

# DESIGN RULES AS PARAMETERS TO INCLUDE MATERIALS IN THE DESIGN PROCESS

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2018 INTERNATIONAL SEMINAR  
DESIGN, STRUCTURE, AND ARCHITECTURE  
UCL | UNB | UNIROMA2

«Résoudre un problème consiste de plus en plus souvent à écrire un système d'équations aux dérivées partielles et à lui chercher des solutions vérifiant les conditions aux limites.»

Antoine Picon

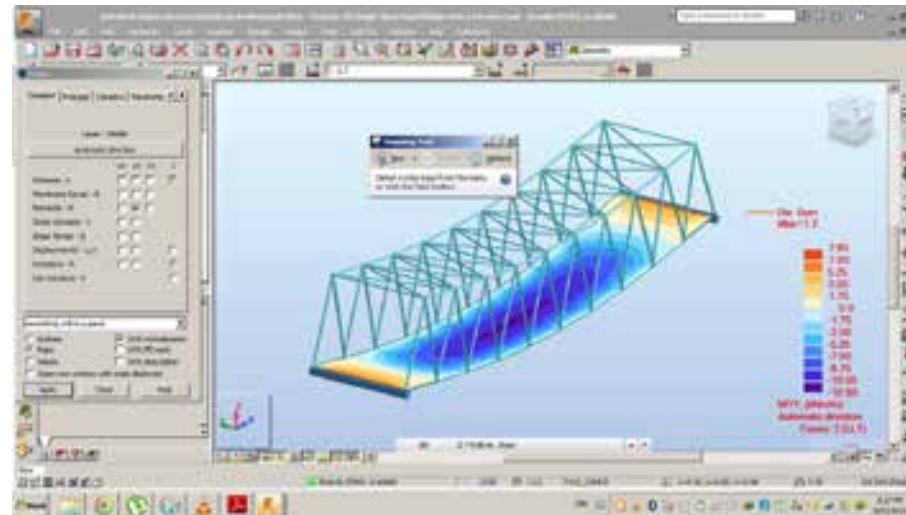


Image d'illustration

« (...) by separating knowledge from self-reflective experience the knowledge divorced from the reality. »

Sandkühler,  
1938

« Architecture faces an opposing concept in the form of a contradiction which today still forms the crux of the animosity between structural engineers and architects. »

K-E Kurrer,  
The history of the theory of structures

VIOLET-LE-DUC

MUSMECI

CONZETT

CHAIR OF STRUCTURAL DESIGN, ETH

STRUCTURES ET TECHNOLOGIES

COMPOSITE THOUGHT

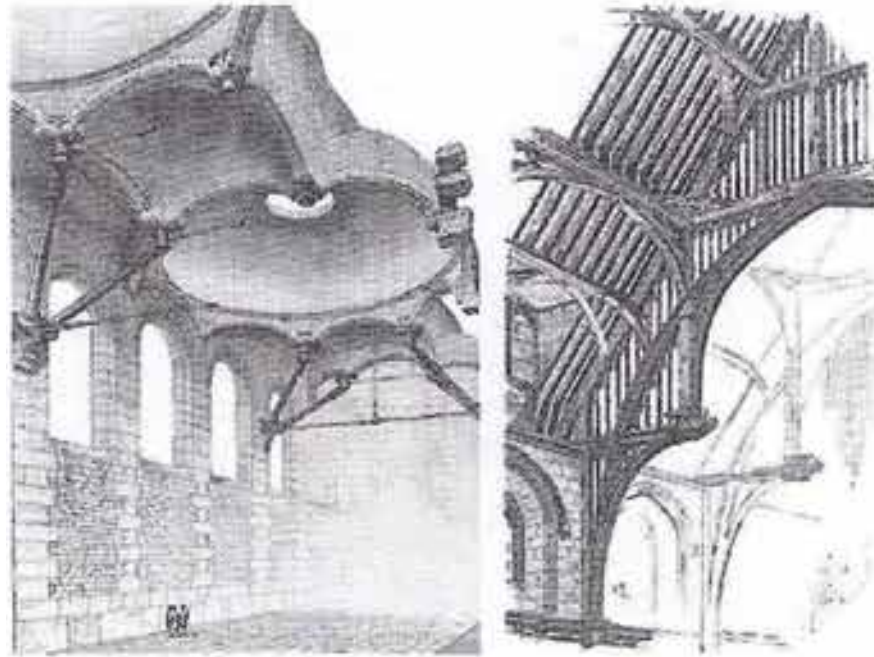
MATHEMATICAL THOUGHT

ANALOGICAL THOUGHT AND GRAPHIC STATICS

COMBINATORIAL EQUILIBRIUM MODELLING - CEM

STRUCTURAL DISCOURSE

Structural design approaches



« Violet-le-Duc used them [model thinking and analysis] based on material characteristics. He practiced the design strategy of translation ; he then transformed the result. »

