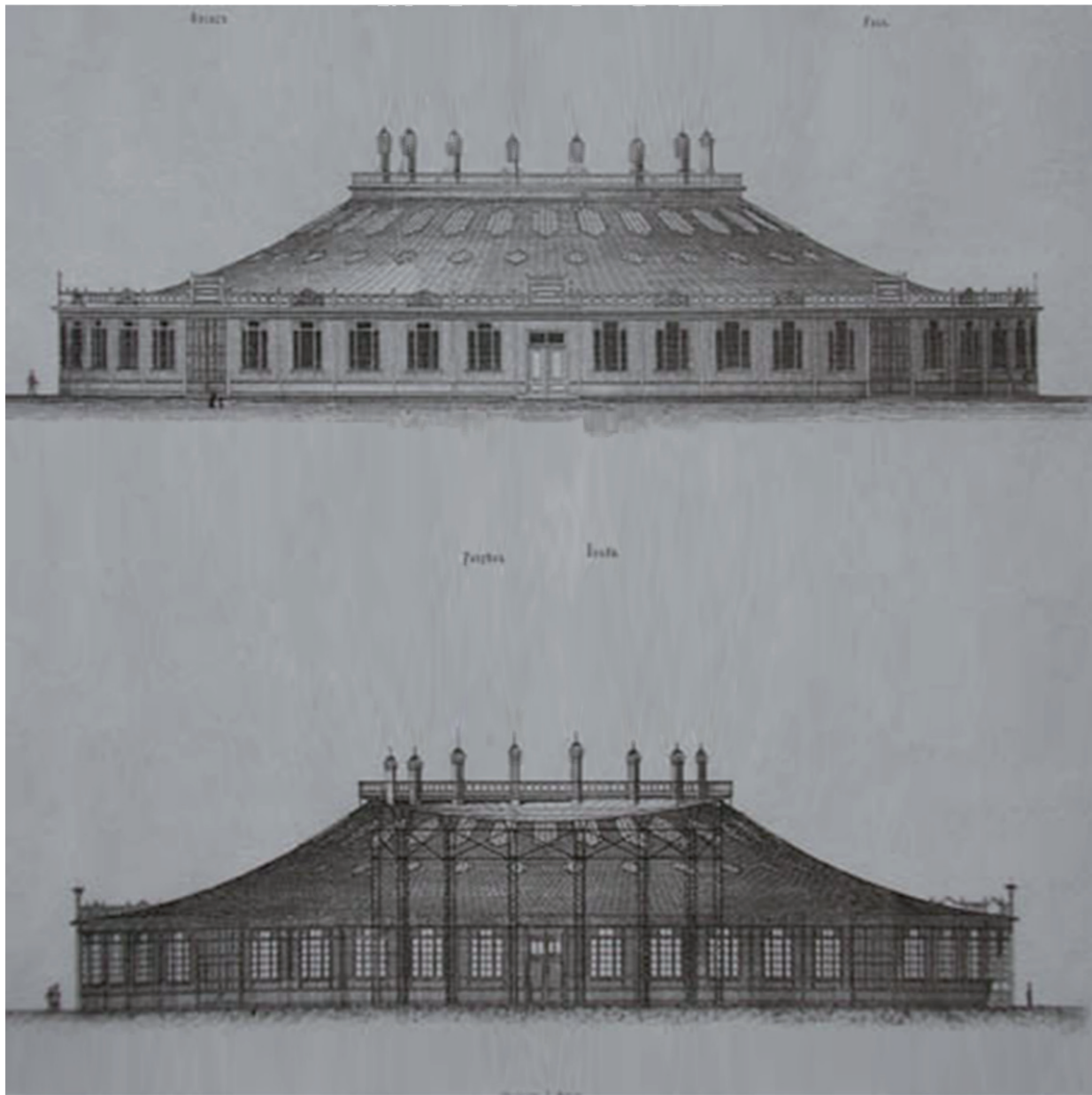


# References



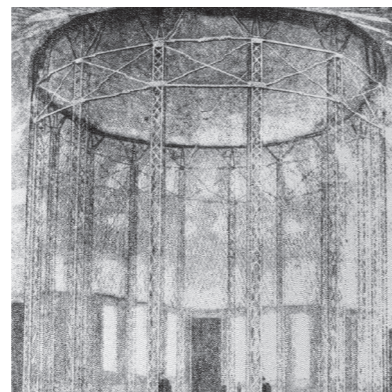


## Shukhov first developed structural analysis for tensile engineering

He designed eight pavilions for the Nizhny Novgorod Fair in 1886, one of them was covered by a steel tensile grid. It opened a new era in tensile structure as he was the first able to calculate this shape. All the other early attempts in tensile architecture were based on the suspension bridge as a prototype. Until the 1950s there was nothing comparable constructed.



Historical

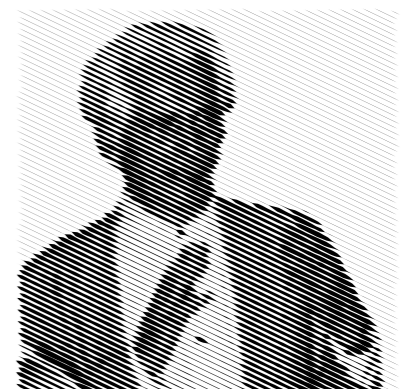






## Otto Frei went further in the comprehension of membrane forms

He designed and studied complex membrane shapes, and pioneered the construction field of such types of structures in so complex arrangement, with the Munich Stadium, a net of acrylic glass stabilized by steel cables.



# Historical

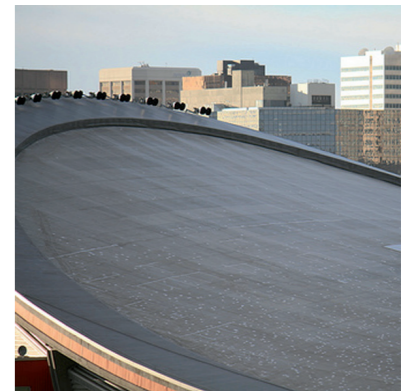




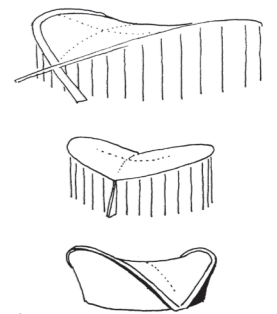


## A concrete exemple: the Pengrowth Saddledome in Calgary

The saddle shape roof is an inverted hyperbolic paraboloid. It is made out of post tensioned concrete. As this is an ice arena, the first spacial goal was to put more seats in the center ice region and it was achieved through this form. The weight of the concrete prevent too much deformation when the roof is loaded.



# Historical







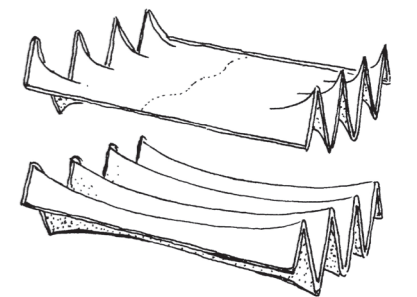
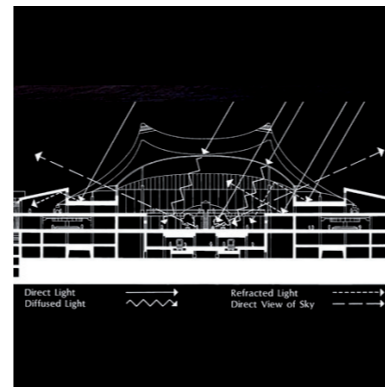
## Parallel but opposed: cables and fabric

The main hall of the Denver international airport is covered by a plastic fabric tensioned between opposite-curvature cables. It is supposed to be «aesthetically designed to be reminiscent of the snow-capped Rocky Mountains in winter».

