragfähigkeit)
≠
Tragwerksentwurf
(Entwurfshaltung)

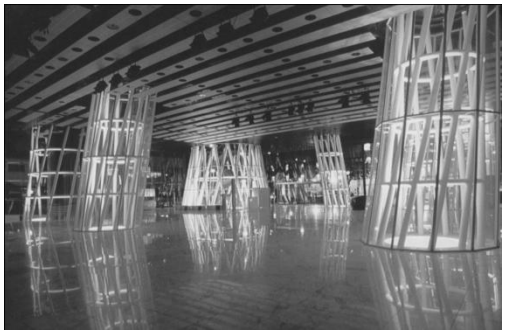
... als Ausgangspunkt für die Frage nach
physikalischer Notwendigkeit und gestalterischer Freiheit



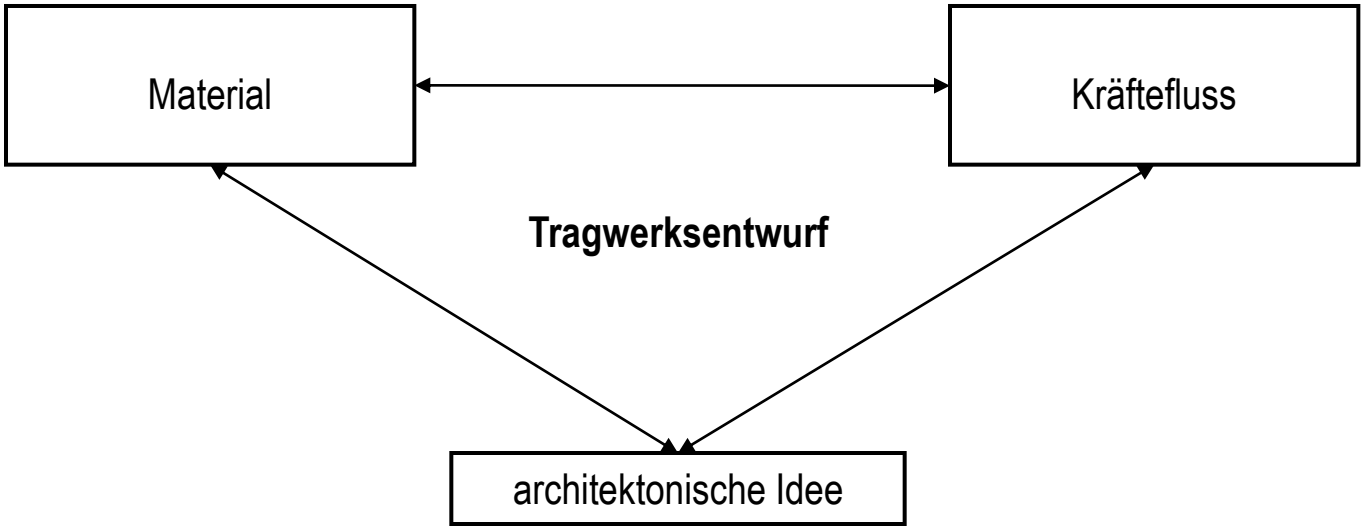
... als Ausgangspunkt für die Frage nach
physikalischer Notwendigkeit und gestalterischer Freiheit



... als Ausgangspunkt für die Frage nach
physikalischer Notwendigkeit und gestalterischer Freiheit



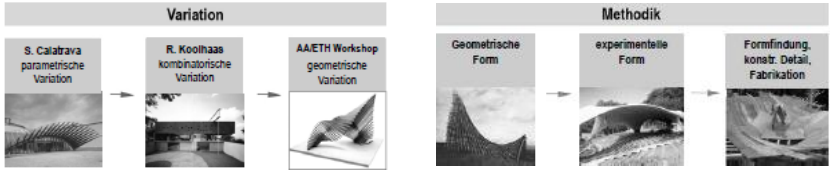
Livio Vacchini, Shigeru Ban, Christian Kerez, Toyo Ito

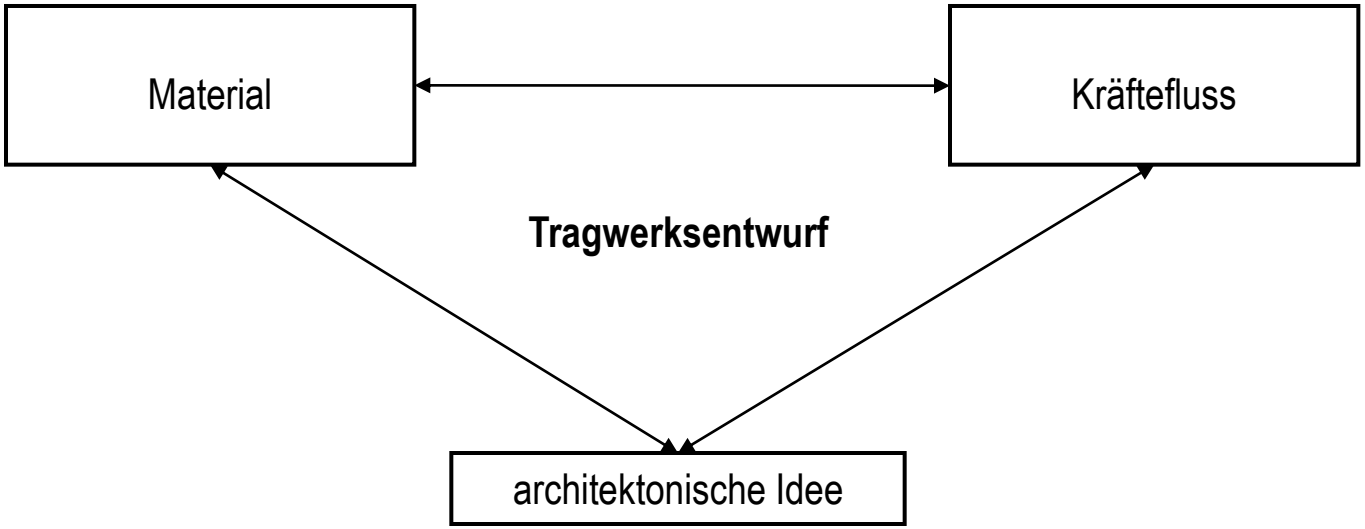


... als Ausgangspunkt für die Frage nach
physikalischer Notwendigkeit und gestalterischer Freiheit

Was?

Wie?





Wie?

Tragwerksentwurf IV

Wie?

Tragwerksentwurf IV

Variation

Experimentieren

Wie?

Tragwerksentwurf IV

Variation

Parametrische Variation
Kombinatorische Variation
Geometrische Variation

Variation

lat. *variare* „verändern“

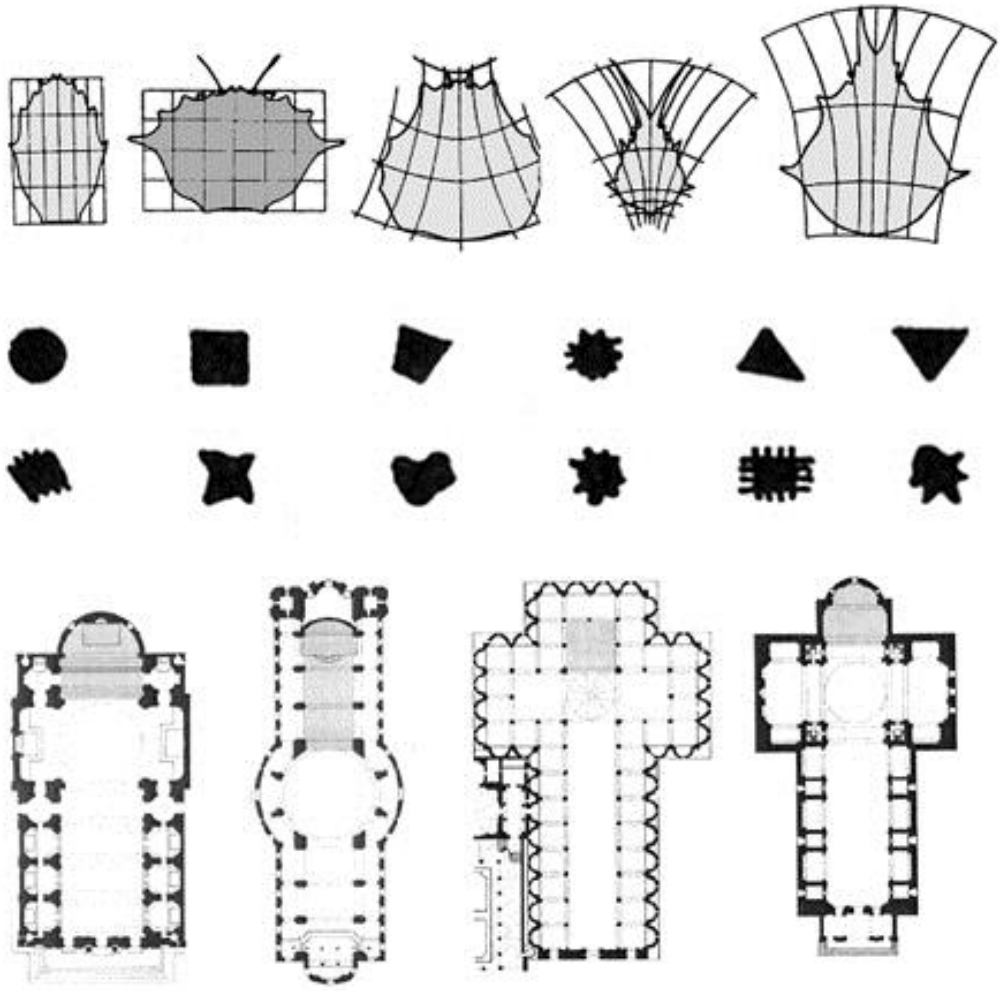
bei der Variation als entwerferische Methode
geht es um das kontrollierte Abändern von Eigenschaften

die Variation ist eng verknüpft mit der Repetition,
der unveränderten Wiederholung

Variation und Repetition bedingen sich gegenseitig

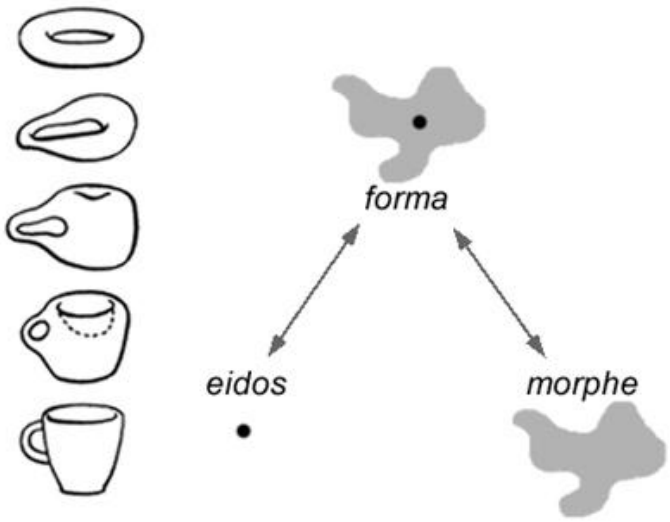
Variation und Repetition

Variation und Repetition: Typ



D'Arcy Thompson: Variationen der Morphologie von *crustacean caraparces*
Kandinsky: Beispiele der Punktformen
Architekturtyp christlicher Sakralbau longitudinal