Tom F. Peeters,  
The introduction of iron in construction

## ELASTIC THEORY

### Principle

Deformation bound with constrain  
(Navier and the elastic modulus)

### Approach

- 1/ equilibrium equations
- 2/ material properties : elastic deformation
- 3/ geometrical properties :  
compatibility with boundary conditions

=> structural analysis

## PLASTIC THEORY

### Principle

Excessive bending in local sections modify the  
stress distribution

### Approach

- 1/ equilibrium equations
- 2/ yield criterion
- 3/ collapse mechanism

=> structural design

« Culmann's graphical statics not only rationalised the design work of the structural engineer, but at the same time also aestheticised it because the force diagrams and construction drawings occur in the twin form of both the sensual consciousness and the sensual need. »

K-E Kurrer,  
The history of the theory of structures

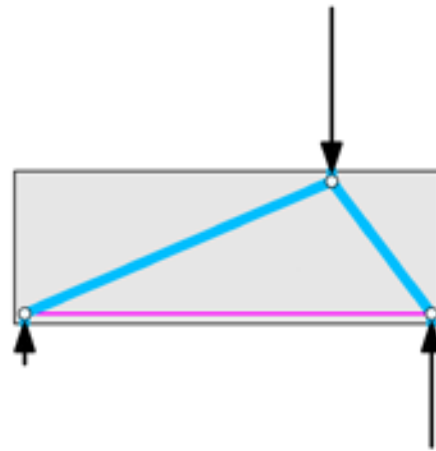


diagramme des situations

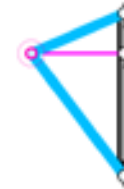
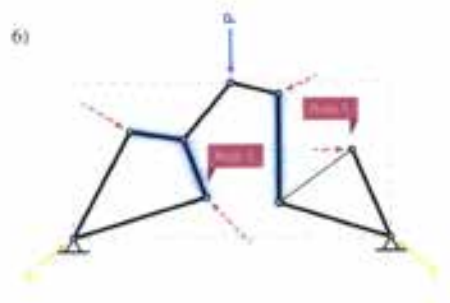
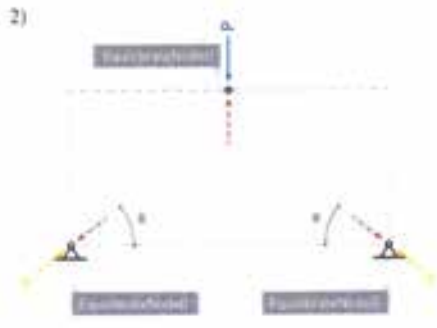


diagramme des forces

« But neither in digital (...) do material properties play a major defining role in the process ; material is merely a subordinate means of tracing the form and making it buildable »

T. Kotnik and M. Weinstock  
Material, Form and Force



Juney Lee  
 computationally automated  
 random generator

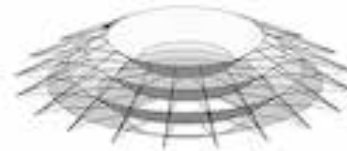
COMBINATORIAL EQUILIBRIUM MODELLING  
 (ETH zurich - Chair of structural design)



A. Hanging-Ring Scheme



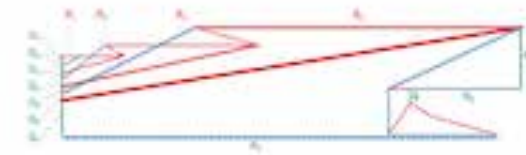
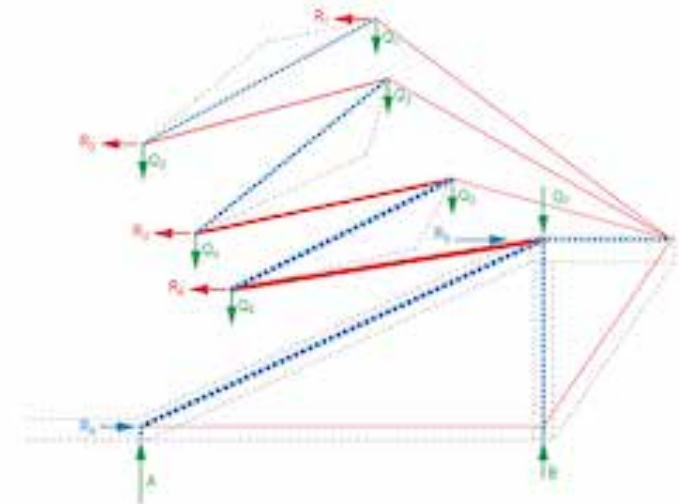
B. Vertical Levels