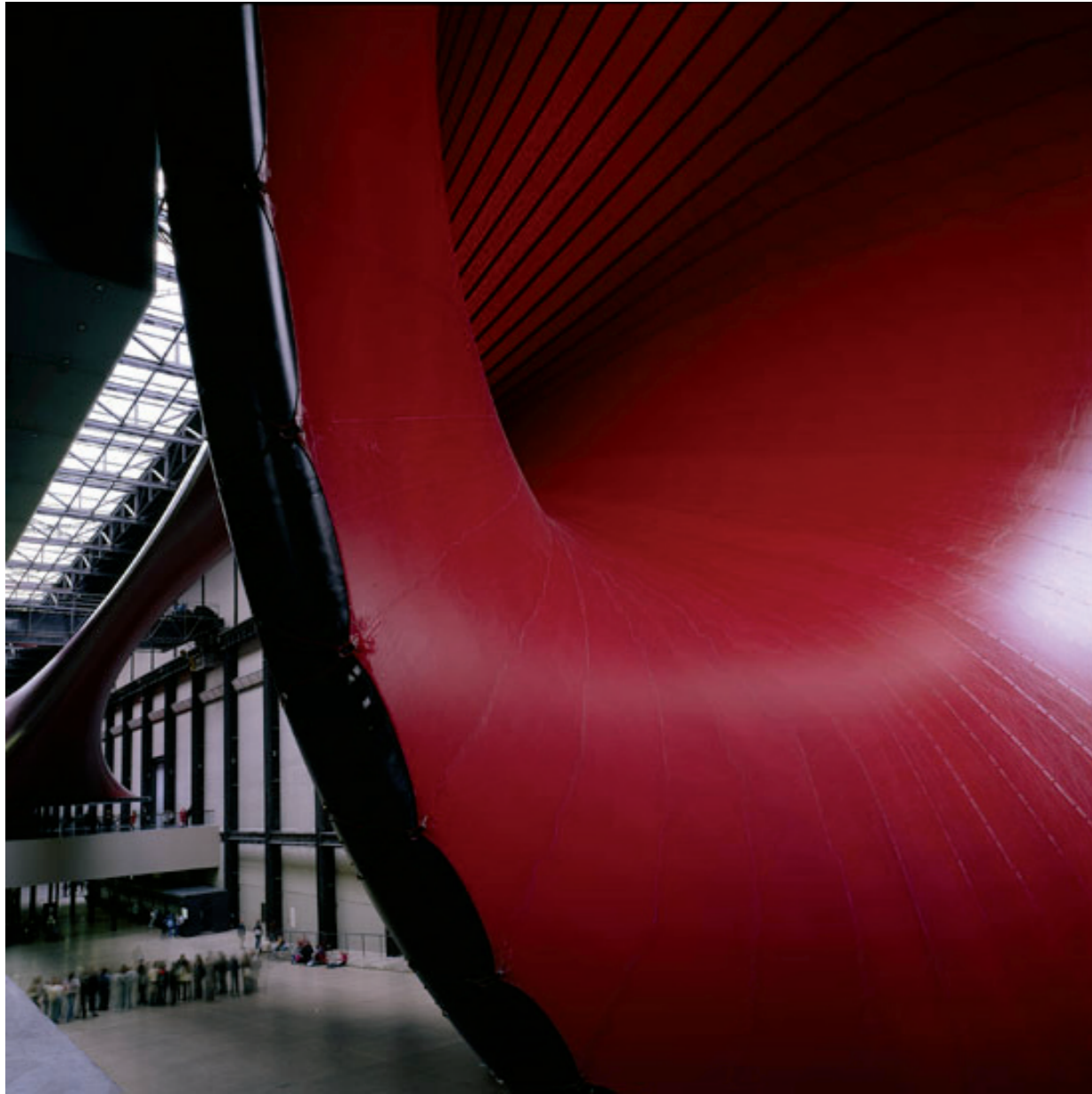
In 2003 heavy snow tore a hole in the roof. Over two feet of snow forced the airport to close.



Historical



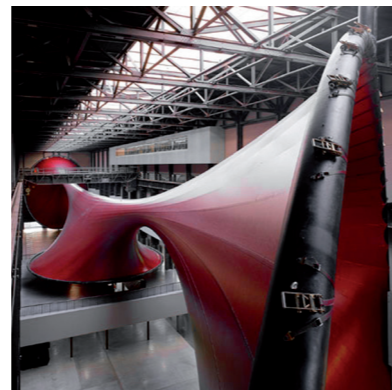
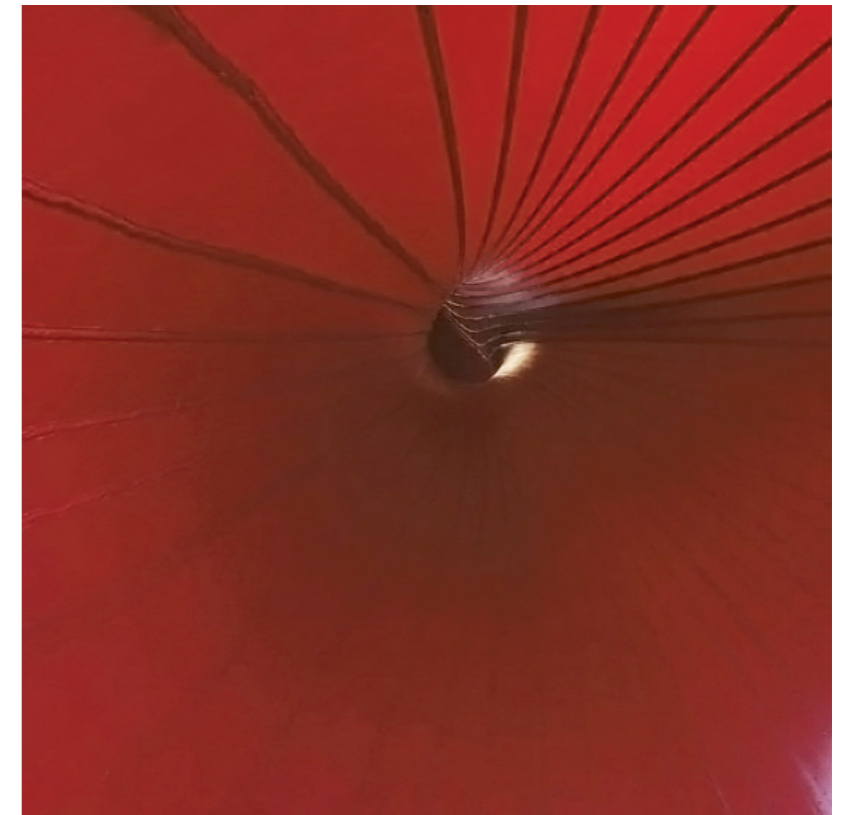




## The Flesh reference

Marsyas is a sculpture from Anish Kapoor. It was installed in the Turbine Hall in 2002. The geometry is based on three rings, two vertical and a horizontal one. A PVC membrane joined them together. The resulting overall form is a volume that shifts from a vertical condition to horizontality then back to verticality. He used the length of the hall to challenge its gigantic height.

Anish Kapoor describes the membrane as « a flayed skin »( Marsyas is a satyr in Greek mythology, flayed alive), hoping that the dark red suggests something « of the bodily ».