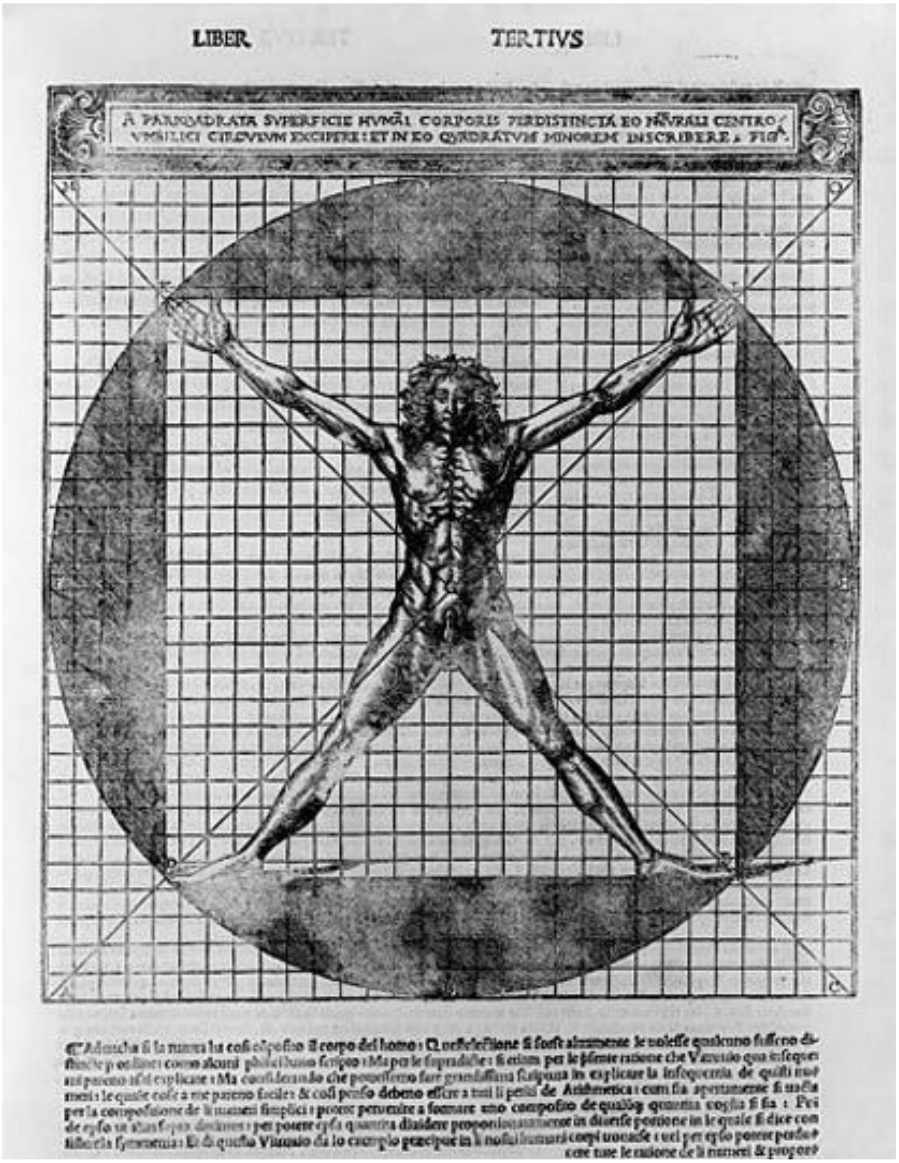
Variation und Repetition: Typ

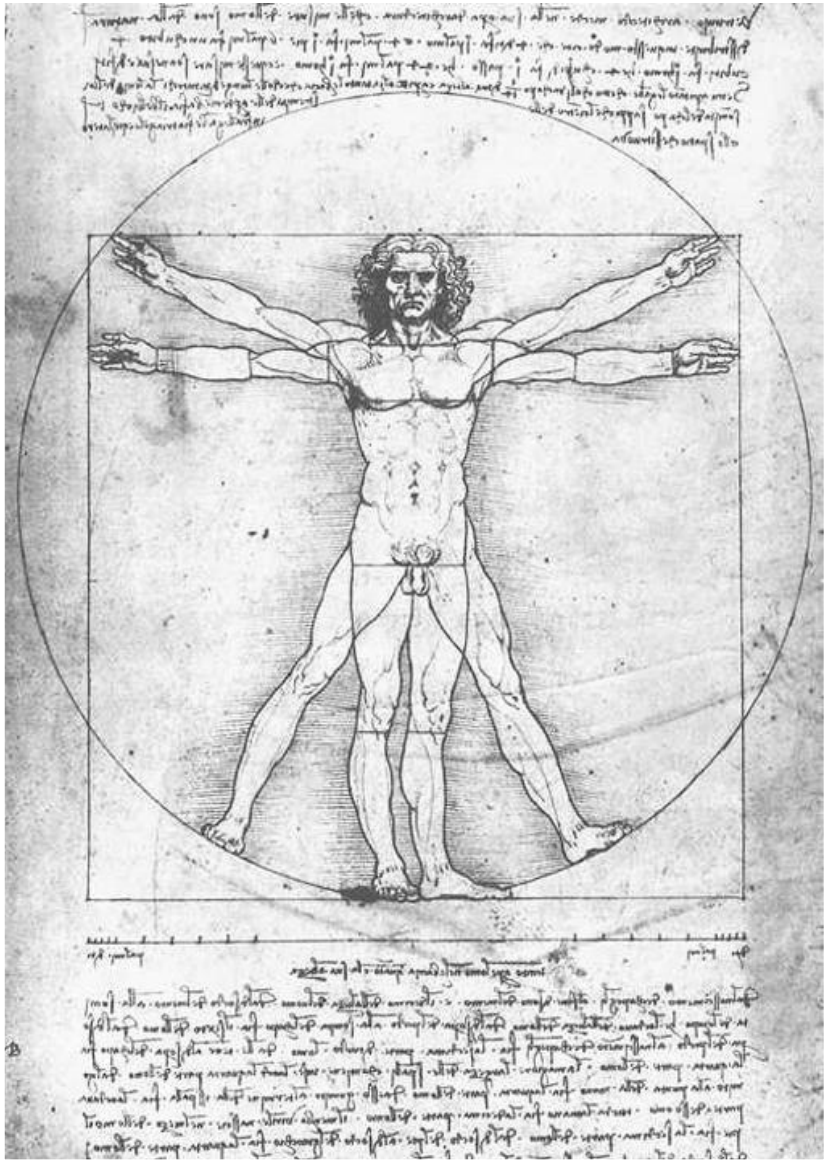


„Das Wort Typus bezieht sich nicht so sehr auf das Bild einer zu kopierenden oder vollständig nachzuahmenden Sache als auf eine Idee, die dem Modell als Regel dient. ... [Der Typus] stellt eine Art Kern dar, an den in der Folge alle Entwicklungen und Formvarianten, deren das Objekt fähig ist, in einer bestimmten Ordnung anknüpfen. Deshalb sind 1000 Dinge aller Art auf uns gekommen, und es ist eine Herausforderung von Wissenschaft und Philosophie, deren Ursprung und letzte Ursache zu erforschen, um die Gründe für ihre Entstehung zu begreifen. Das also ist es, was in der Architektur wie in jedem anderen Zweig der menschlichen Erfindungen und Institutionen als Typus zu bezeichnen ist .“

Antoine Chrysostome Quatremère de Quincy (1755 – 1849)

Variation und Repetition: Ideal

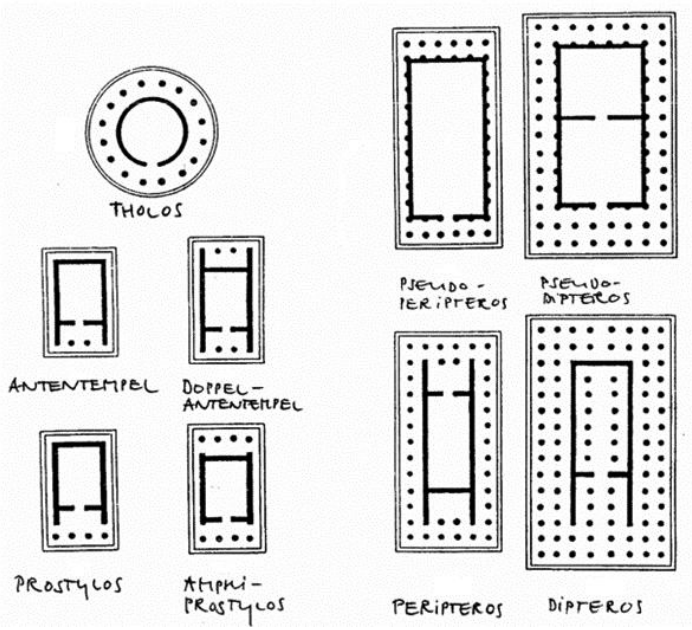


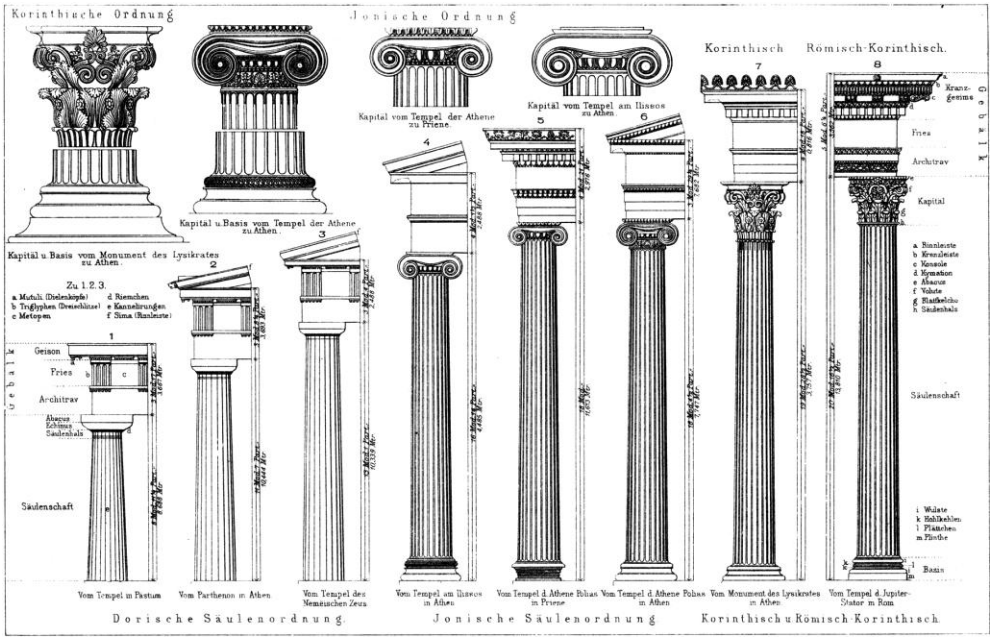


Vitruvscher Mensch nach Cesare Cesariano (1475-1543) und Leonardo da Vinci (1452-1519)

Variation und Repetition: Typologie und Proportion

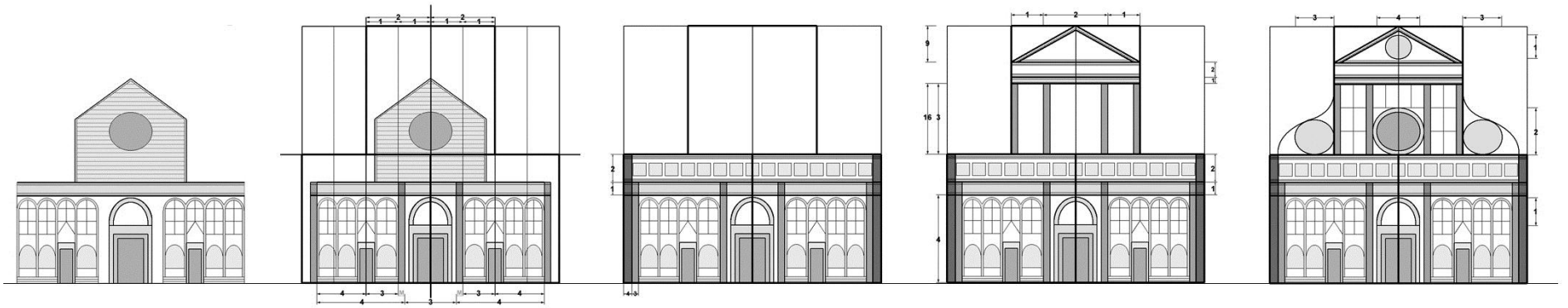
Dorischer Tempel , Agrigento, 5. Jhd. v. Chr.