C. Stabilizing Cables



D. Bracing cables



— tension  
 - - - - - compression

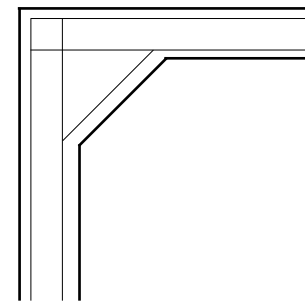
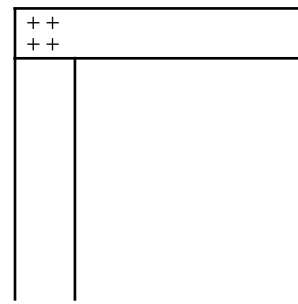
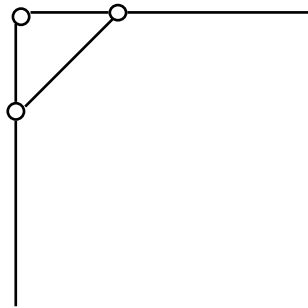
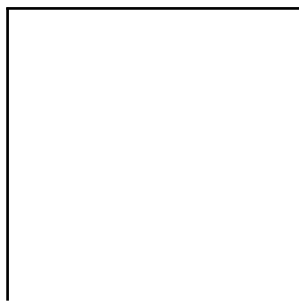
Tokyo Olympic Stadium / Pierluigi D'Acunto, Lukas Ingold, Patrick Ole Ohlbrock

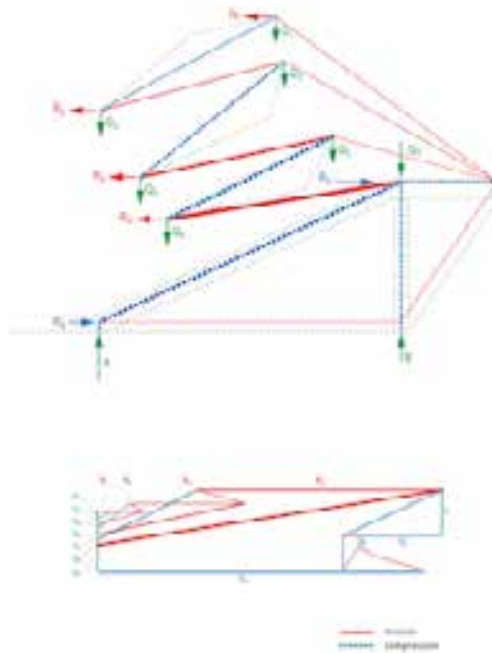
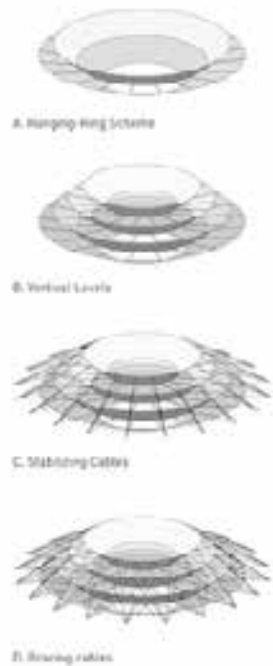
« The designer has an opportunity to devise more suitable structural definitions for producing efficient and reliable structures if structural elaboration is modelled on writing a sound discourse, with its own grammatical rules and specific vocabulary. »

Denis Zastavni,  
An equilibrium approach on a structural scale  
to structural design

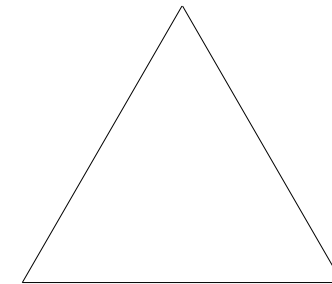
« Materialised forms and formed materials are complementary principles of materiality - distinguishable, but not dividable. »