Contemporary



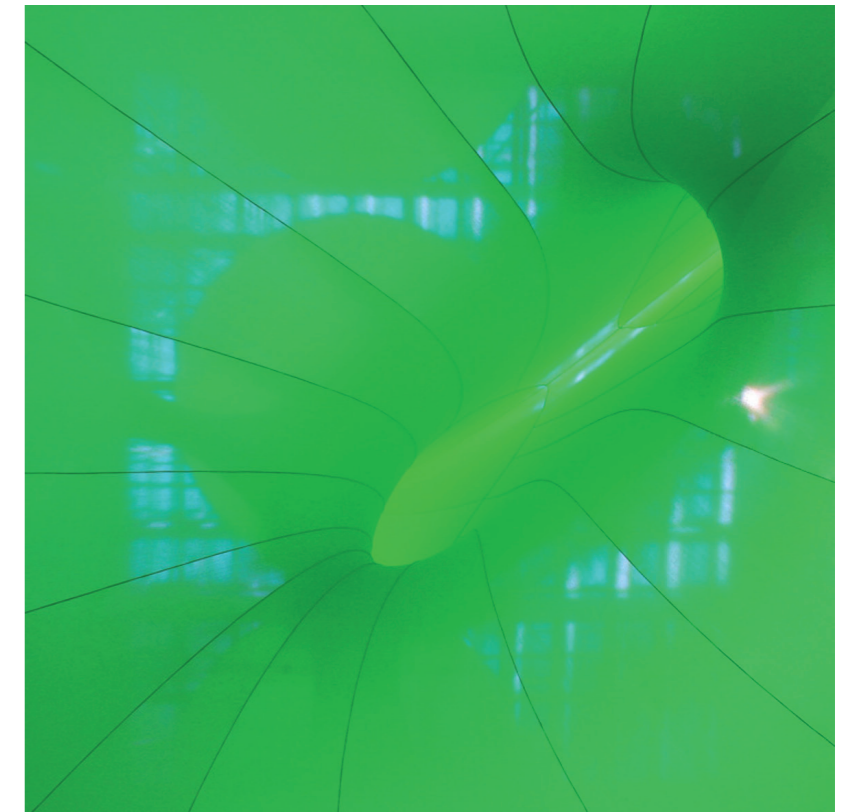




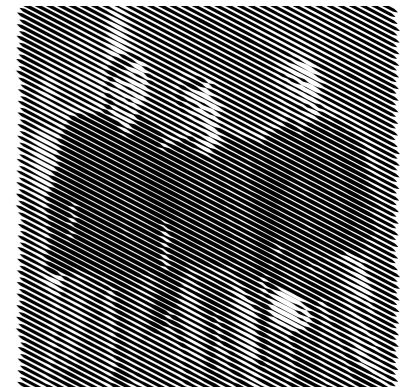
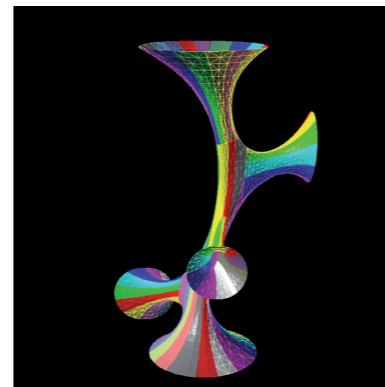
## The Green Argument

The Green Void from LAVA is an installation in the Custom house in Sydney. It is a statement on today's architecture, reading it as the ability to transform a preconceived space, and taking full advantage of the digital media and processes. « The project renounces on the application of a structure in the traditional sense. Instead, the space is filled with a 3-dimensional lightweight-sculpture, solely based on minimal surface tension».

It is self-labelled sustainable as its shape is a minimal surface and therefore use a minimum amount of material. Moreover the all-digital workflow allows to reduce the material's loss during the cutting process. The total weight of the fabric is 45 kilograms resulting in a easy transport and installation.



Contemporary



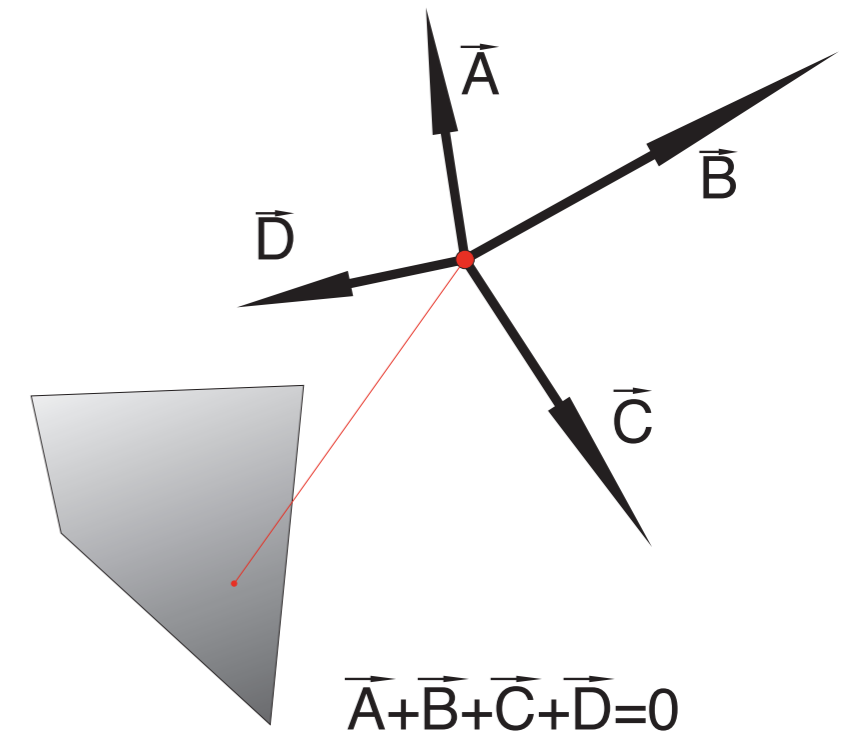




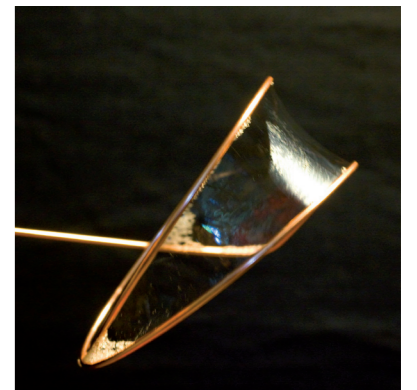
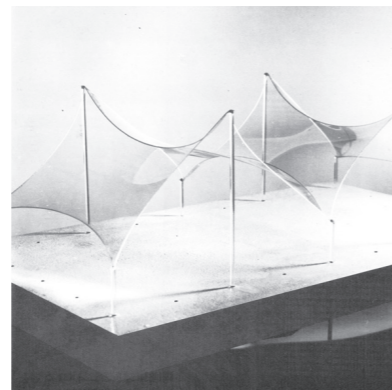
## Bubble models and Minimal surfaces

The bubble has the interesting property of minimizing his potential energy, taking a geometry also known as a minimal surface. It will be the shape of a tensile structure in a stable condition too.