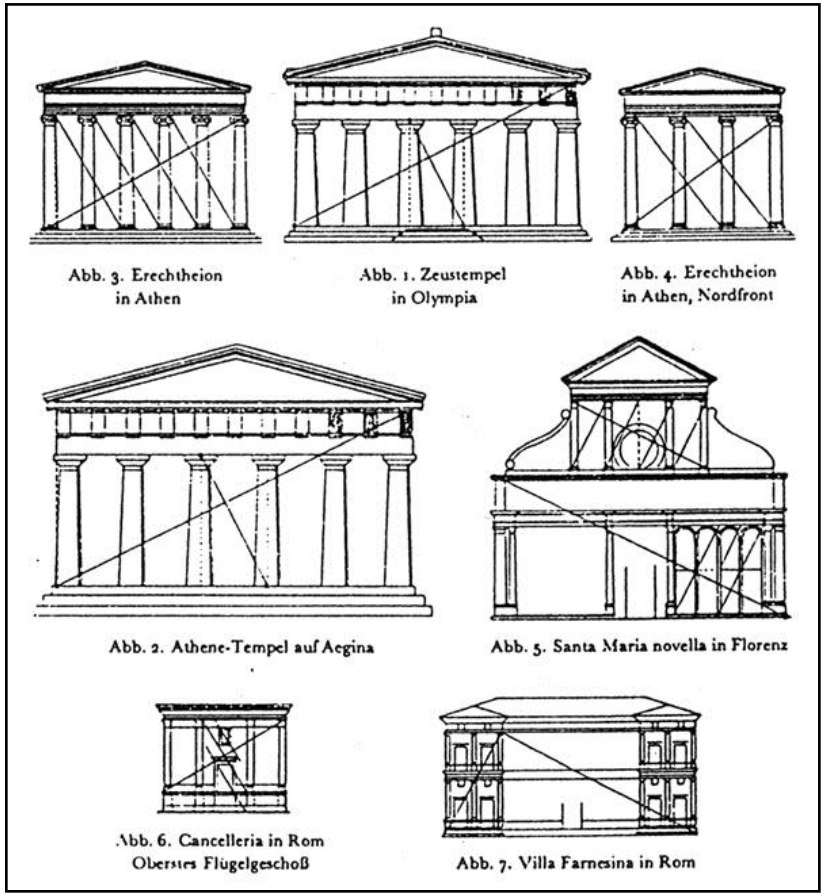


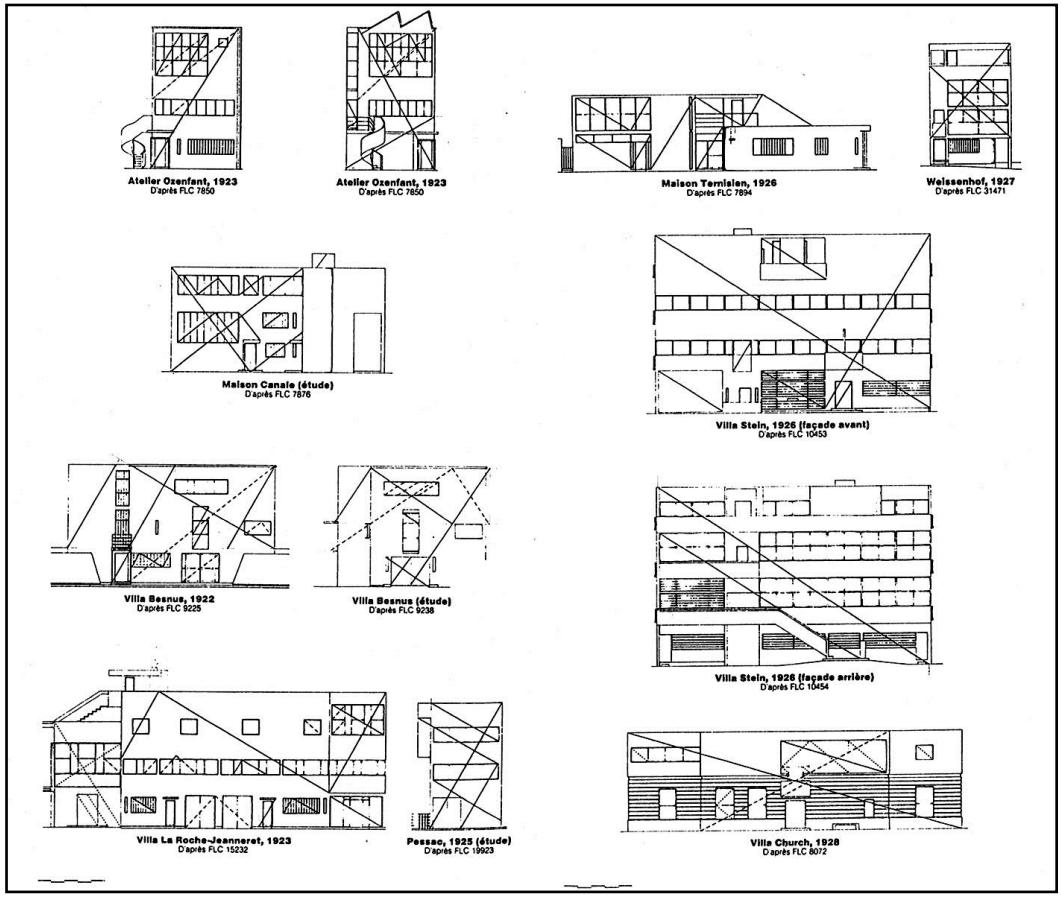
Variation und Repetition: Proportion

Santa Maria Novella, Florenz, 1456-58
Arch: Alberti



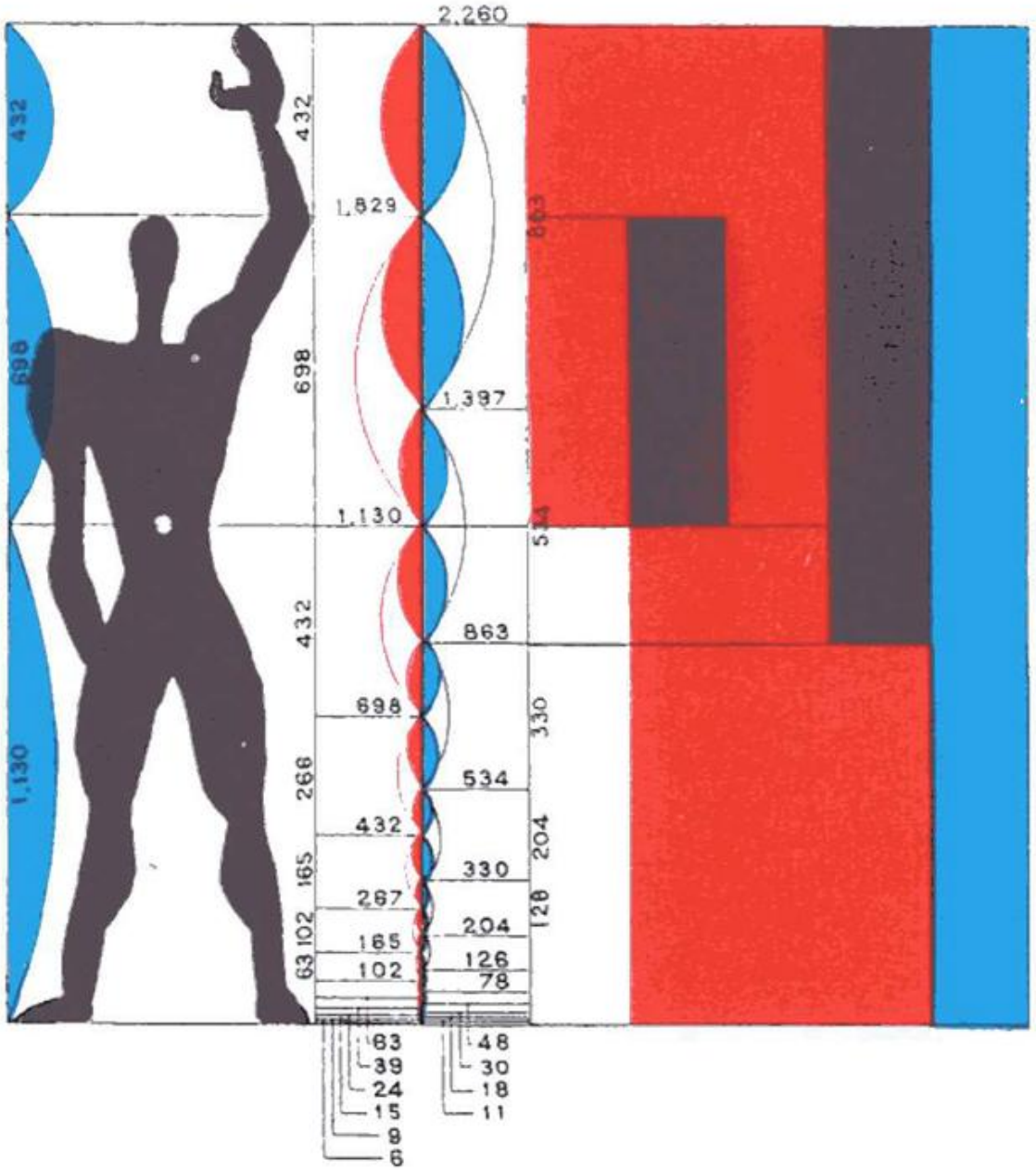
Variation und Repetition: tracés régulateurs

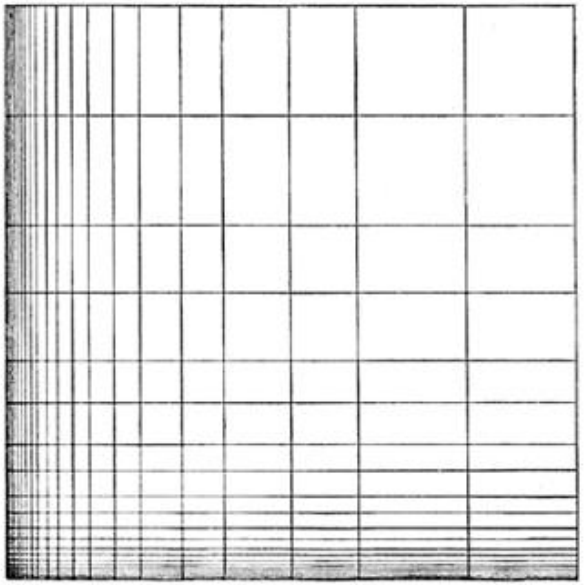


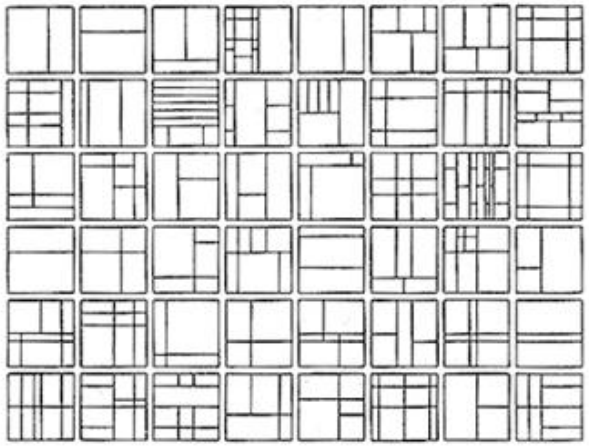


Regellinien bei Wölfflin und Le Corbusier

Variation und Repetition: Modulor





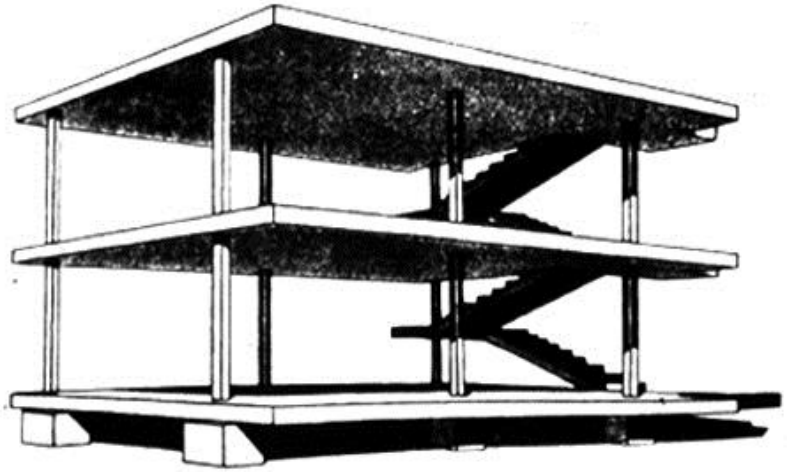


Modulor-System von Le Corbusier: Raster und Modulor-Spiel

Das neutrale Tragwerk als Hintergrund

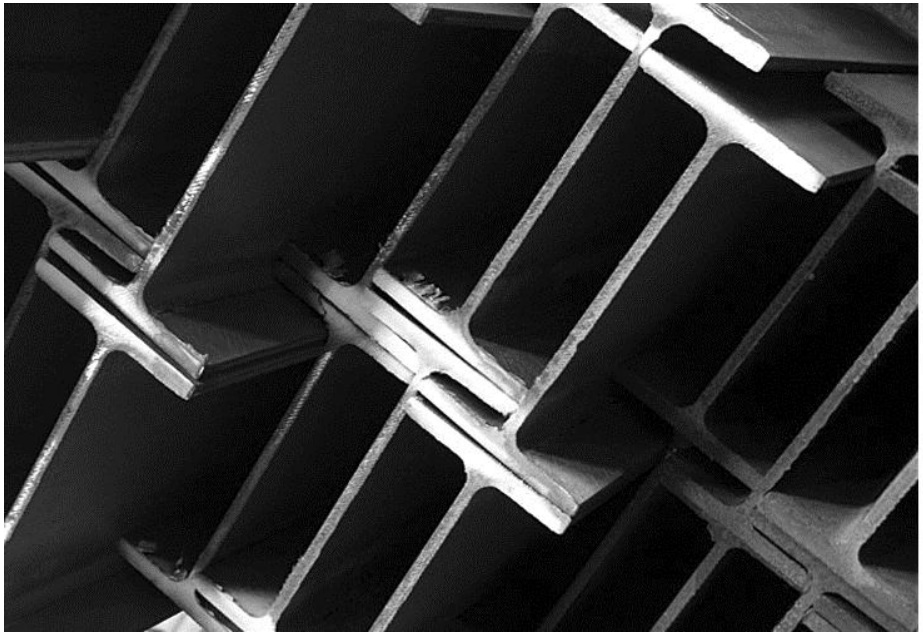
Le Corbusiers:
Fünf Punkte zu einer neuen Architektur