T. Kotnik and M. Weinstock  
Material, Form and Force





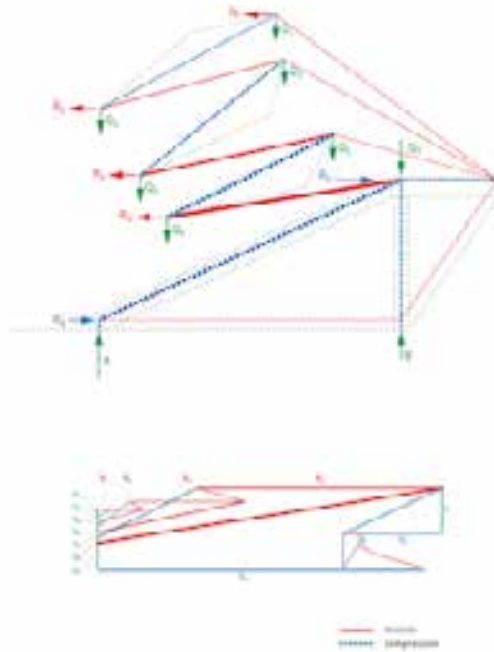
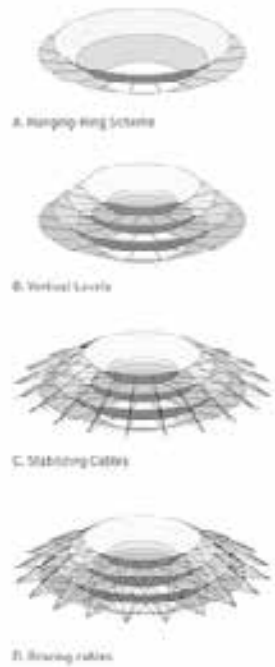
INNER FORCE FLOW