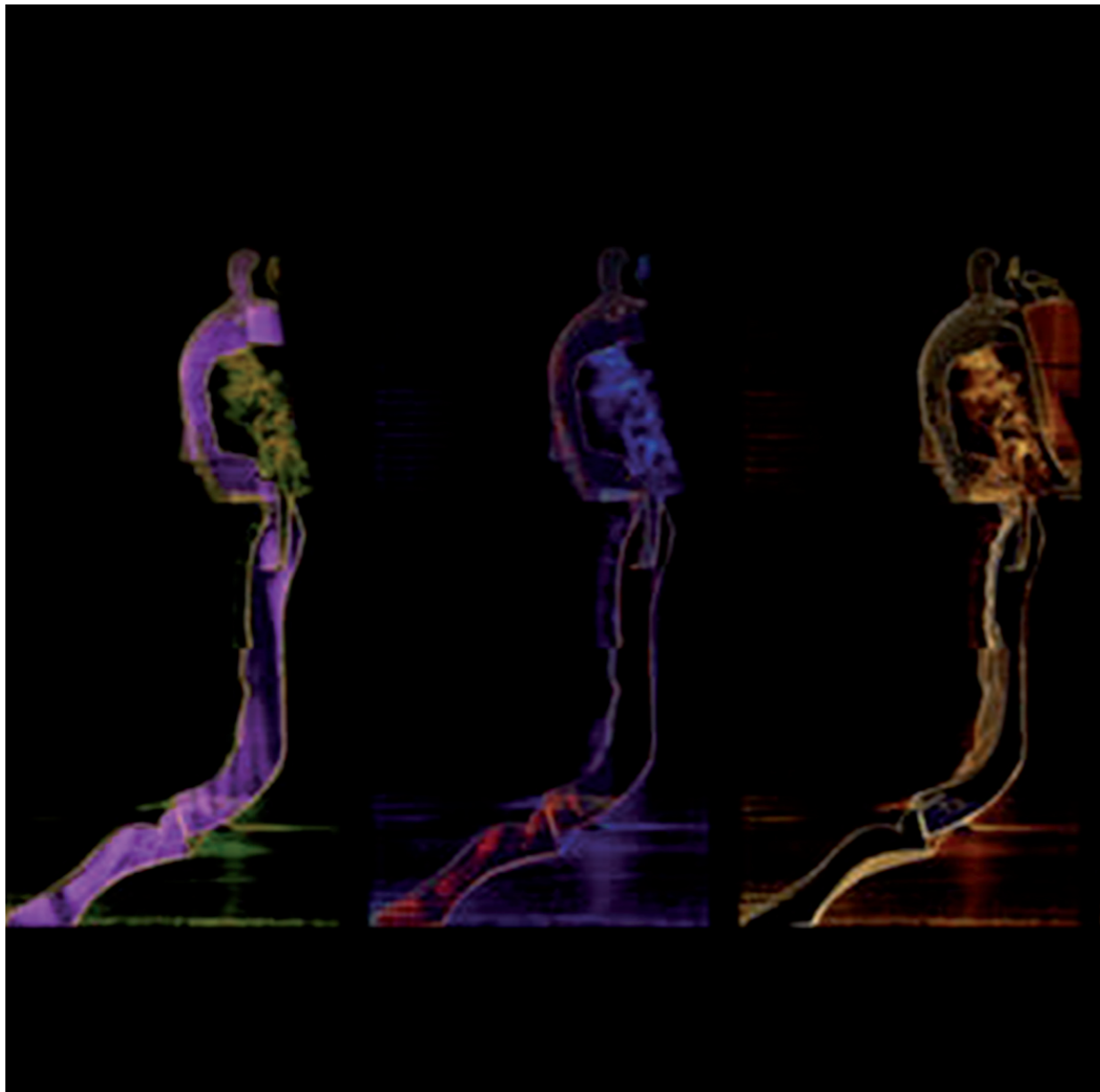
In the 70s, Otto Frei conducts researches in form finding with soap film. He developed advanced techniques to create soap models with complex forms that last long enough to study. At this time and until the 90s, it was the only way to predict accurately the equilibrium state of a membrane. The next step was the digital modelisation and simulation of such behavior together with finite element analysis for the structural verification.



Form approach







## Gilles Deleuze stated a theory about «the body without organs»



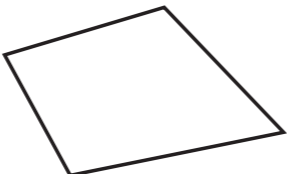




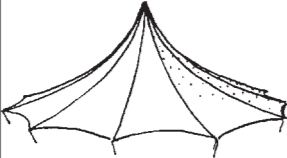
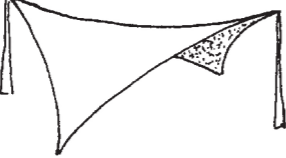

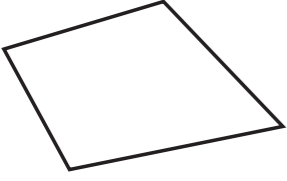


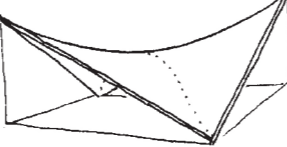
It is an interesting statement written in *Anti-Oedipus*, that Georges Teysot resumes shortly: «*In the logic of Sense* (1969), Gilles Deleuze alluded to what Antonin Artaud uttered on leaving the psychiatric hospital in Rodez: « No mouth No tongue No teeth No larynx No oesophagus No stomach No belly No anus I will rebuild the man that I am.» This appeal invoked a continuous, fluid body of blood and bone, one not reduced to each of its organs. Later, Deleuze and Félix Guattari would hypothesize a body conceived as a libidinal machine, a « desiring machine» that points to the theoretical possibility of a «body without organs.»

After a lot of effort he conclude that on a theoretical point of view the social communication would be limited to surface interactions. On a building level this is pretty much true, even if they behave as organism, they tend to react to each other as surfaces. And tensile structures have a very complex yet rich surface to speak to the world.

# Interpretation



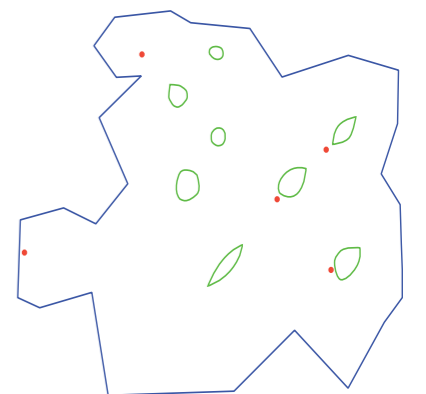
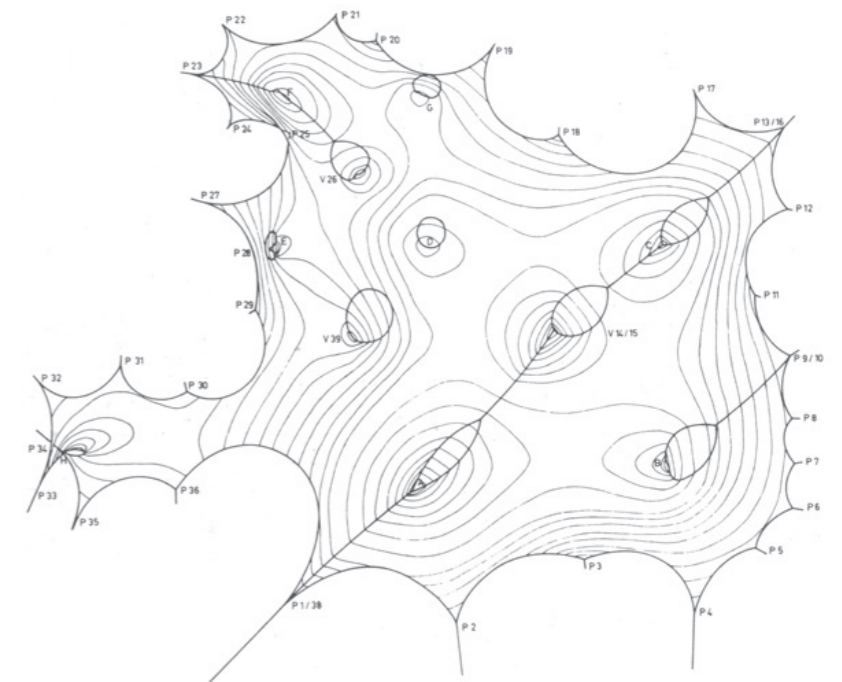