Die Stütze
Der Dachgarten
Die freie Grundrissgestaltung
Das Langfenster
Die freie Fassadengestaltung



Weissenhof, Stuttgart, 1927; Villa Savoye, Poissy-sur-Seine, 1928-31, Arch.: Le Corbusier

Standardisierung als Teil des industriellen Bauens

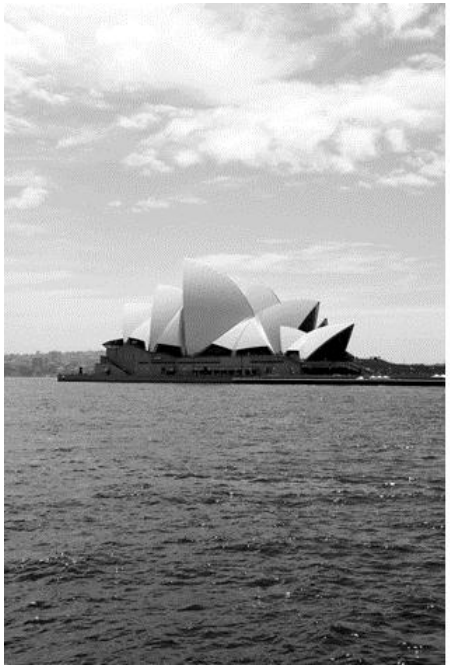


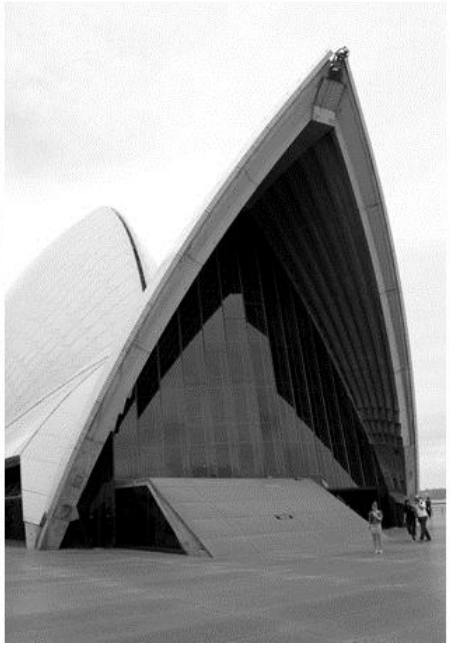
Standardisierte Massenprodukte

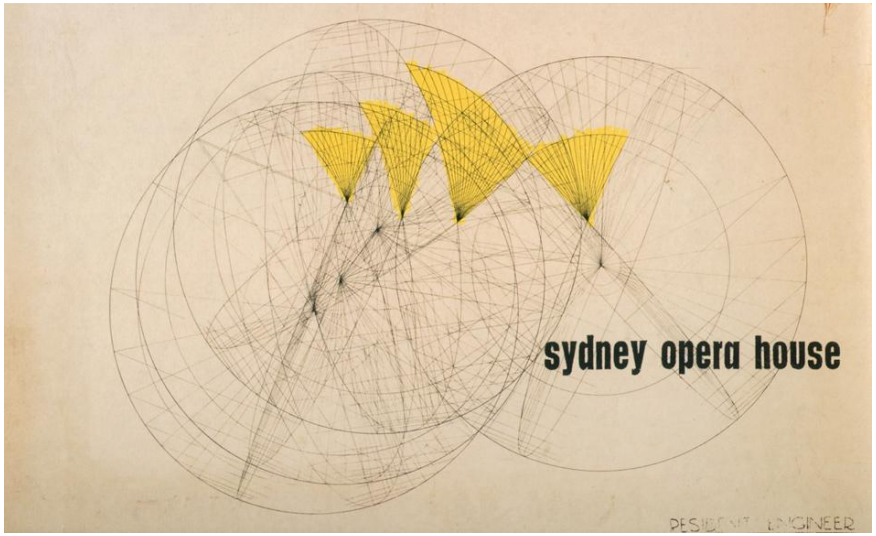
Repetition von standardisierten Elementen