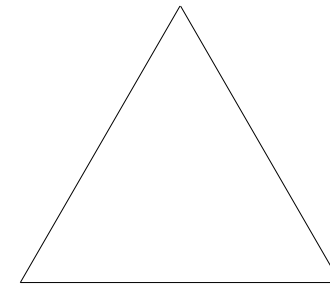
MATERIALIZATION  
 OF FORM

DESIGN IDEA

Tokyo Olympic Stadium / Pierluigi D'Acunto, Lukas Ingold, Patrick Ole Ohlbrock



INNER FORCE FLOW

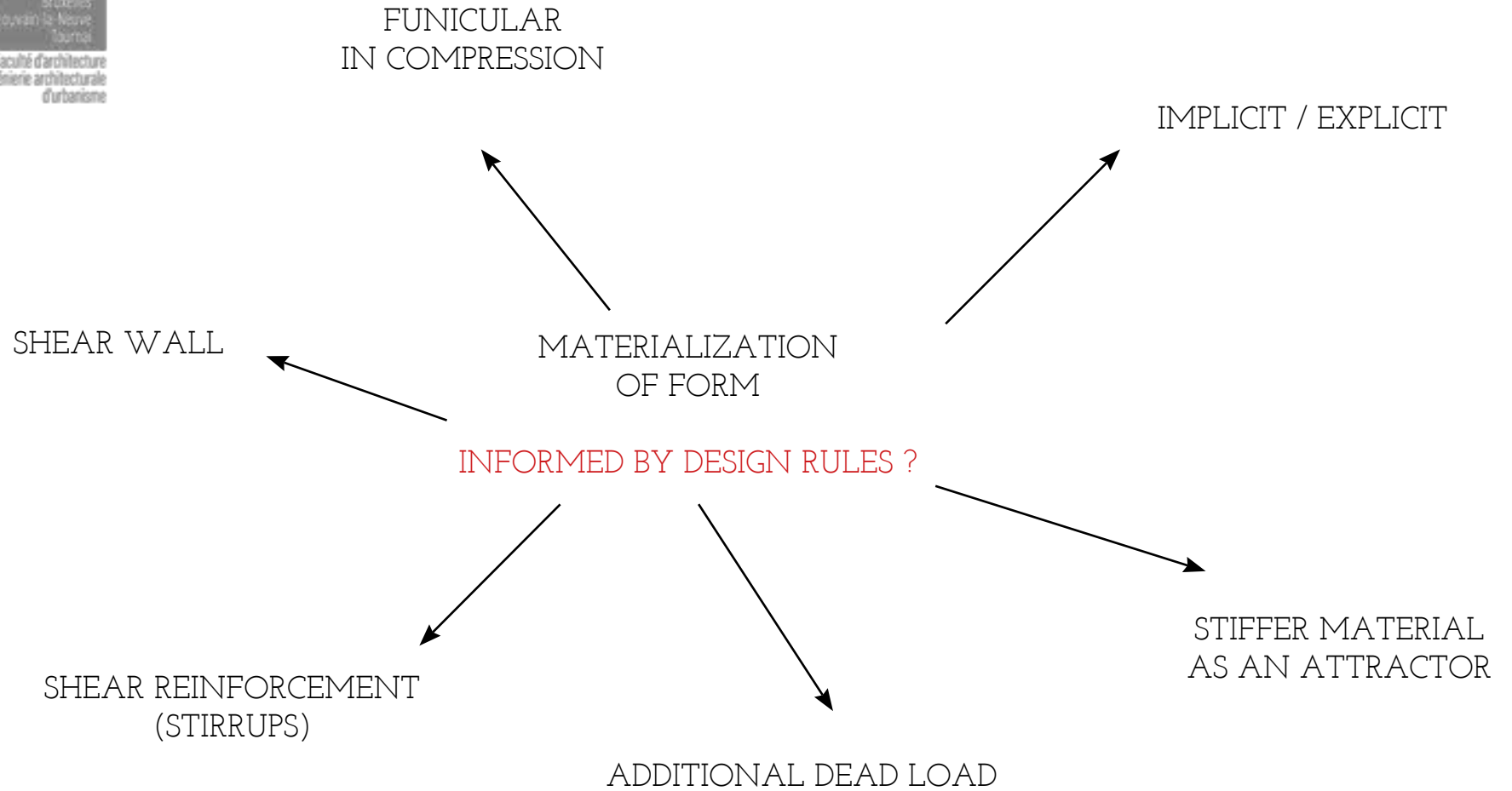


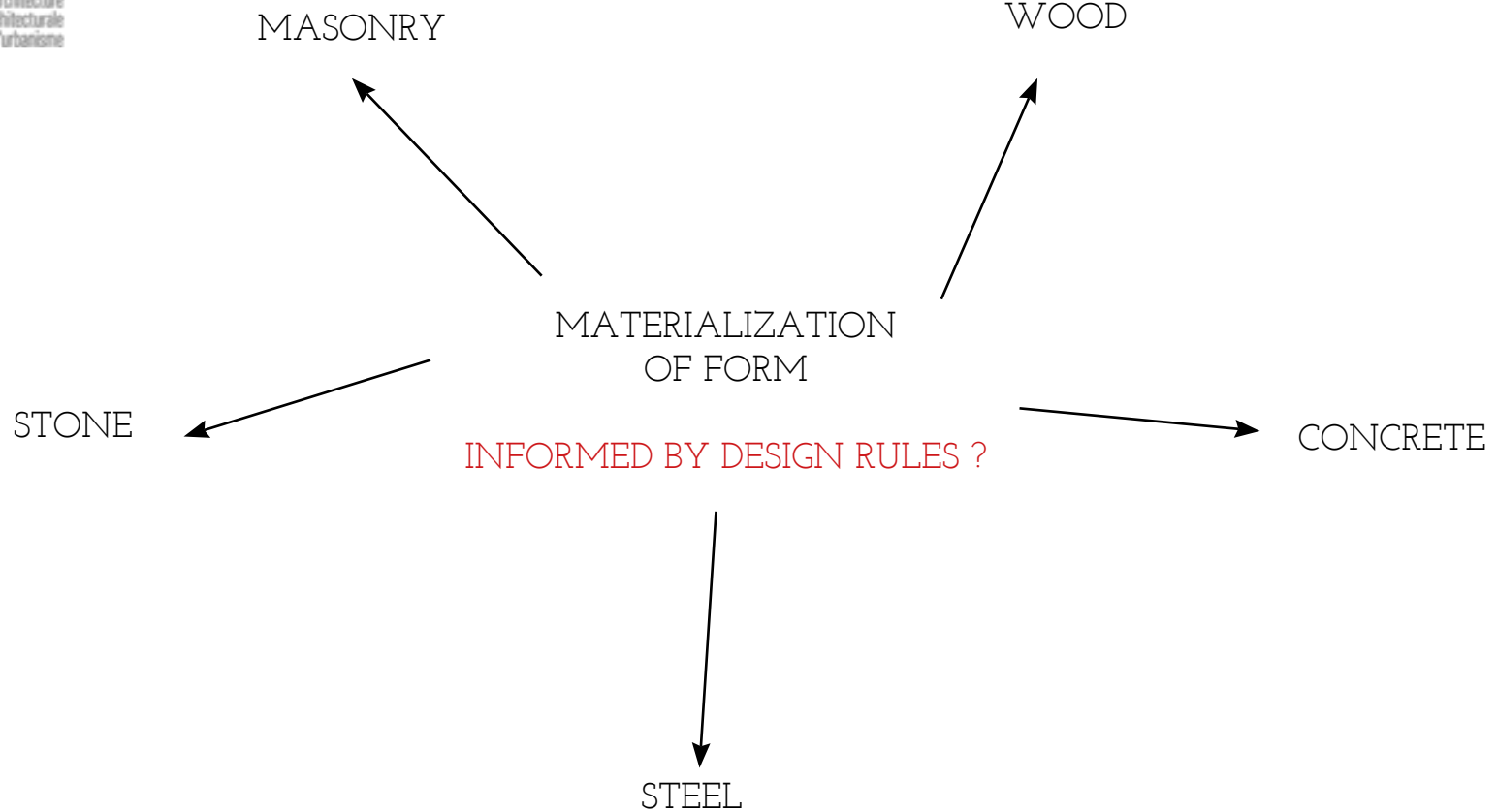
MATERIALIZATION  
 OF FORM

DESIGN IDEA