	 Point(s)	 Flexible Border	 Rigid Border
 Point(s)	not possible without borders		
 Flexible Border			
 Rigid Border			

# Input/Output, the Data point of view

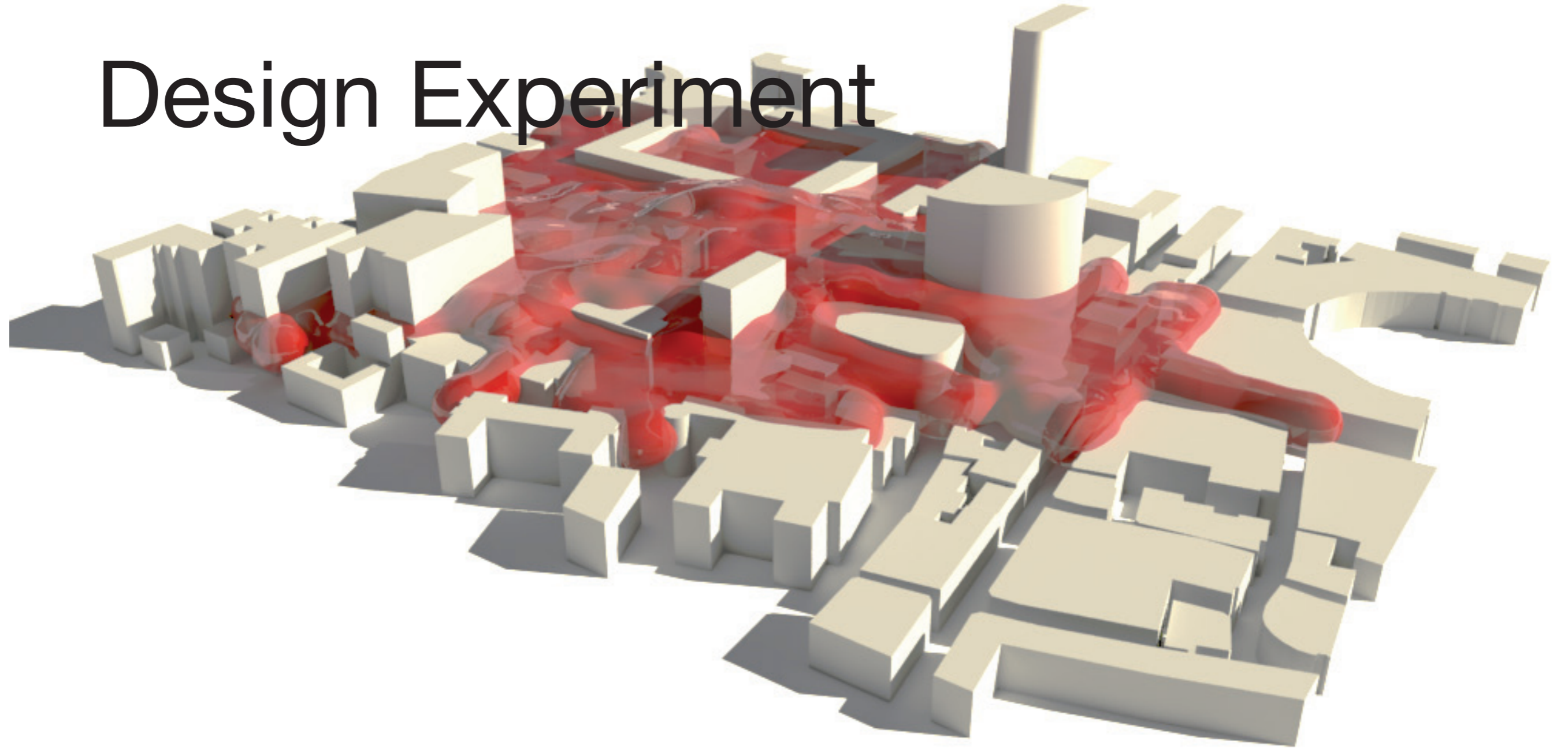
The form of a tensile structure is defined with very few but mandatory items: its borders. They can be either rigid –like beams– or flexibles –like cables– but without them the membrane collapse. It can be enriched by inner points. The last thing that can influence the final geometry is the elasticity of the membrane’s material.

We can consider a tensile structure as a field of data where the input is its minimum definition (borders, points and elasticity) and the output a plotted membrane of whatever complexity.



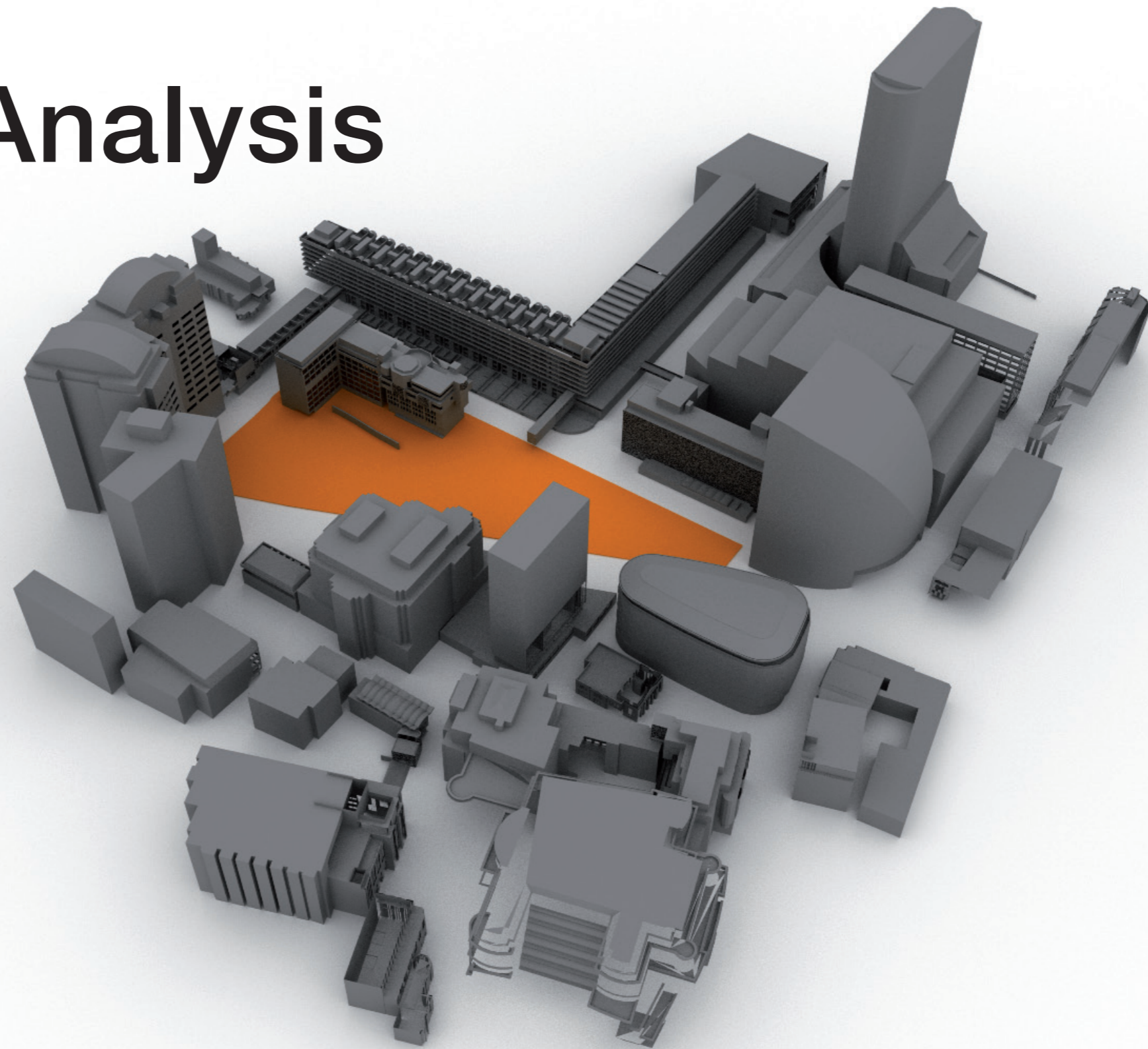


# Design Experiment





# Site Analysis





# Housing Through Time





# Housing through Time

I will consider a limited period of time as it is not possible to be exhaustive about this subject.