Federal Center, Chicago, 1964, Arch.: Mies van der Rohe

Repetition von gleichbleibenden Elementen

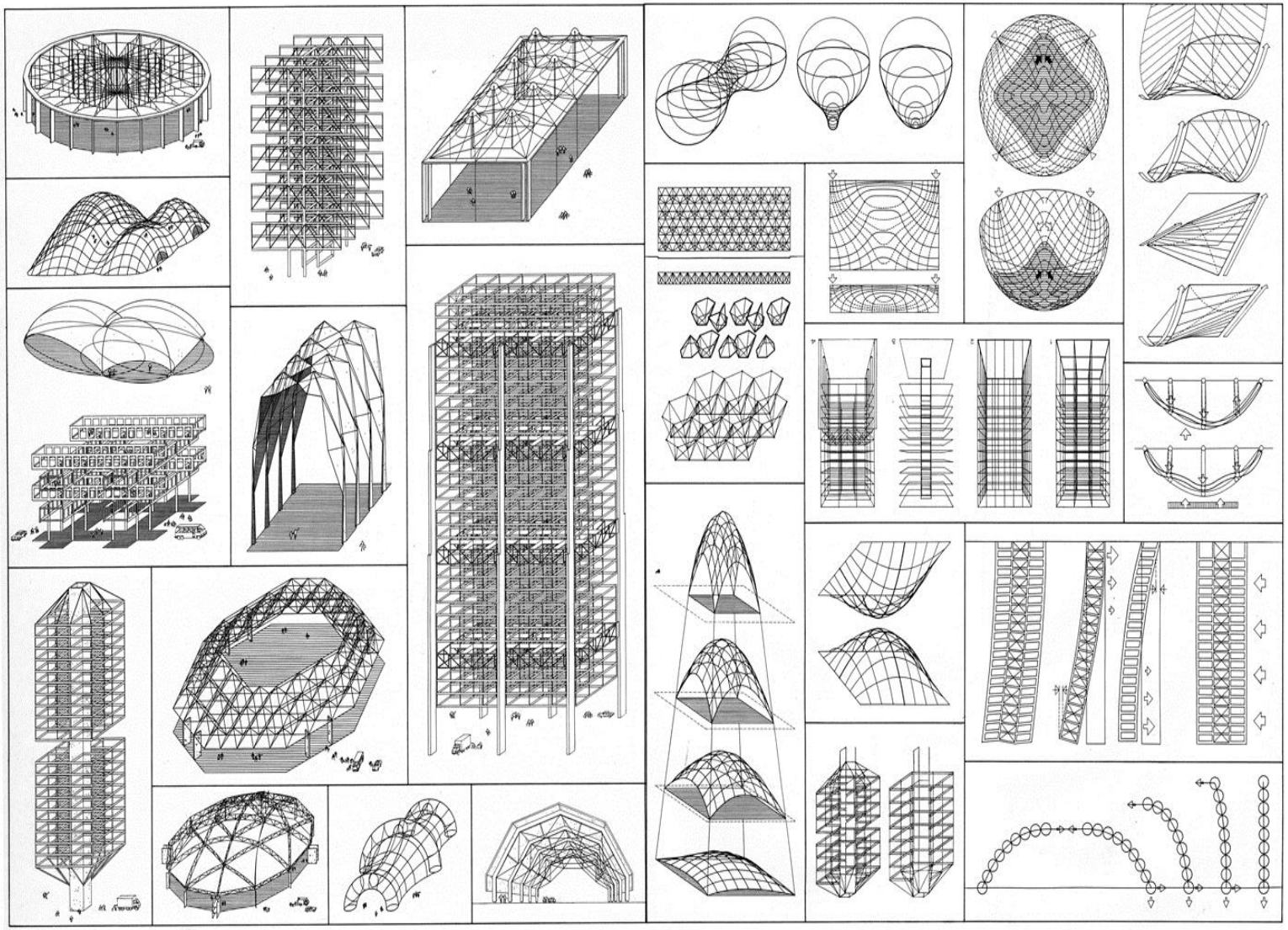






Opernhaus, Sydney, 1957-73,
Arch.: Jørn Utzon

Dominanz des Typologischen im Tragwerk

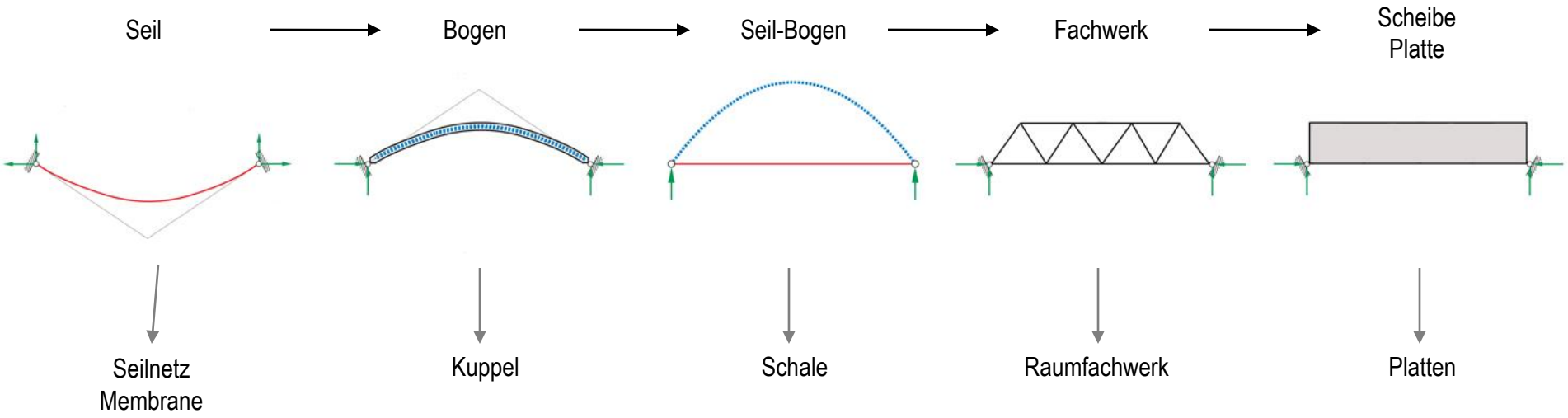


Klassifikation von Tragwerken nach Engel

Variation von Form und Struktur

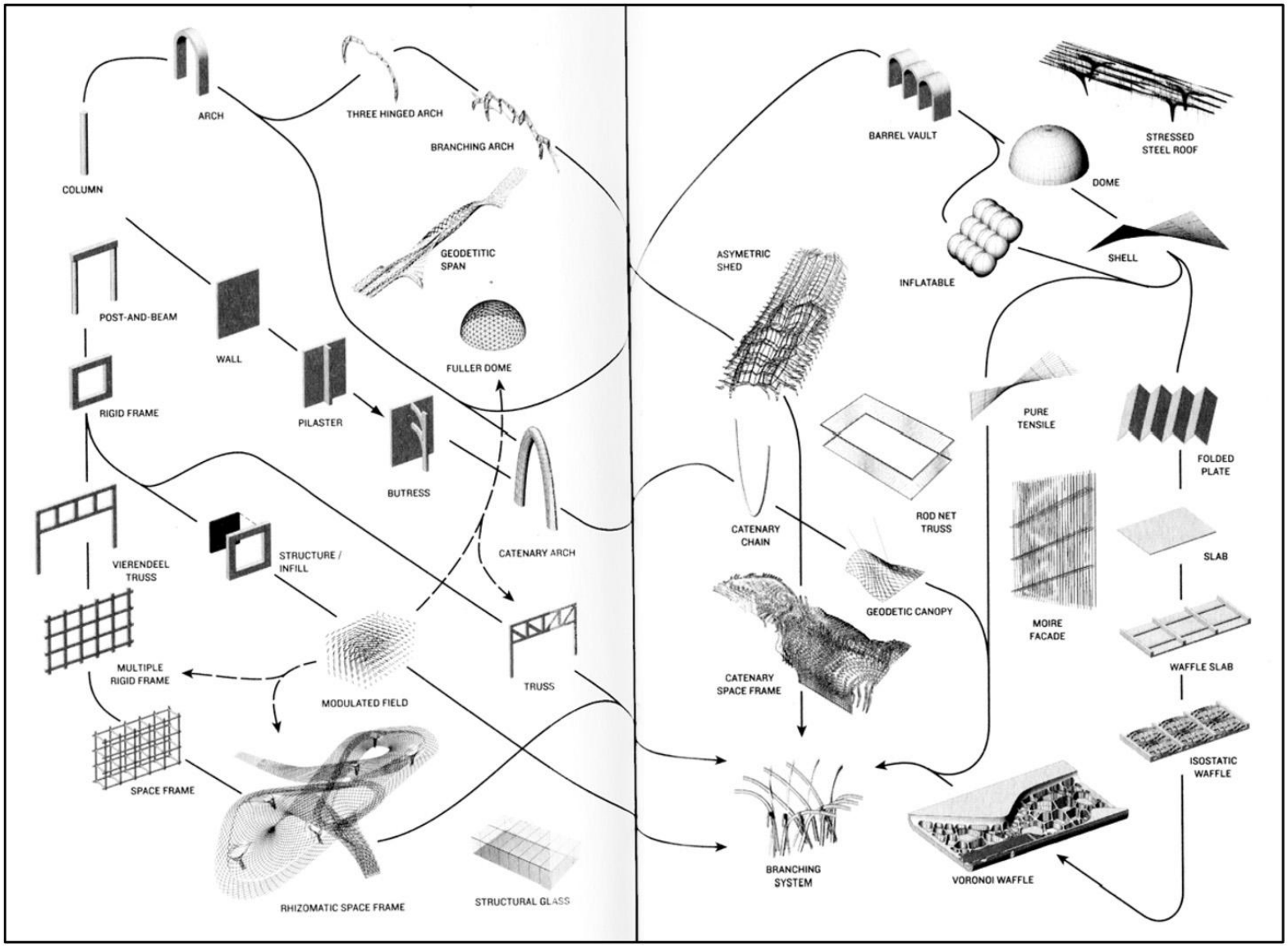
Mercedes-Benz Museum, Stuttgart, 2001-06, Arch.: UN Studio; Centre Pompidou, Metz, 2004-10, Arch.: Shigeru Ban; Metropolitan Opera, Taichung, 2005-13, Arch.: Toyo Ito
Hungerburgbahn, Innsbruck, 2006-07, Arch.: Zaha Hadid; Walt Disney Concert Hall, Los Angeles, 1988-2003, Arch.: Frank Gehry; National Aquatic Center, Bejing, 2003-07, Arch: PTW Architects

Unterschiedliche Tragelemente als System zunehmender Komplexität



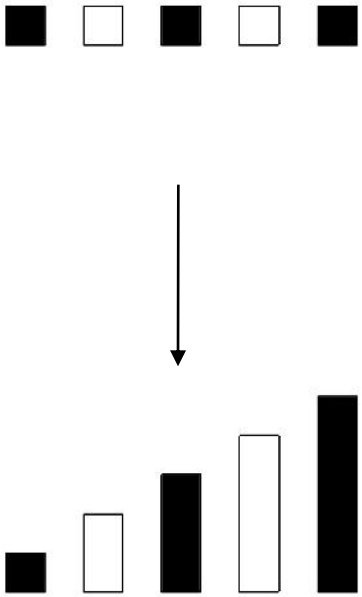
~~Typologische Klassifikation von Tragwerken~~
Kontinuum des Kräfteflusses durch den Raum