INFORMED BY DESIGN RULES ?

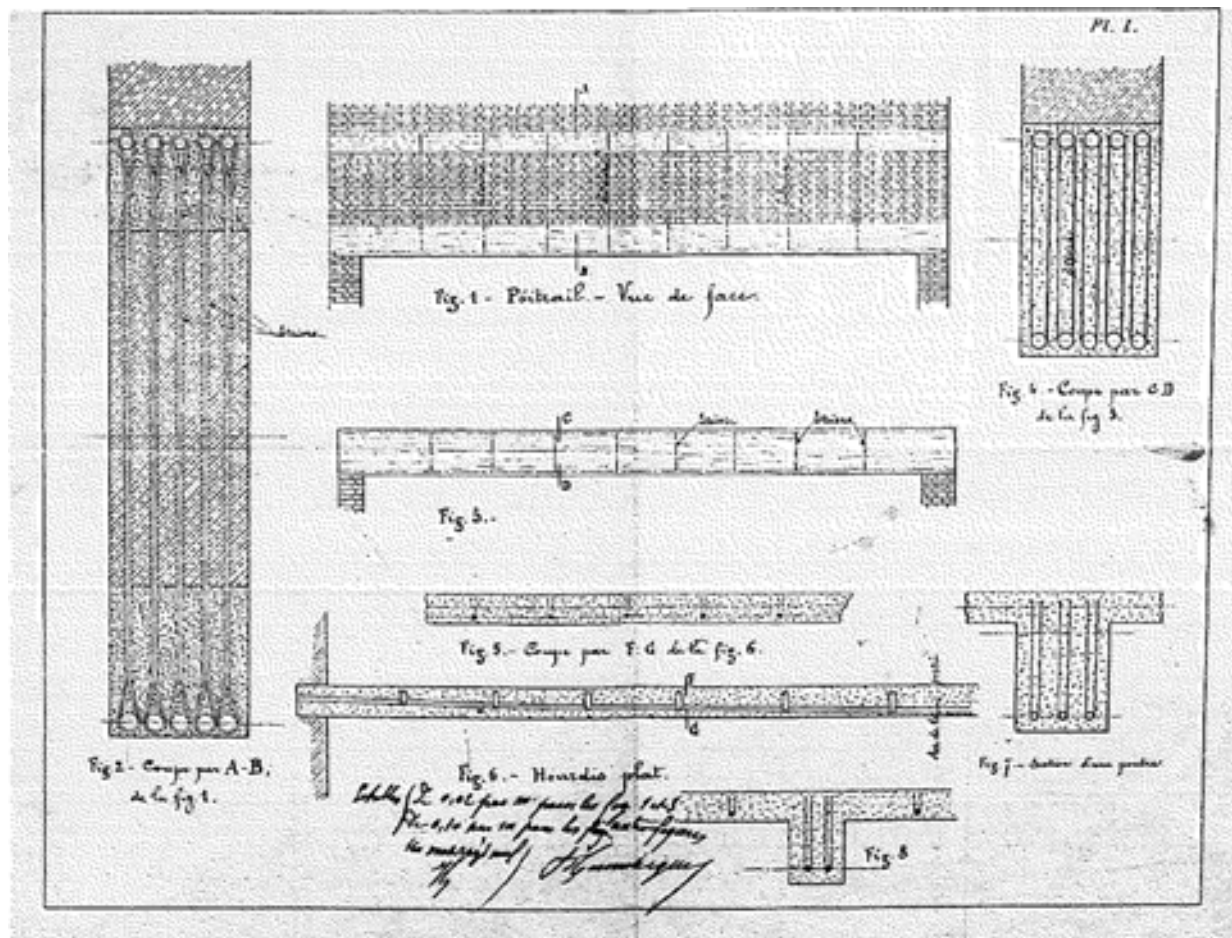
Tokyo Olympic Stadium / Pierluigi D'Acunto, Lukas Ingold, Patrick Ole Ohlbrock