I have chosen a few topics to look at, from prefabrication to high rise.

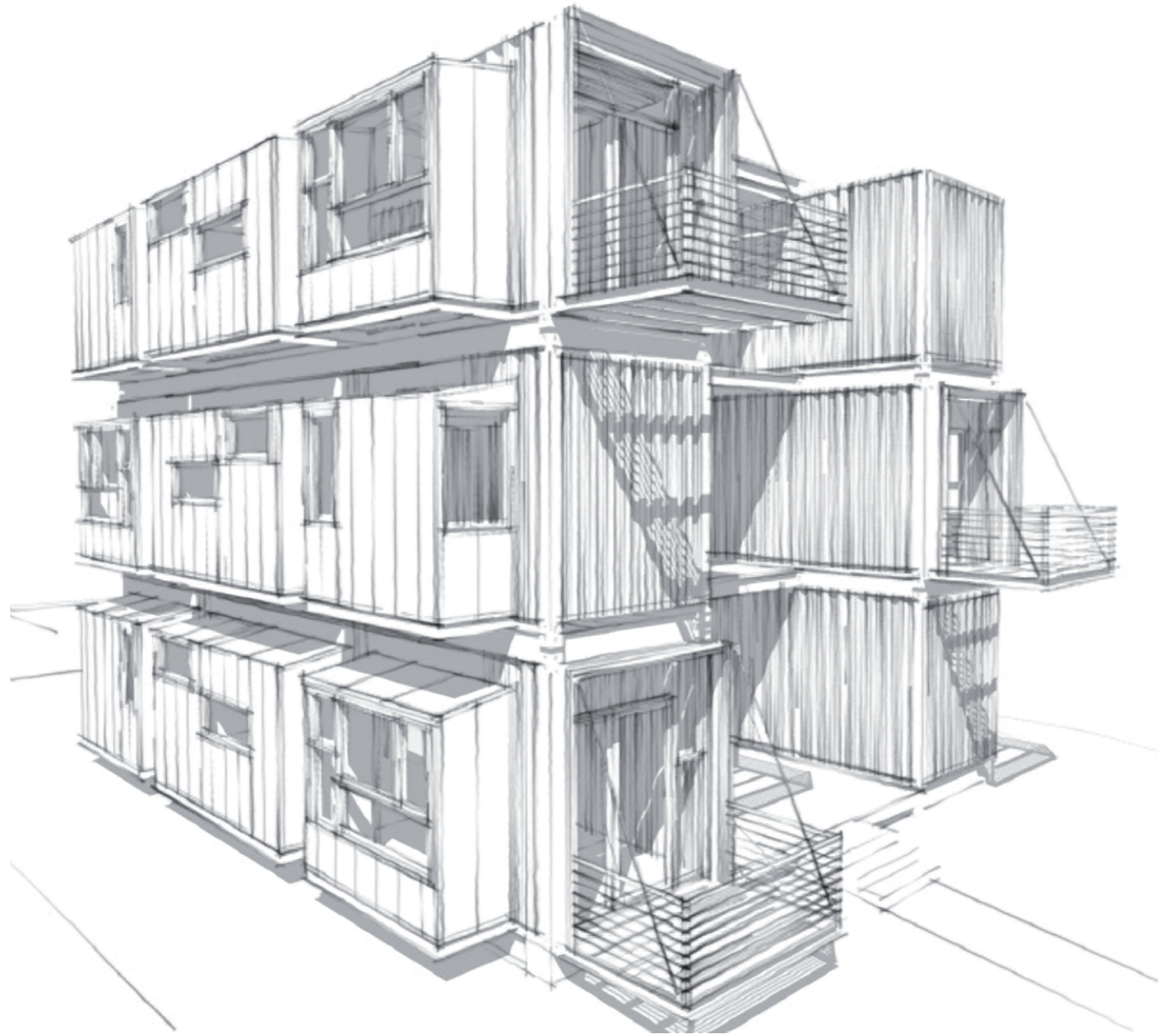
The prefabrication widely held idea, refers to concrete works of the 50's. It is mainly due to Europe reconstruction after the war, where cost and time efficient building methods were mandatory. But the very first engineered prefabricated structure to be known is a road made out of wood, 3900 BC in England.

The prefabrication as we understand it today in architecture arose with the industrial revolution. First with steel systems and later with concrete.

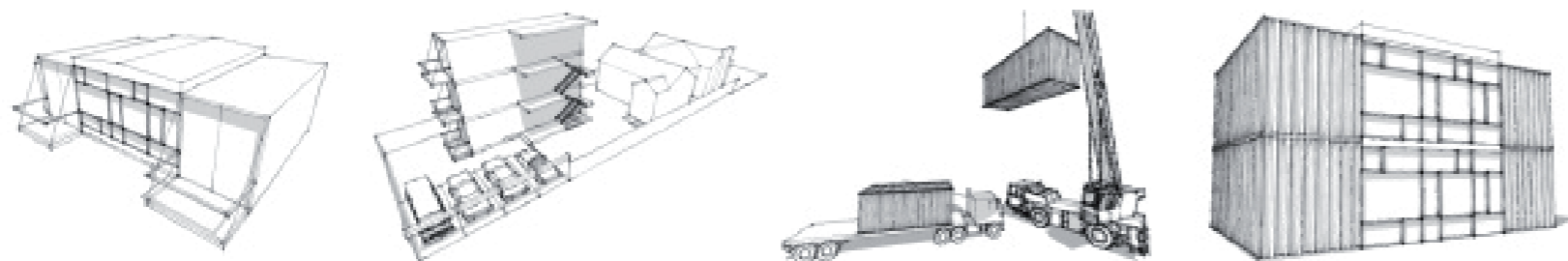
The high rise topic is strongly linked to steel and concrete emergence but has a huge spatial and social impact.