Variation von Tragwerk als entwerferische Möglichkeit

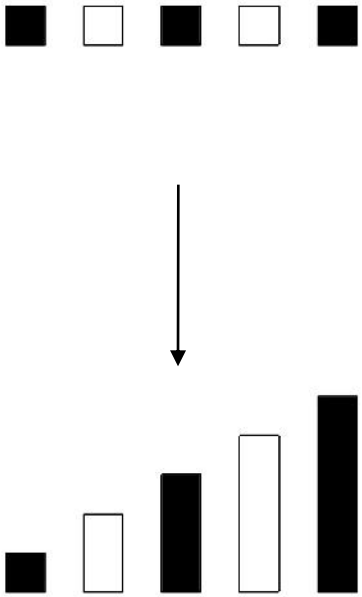


Reiser + Umemoto: Atlas of Novel Tectonics, 2006

Taxonomie des Variierens von Tragwerk

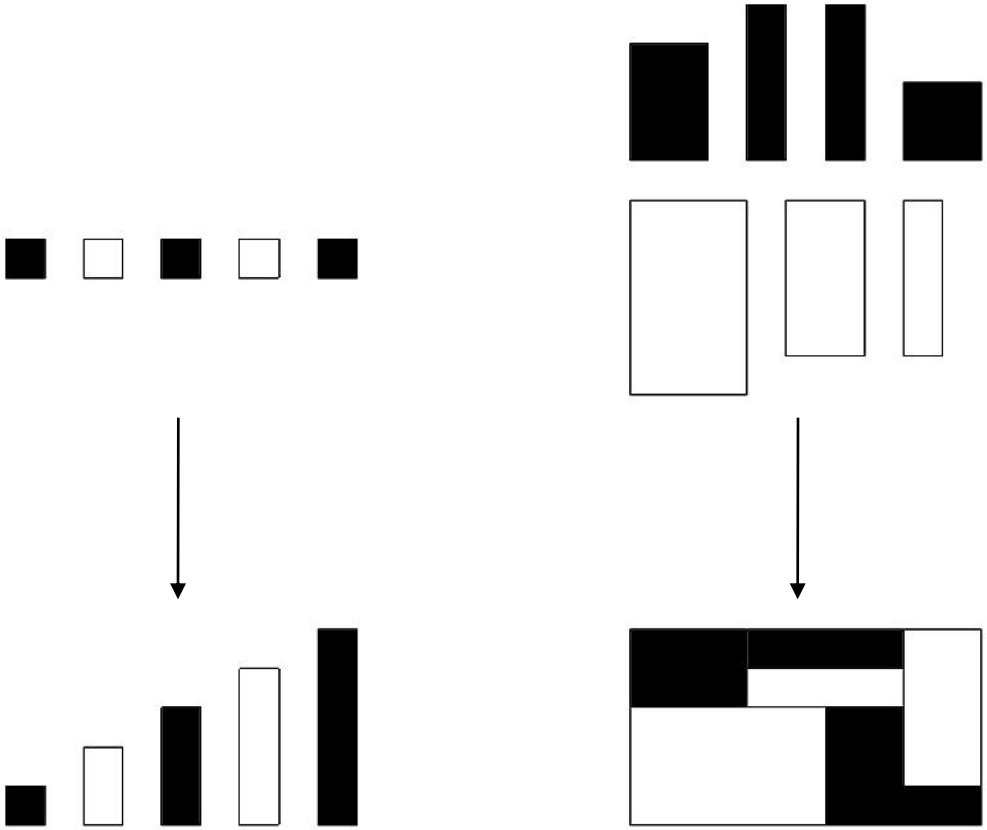


Taxonomie des Variierens von Tragwerk



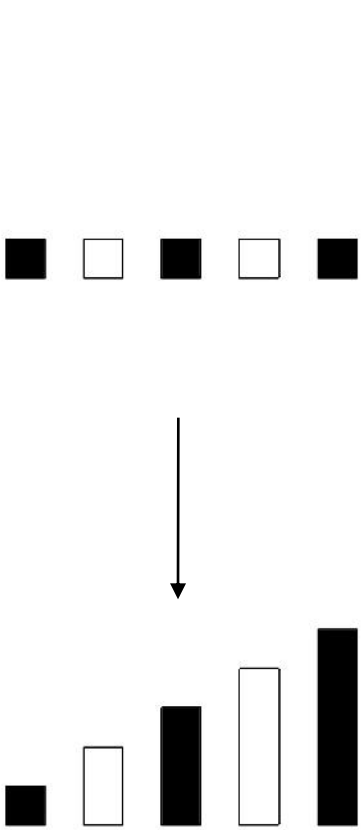
parametrische Variation

Taxonomie des Variierens von Tragwerk

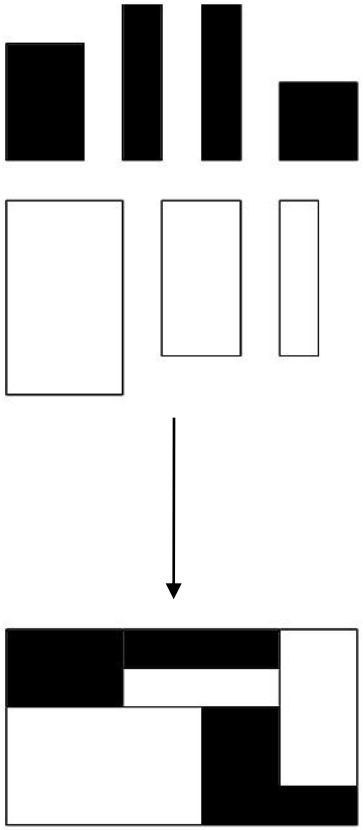


parametrische Variation

Taxonomie des Variierens von Tragwerk

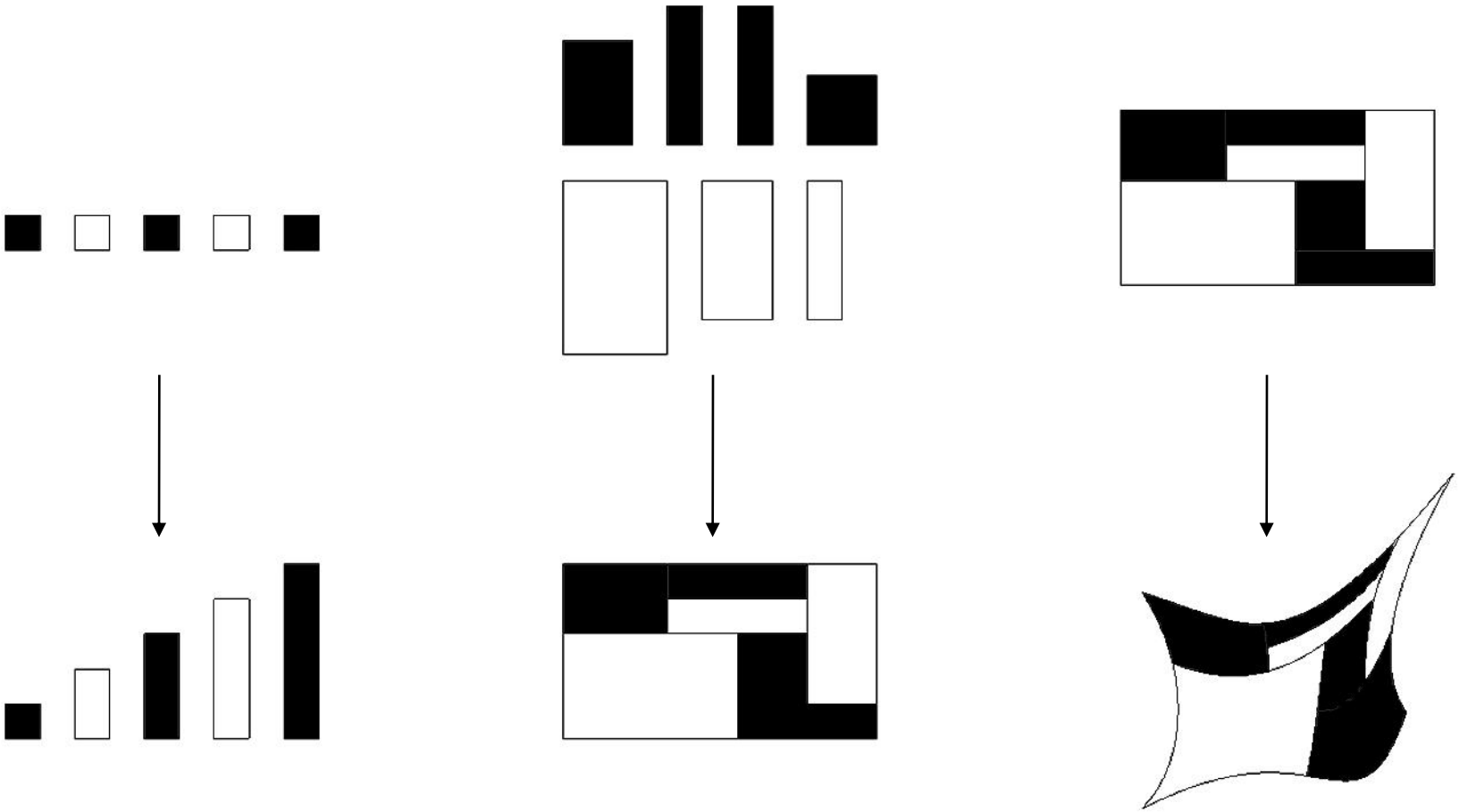


parametrische Variation



kombinatorische Variation

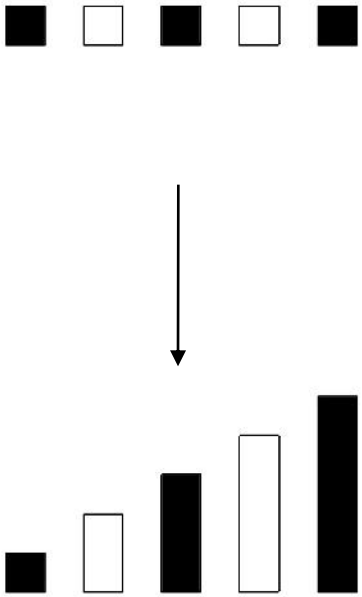
Taxonomie des Variierens von Tragwerk



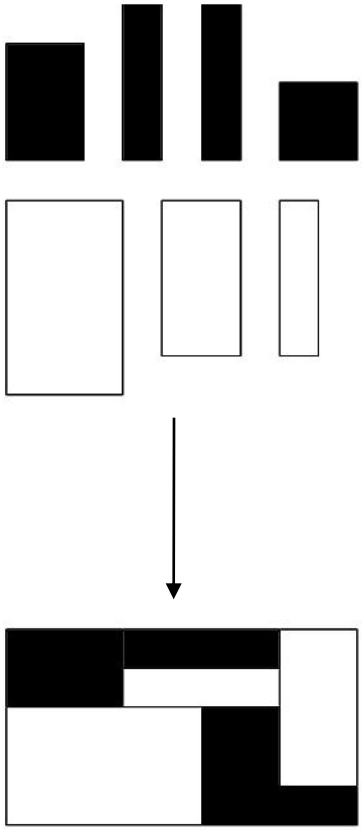
parametrische Variation

kombinatorische Variation

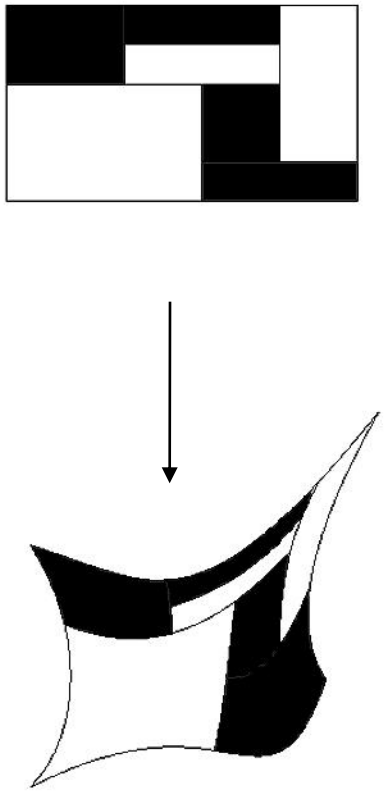
Taxonomie des Variierens von Tragwerk



parametrische Variation

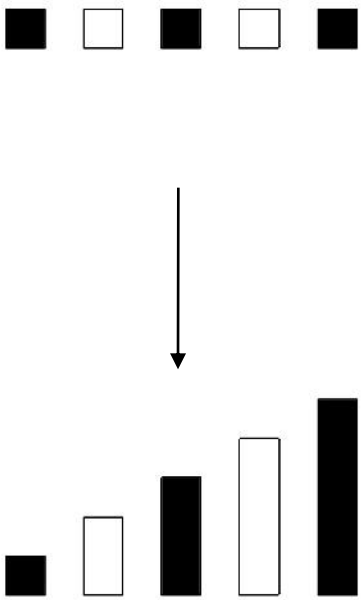


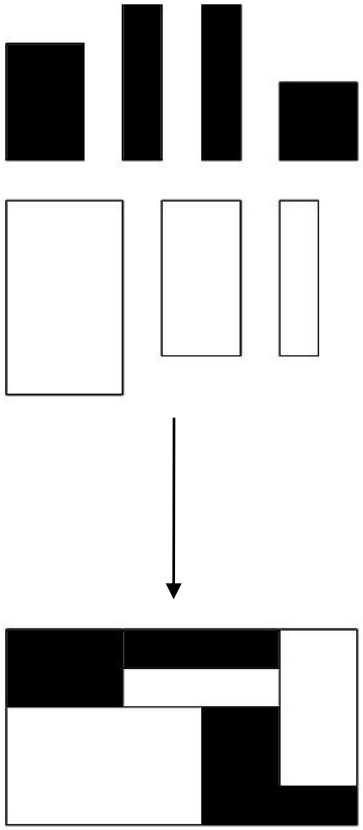
kombinatorische Variation

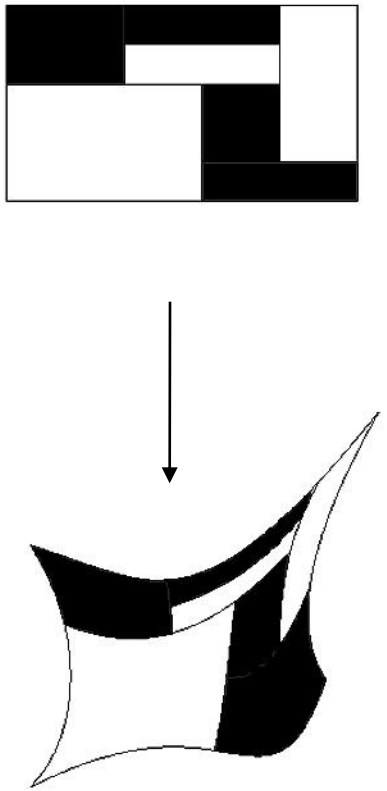


geometrische Variation

Taxonomie des Variierens von Tragwerk



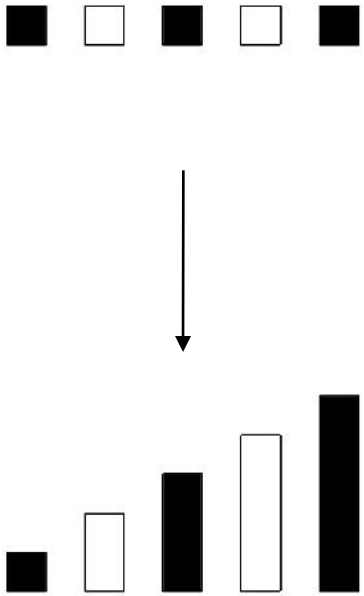




Santiago Calatrava: parametrische Variation

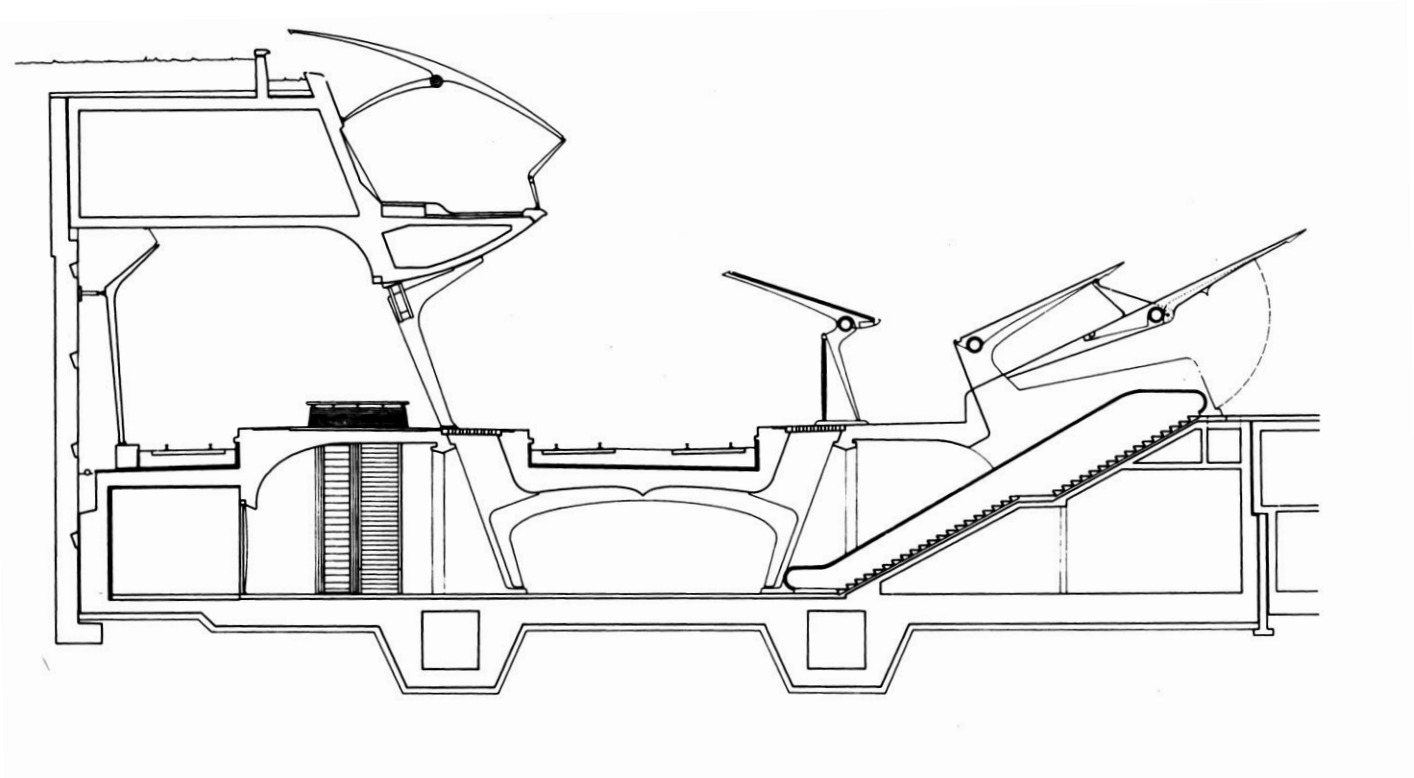
kombinatorische Variation

geometrische Variation