« Le bois a ses fibres, son gabarit naturel (l'arbre) ; la pierre a sa masse, comprimée entre le parallélisme des banches ; la brique a son module. Le béton armé seul n'a pas de géométrie inductive ou de vecteur organisateur. La poudre de ciment, le tas de sable, le linéaire façonnable des fers constituent des stocks sans allure, avant que le moule ne fixe une apparence au béton armé et ne raidisse son profil.»

Cyrille Simonnet,  
Le béton, histoire d'un matériau

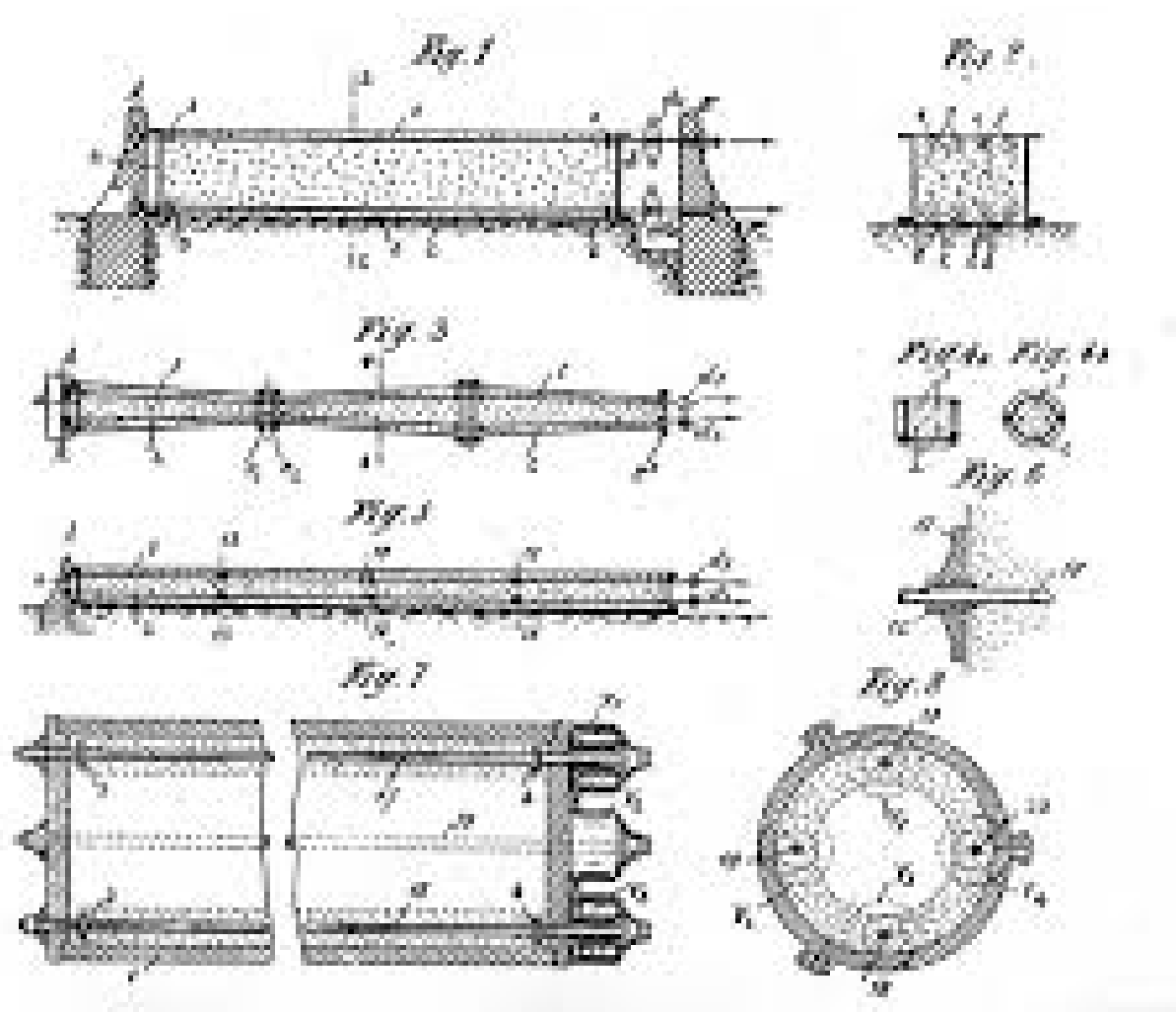


Hennebique - Additif brevet 07 août 1893 - suite





Robert Maillart - 1908, Zürich



Freyssinet - Brevet 1928

« Es kann nicht die aufgabe des holzbaus sein, jegliches sta-  
tische system in holz nachzubauen. Der holzbau hat seine  
eigene sprache. »

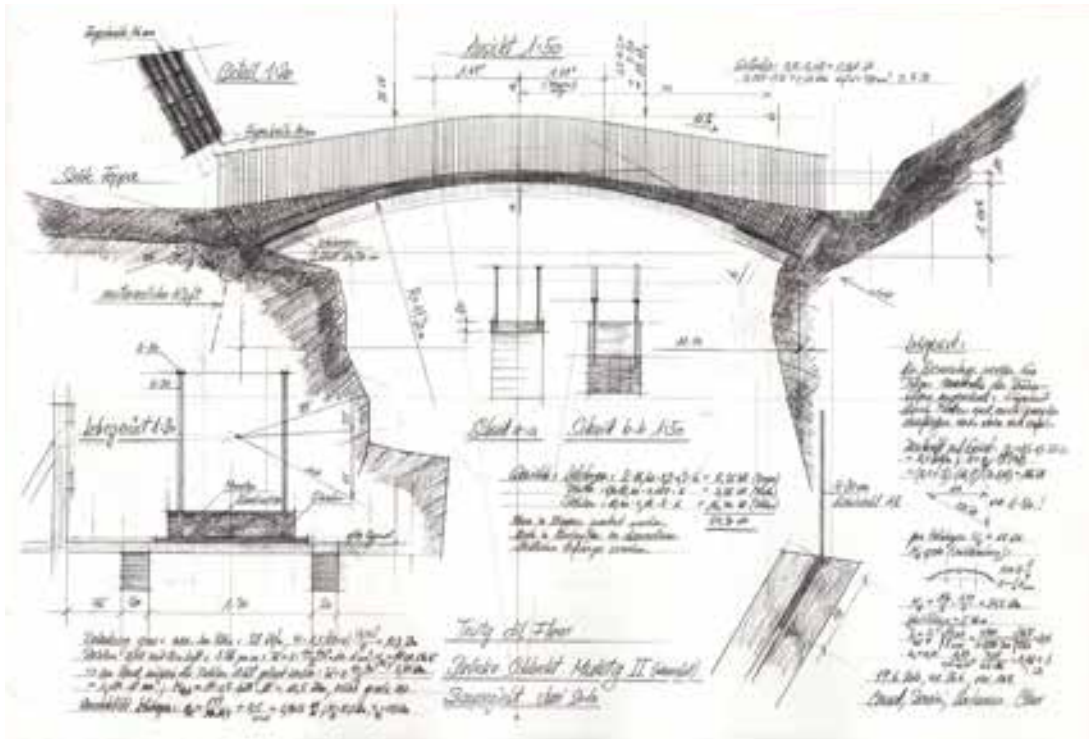
Bauartgerechte holzkonstruktionen  
Stefan Polonyi



« The strut has been abstracted from its initial function of direct strutting and load transfer »

Mario Rinke and Tony Kotnik,  
From construct to type





Landscape and Structures,  
A personal inventory of Jürg Conzett, photographed by Martin Linsi

« Il est vrai qu'on cherche très tôt à trouver le matériau juste. Souvent, on trouve des projets en bois où on a l'impression qu'ils ont pris une construction en acier puis l'ont réalisée en bois. »

« (...) il n'y a pas d'élément superflu »

Jürg Conzett,  
In discussion with Jürg Conzett

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