# Prefab.

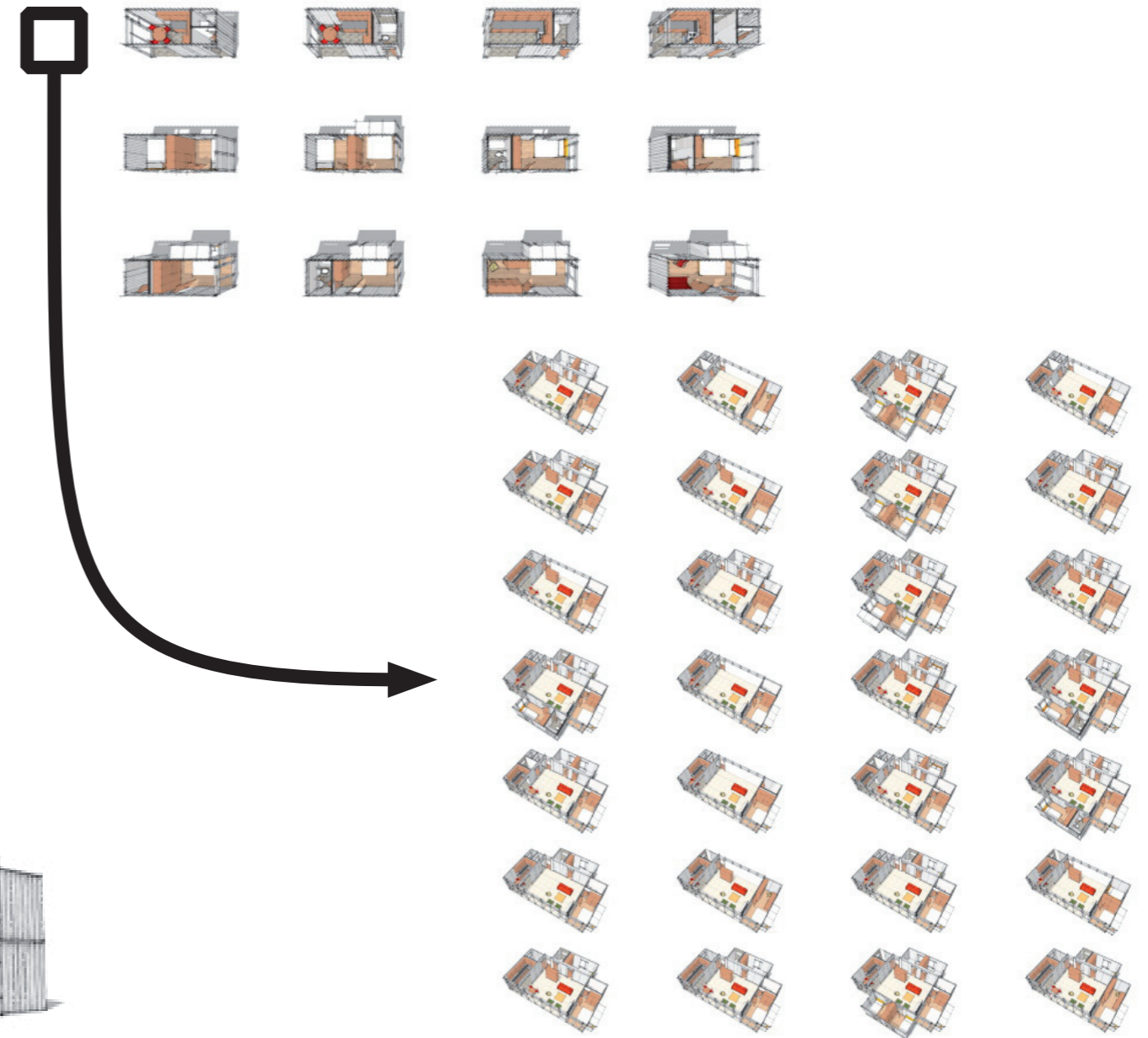


Exemple of a prefabricated house: the IBU system designed by Lamidesign



Prefabrication at a building scale is widely used, mainly for one to three-storeyed houses. As is it cheaper to build, it is strongly anchored as a social fact that prefabricated buildings are for the low class.

There is a lot of effort put to bring prefabricated houses in a better light. The green argument is once again pointing his nose, as prefabrication allows to reduce the construction'stime on site.



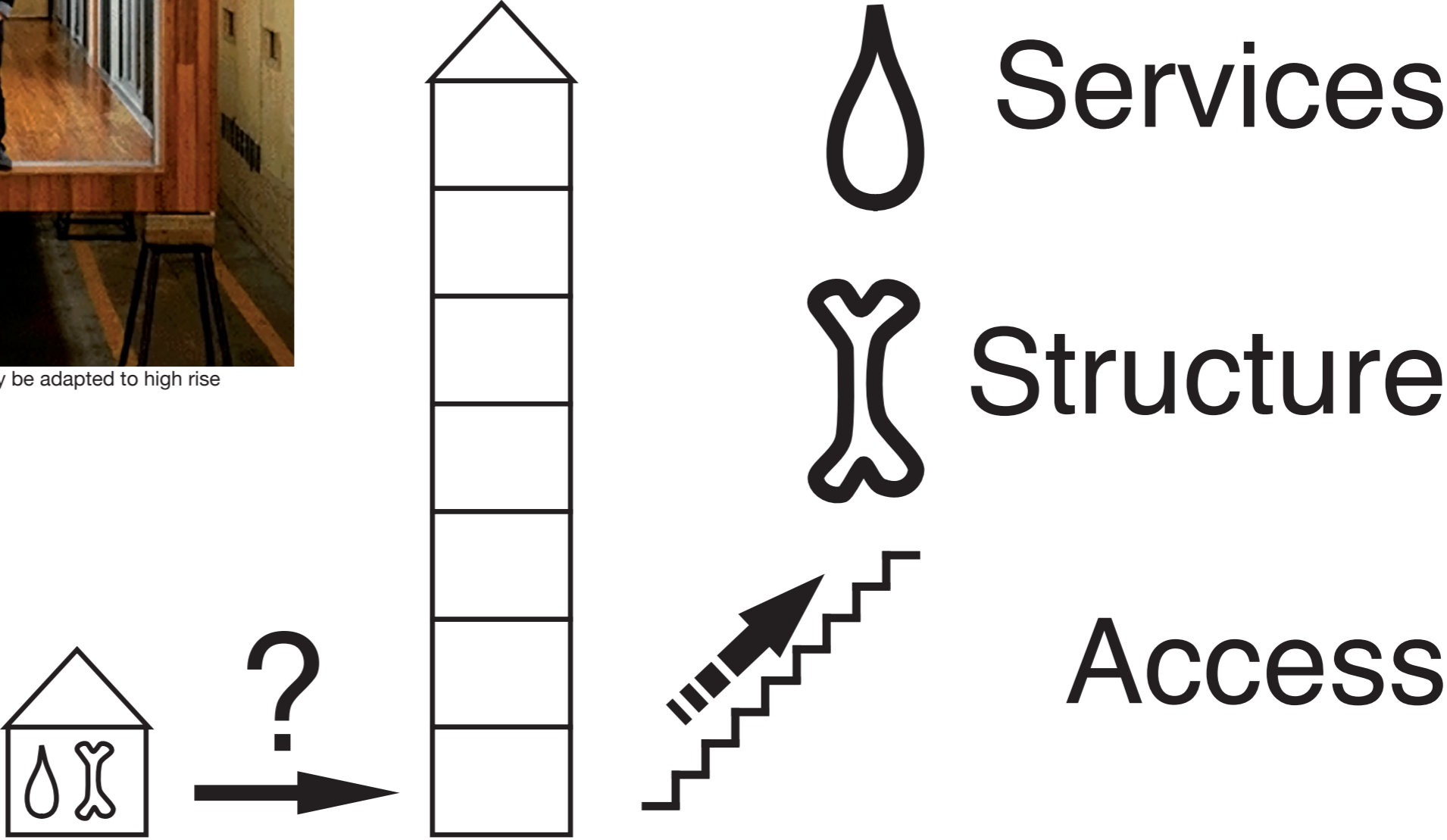


# High Rise Prefabrication

High Rise prefabricated housing is not so common as the scale introduces some typical problems, that finally reduce its financial appeal. The structure as a first problem is not linearly scalable. But it introduces an interesting building life model, replacing one module when let's say a new inhabitant comes, or just taking them all away to pile them back in an other place. The loose part is usually the adaptation to the site but this can be questioned in an urban context.