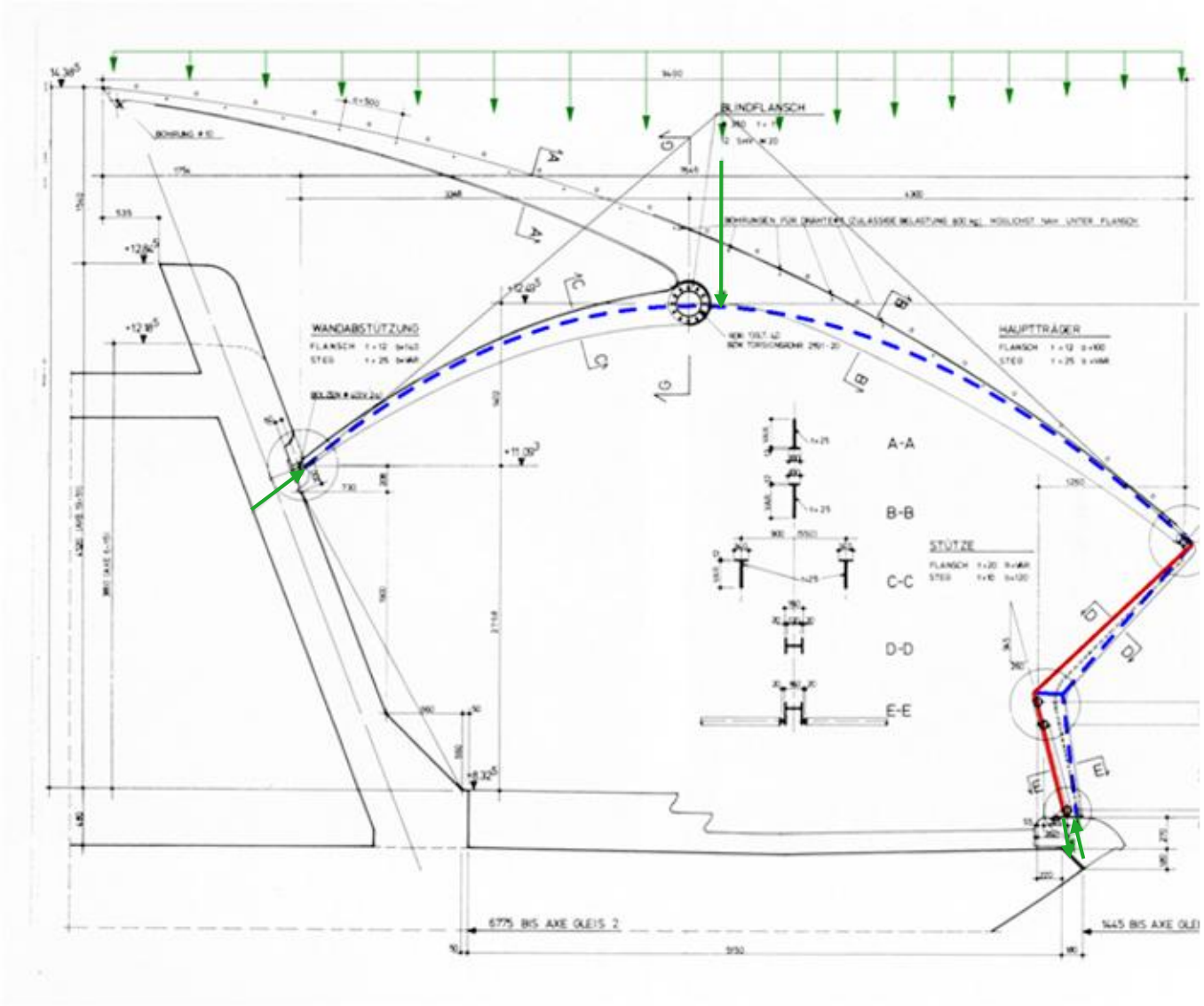
Bahnhof Stadelhofen, Zürich, 1983 – 1990, Arch.: Santiago Calatrava

Repetition expressiver Elemente



Schnitt, Bahnhof Stadelhofen, Zürich, 1983 – 1990, Arch.: Santiago Calatrava

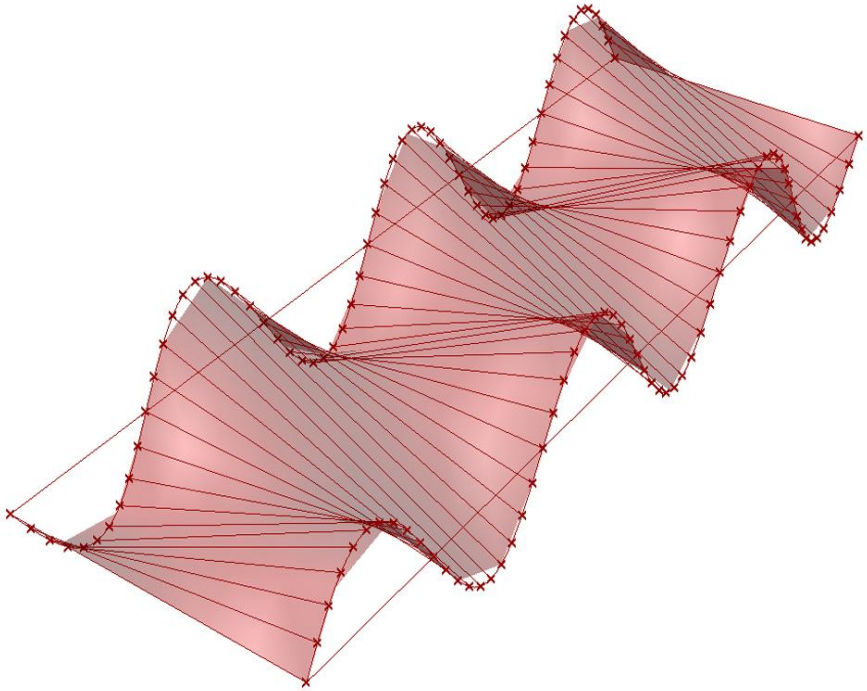
Geformter Kräftefluss



Galerie, Bahnhof Stadelhofen, Zürich, 1983 – 1990, Arch.: Santiago Calatrava

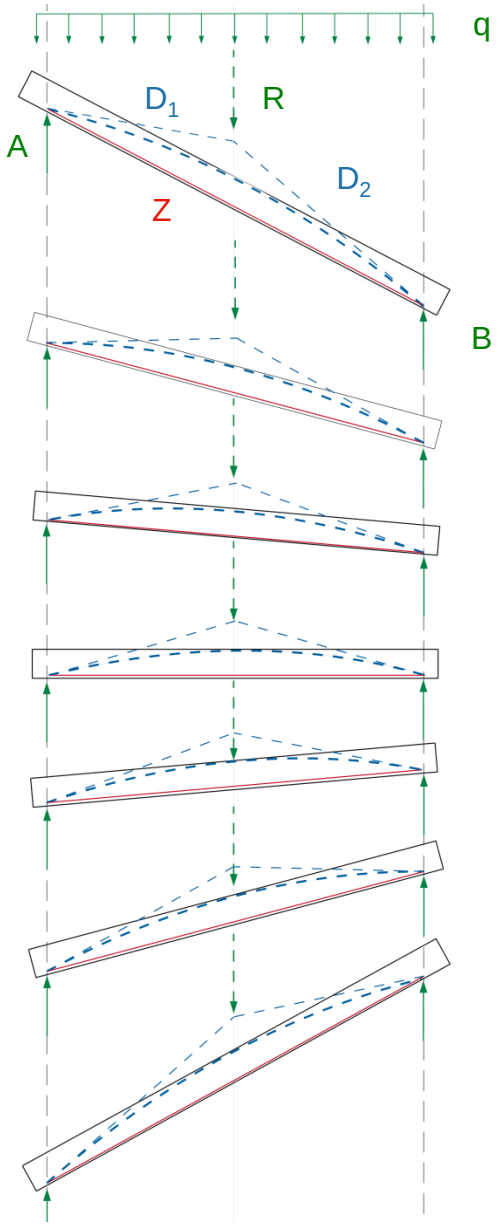
Bodegas Ysios Laguardia, Álava, 1998-2000, Arch.: Santiago Calatrava

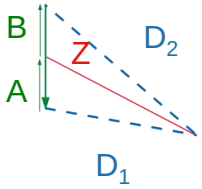
Repetition des Elements
Variation der geometrischen Lage



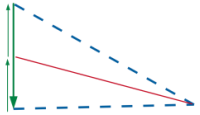
Bodegas Ysios Laguardia, Álava, 1998-2000, Arch.: Santiago Calatrava

Variation der inneren Kräfte





$D_1 << D_2$



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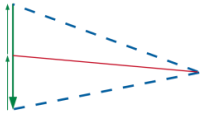
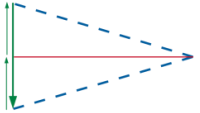


$D_1 \approx D_2$



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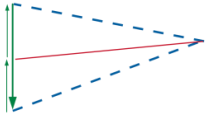
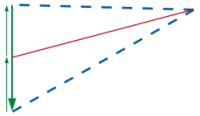
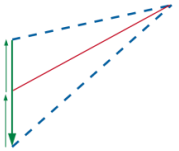


$D_1 \approx D_2$



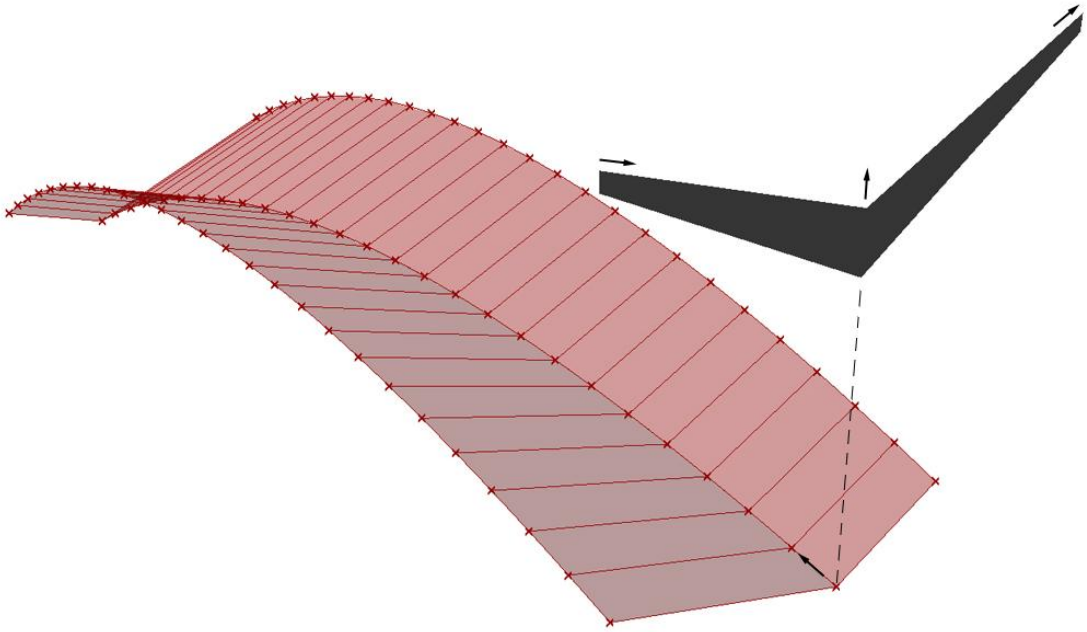
$D_1 > D_2$



$D_1 >> D_2$

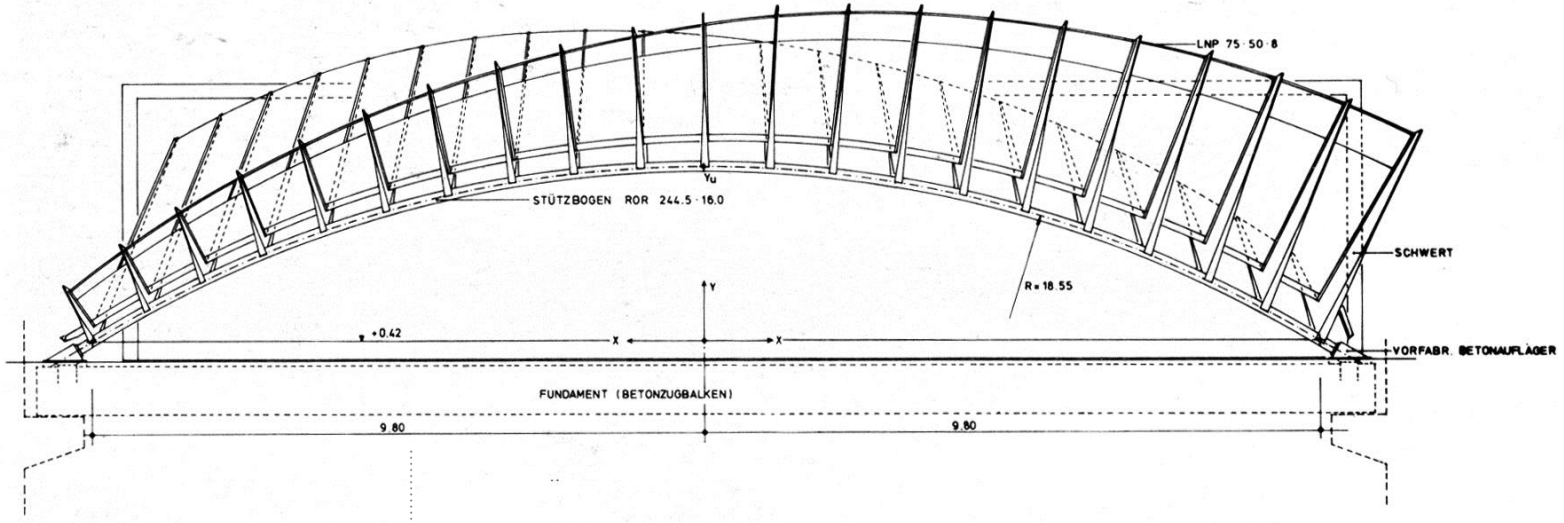
Eingang, Kantonschule, Wohlen, 1988, Arch.: Santiago Calatrava