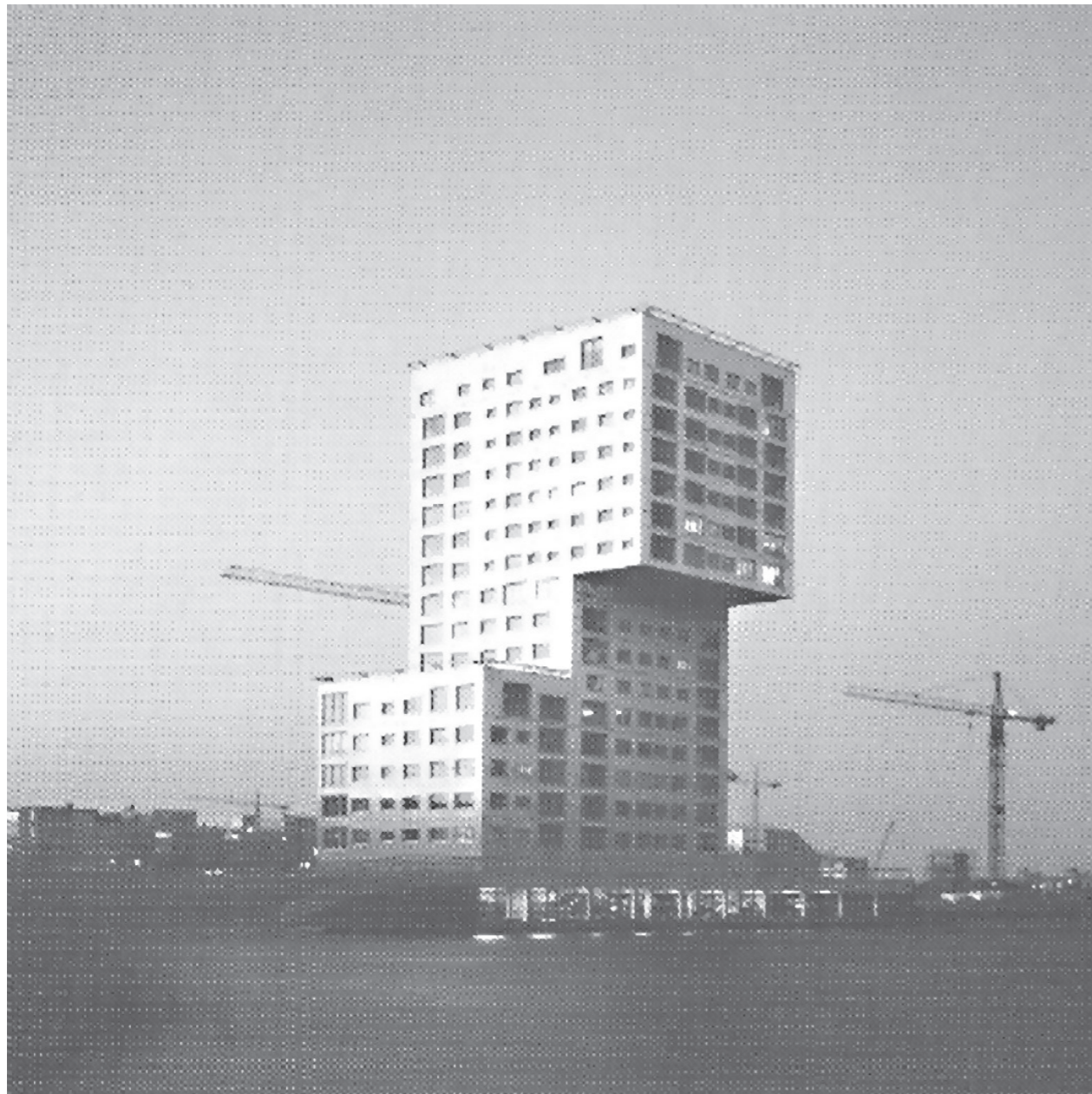


A «pre-build» module apartment made by Modscape that could possibly be adapted to high rise



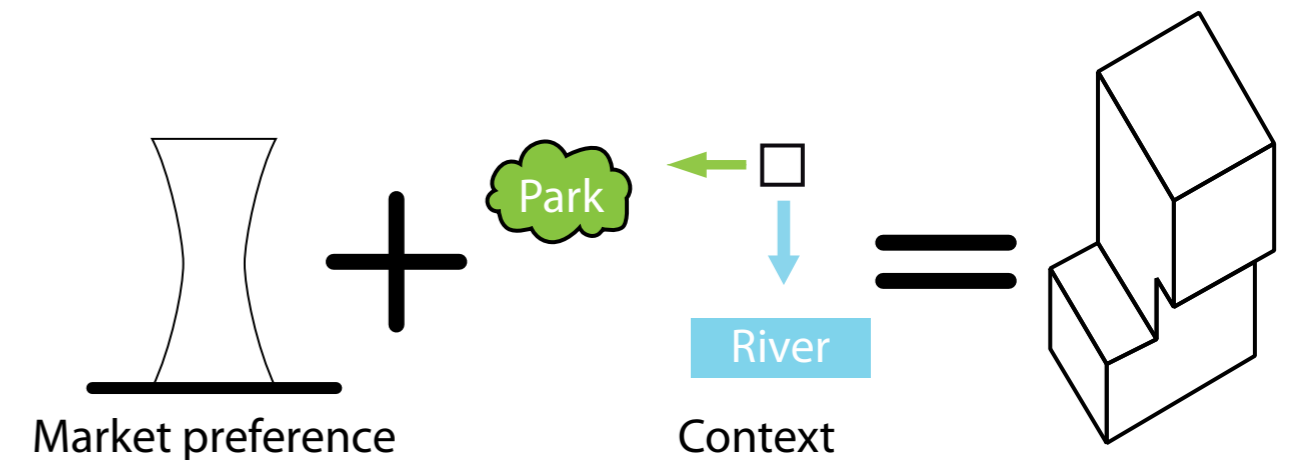


# High Rise Housing



The Silverline Tower in Amsterdam

High rise is often referred to as a way of living. But it has several more direct architectural consequences. At an urban level, high rise will mean high density too. This has some market and social meaning to deal with. High density is often a response to the rise of the land's price. As high buildings are usually built in the centre of a city and the centre of the city is statistically where people more often go to work, it reduces the traffic. Therefore to build high is becoming green and helps reducing pollution. A giant advantage of the high living is the potential views offered. But a common backface is the anonymity of every single soul in the building.



# Bibliography

## Books:

- Tensile Surface Structures, A Practical Guide To Cable and Membrane Construction; Michel Seidel; Ernst & Sohn; 2009
- Membrane Designs and Structures in the World; Kazuo Ishii; Shinkenchiku-sha Co.; 1999
- Tensile Architecture; Philip Drew; Crosby Lockwood Staples; 1979
- Forming Bubbles; Otto Frei; Karl Krämer Verlag; 1987
- Tensile Structures; Otto Frei; MIT Press; 1973
- Light Structures; Jörg Schlaich and Rudolf Bergermann; Prestel; 2003
- Textile Composites and Inflatable Structures, Eugenio Onate and Bern Kröplin, Springer, 2005
- show me the future, Werner Sobek, av editon, 2004
- The social Logic of Space, Bill Hillier and Julienne Hanson, Cambridge University Press, 1984
- Logique du Sens; Gilles Deleuze; Les Editions de Minuit; 1969

## Papers:

- Elipses excéntricas, Zénith de Estrasburgo; Massimiliano y Doriana Fuksas; in Arquitectura Viva 117 p.96-99; 2007
- High Rise Flats, in AW 196, 2003