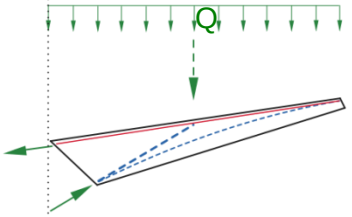
Variation des Elements
Variation der geometrischen Lage

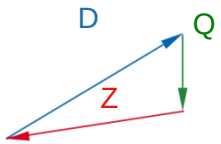


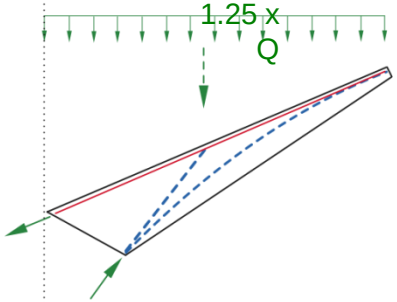
Eingang, Kantonschule, Wohlen, 1988, Arch.: Santiago Calatrava

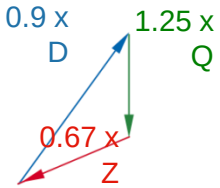
Variation der inneren Kräfte







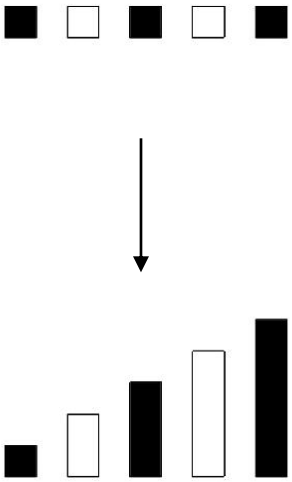




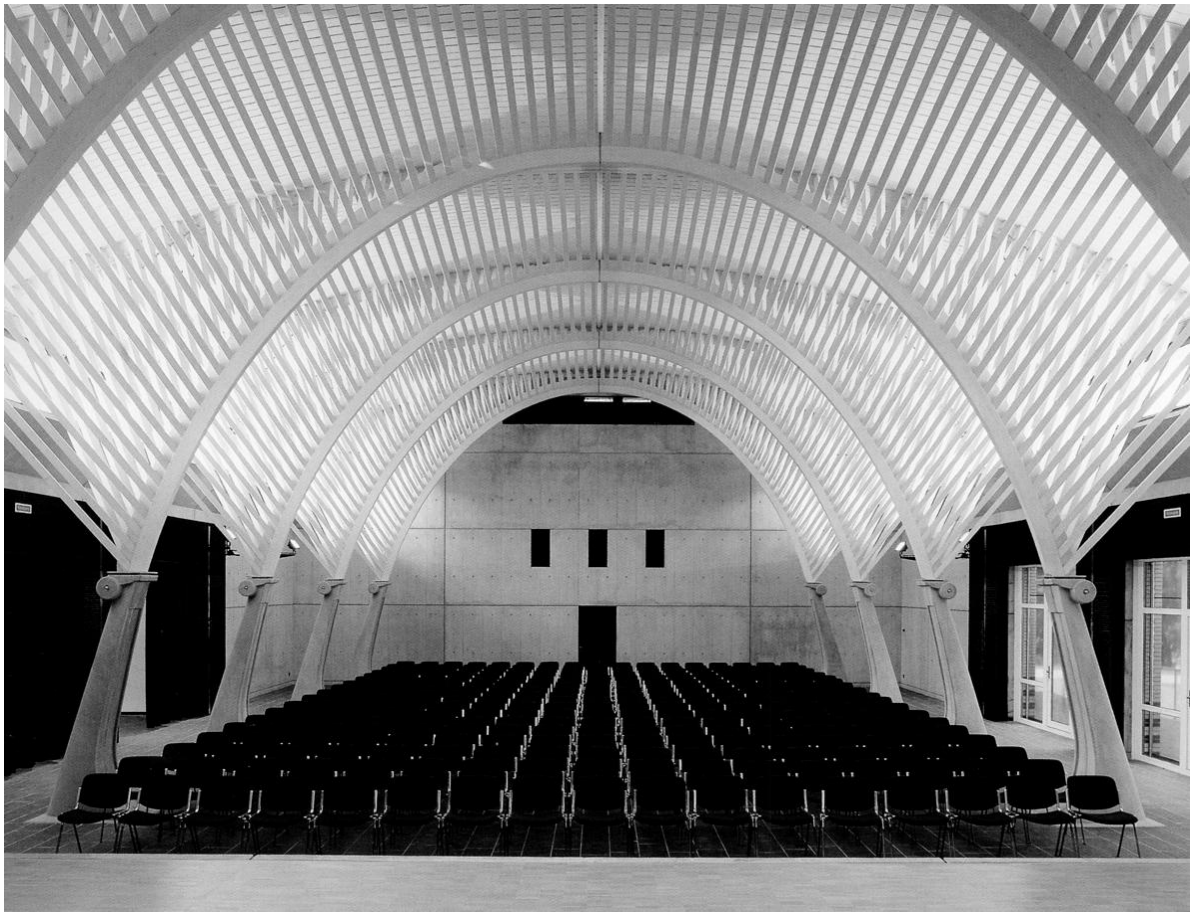
zwischen Repetition expressiver Elemente
und
Expression durch parametrische Variation

“Calatrava expresses the effects of static forces, rather than concealing them behind a bland facade, and he concentrates on mechanisms which operate within a formal system of architectural principles...“

Ben van Berkel & Caroline Bos



zwischen Repetition expressiver Elemente
und
Expression durch parametrische Variation

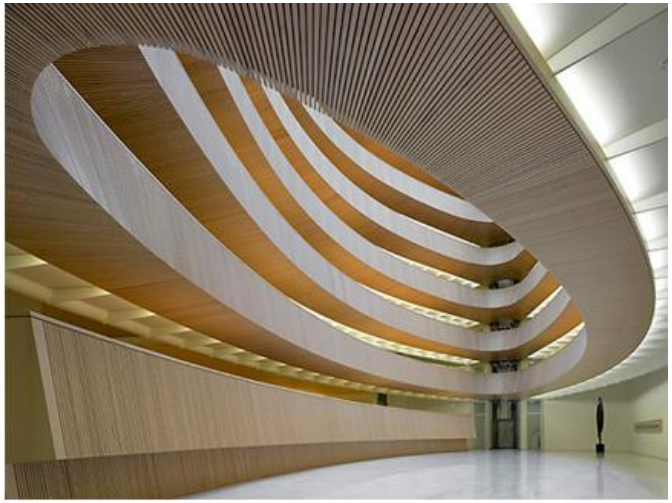


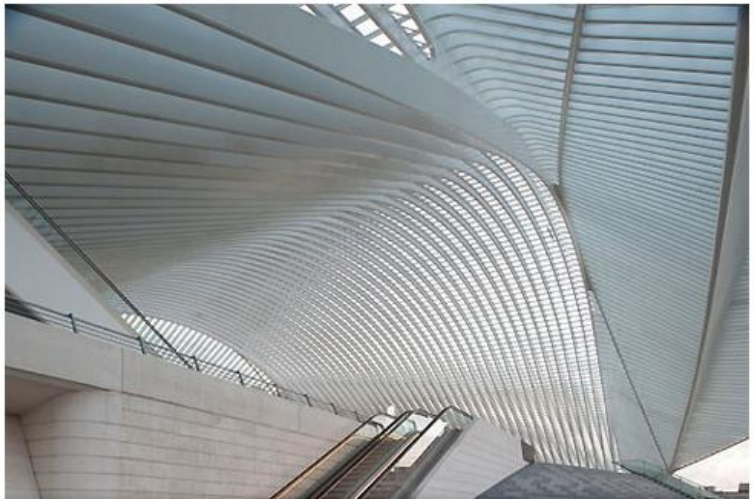
Aula, Kantonschule, Wohlen, 1988, Arch.: Santiago Calatrava

zwischen Repetition expressiver Elemente
und
Expression durch parametrische Variation

Art Museum, Milwaukee, USA, 1994-2001, Arch.: Santiago Calatrava

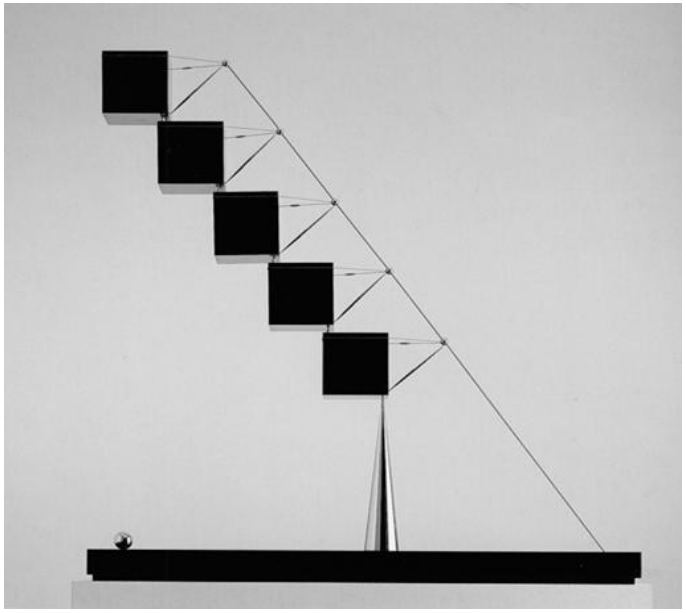
zwischen Repetition expressiver Elemente
und
Expression durch parametrische Variation

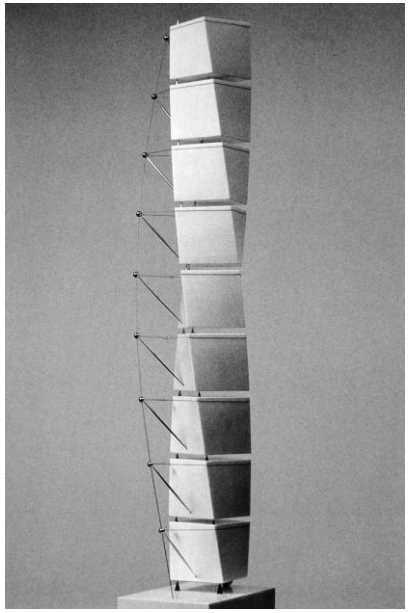


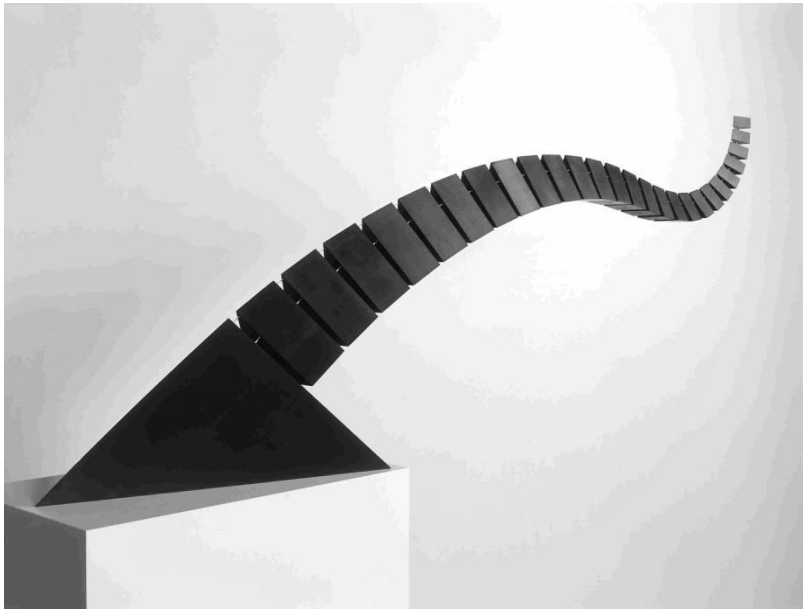


World Trade Center Hub, New York, 2005-13; Art Museum, Milwaukee, 1994-2001; Bibliothek Rechtwissenschaftliches Institut Uni Zürich, 2004
Estação Oriente , Lissabon, 1993–98; Bahnhof Guillemins, Lüttich,1998-2009; Bahnhof Saint-Exupéry, Lyon,1989–1994

Variation und Repetition als Themen im Designprozess
Der Kräftefluss als Organisationsform







Running Torso,1985; Turning Torso, 1991; Dinosaur, 2000