ice
Institution of Civil Engineers
Publishing

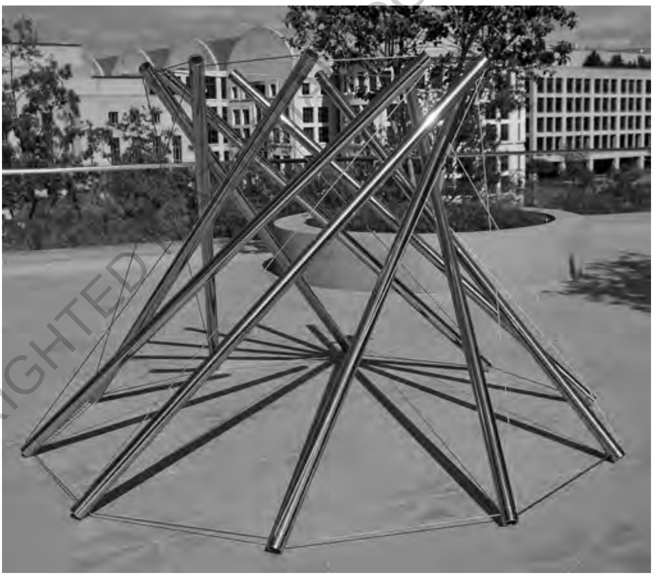
Physical Modelling for Architecture and Building Design

A design practice tool

Olga Popovic Larsen
Royal Danish Academy of Fine Arts (KADK)

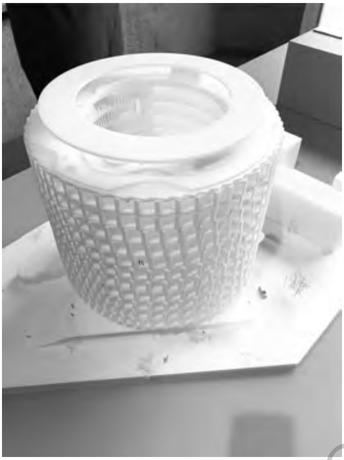
Figure 3.38 Close-up view of Kenneth Snelson's *Tensegrity* sculpture © Barbara Eckstein

Figure 3.39 Kenneth Snelson's *V-X* sculpture © Ron Cogswell



The structural efficiency of a tensegrity results from using pure tension and pure compression members. The loads are transferred through tension, thus there is a *continuous tension* load path and *a discontinuous* set of *compressed* components. The equilibrium of the structure and its stability rely, to a great degree, on the prestress of the compression members, achieved through tension cables. The level of prestress in one member affects all the others, which results in a high level of complexity in the design and construction of the structure. Thus, the design of tensegrities is best explored through physical models.

Figure 4.4 New housing tower for Nordhavn © Olga Popovic Larsen



are yet to be developed but have, however, been planned as volumes of buildings with specific proportions and rough composition. Several of the buildings are presented at a larger scale with a lot of detail in the physical models, such as a parking building with a roof-top green play and recreational area, as well as two silo buildings developed into housing projects. Although having a different materiality and expression, the building models, in their different ways, clearly convey the individual designs.

Figure 4.5 Urban plan model © KADK

Figure 4.27 Model of Zinc Mine Museum by Peter Zumthor, scale 1:26 © Pep Romero Garcés

In his studio, Olafur's multidisciplinary team of about 70 includes craftsman, specialised technicians, architects, archivists, art historians, web designers, film-makers, cooks and administrators. The work in the studio is experimental and explorative supported by research work that is visionary. Eliasson experiments with materials, geometries and effects, in which highly specialised scientific input is often required. He believes that it is important to express and make available to the visitor the construction of the artwork. His view is that the artwork is an option – a model where the essence cannot be found in the work itself – but it is an option that is activated by the users.

In his text *Models Are Real* (Abruzzo *et al.*, 2007, p. 19), Olafur Eliasson states his view on the importance of the viewers and their interaction with the art:

> When surroundings are thought of as stable, we tend to lose a feeling of responsibility for the environments in which we move. Space becomes a background for interaction rather than a co-producer of interaction. But what takes place is, in fact, a double movement: the user's interaction with other people co-produces space which in turn is a co-producer of interaction. By focusing on our agency in this critical exchange, it is possible to bring our spatial responsibility to the fore.

He continues (Abruzzo *et al.*, 2007, p. 19):

> Because models are comprised of two fundamental qualities: structure and time, one way of drawing attention to our co-production of space is a close examination of models.
>
> As objects in general are not static, neither are artworks. These exist in a manifold of instable relationships which are dependent on both the context in which they are presented, and the variety of responses by the visitors.

Over the years, one of Eliasson's close collaborators has been Einar Thorsteinn. Together, they have carried out many geometric studies, which have influenced their exhibitions and design work. Thorsteinn, an Icelandic engineer, mathematician, artist and explorer, had worked with Frei Otto in Germany and, inspired by Buckminster Fuller's work, had investigated geometry, crystallographic and structural principles. The fruitful collaboration between Eliasson and Thorsteinn can be seen in many projects but most directly in *Model Room* (2003). This installation was exhibited at the Louisiana exhibition gallery north of Copenhagen with over 400 various models of what appears at first glance to be lightweight structures, arranged on a wooden table, made of different materials and in different sizes; mixed media models, maquettes and prototypes were shown. When looking at the exhibition, one almost hopes that every engineer would have had the opportunity to experience it, as it is truly inspirational. But with its tactile materiality and formal, yet fully abstract, aesthetics, the installation leaves a powerful impression. It is presented to be experienced and interpreted by visitors, each in their own very personal way. *Model Room* is not only about the physical models; it is about us as much as it is about the models. The models are only a representation of the art, they are there to evoke, to create an experience and to communicate the artworks, artworks that are in close interaction with the visitors.

Another project influenced by Thorstein's geometrical mind is the Harpa Concert Hall and Conference Centre in Reykjavik (2006), a building designed by Henning Larsen Architects, in which Studio Eliasson was involved in creating the large-scale quasi-brick spatial structure for the façade. The three-dimensional geometry is based on fivefold-symmetry space, with the

Figure 4.32 Harpa Concert Hall by Henning Larsen Architects, Reykjavik, Iceland © William Warby

cutter was used, which could cut high-precision complex geometries. This was made possible by the ability to describe the geometry as a ruled surface. It is interesting that all of Gaudí's surfaces, without exception, are based on ruled geometrical surfaces. The production sequence included positioning the stones and cutting them, using CNC-cut plywood templates that allow for ±1 mm precision in the panel production. Once produced, a preassembly full-scale mock-up of a closed ring was made to verify that everything would fit together as planned.

With the high level of precision required, it was envisaged that an hour would be needed for each panel to be completed; however, on testing the process, it proved to be even faster – a full-height wall panel could be assembled in only 38 min. Once brought to site, a whole ring of panels could be installed in only one day.

Arup are continuing with the same approach for the rest of the design for the church, through collaboration with 2BMFG Architects and the Sagrada Família Foundation. The project's success can be attributed to Arup's professionalism, the excellent collaboration between the design and construction team and the use of cutting-edge computational design tools and production technology, supported with physical models. Although very different from the physical models that Gaudí himself sculpted from plaster, the 3D-printed scaled models, as well as the CNC-produced mock-ups and prototypes, are an essential part of the making of this architectural masterpiece. It is only now, using modern technology, that we can complete the project that Gaudí had envisioned (Arup, 2019).

The 2016 Serpentine Pavilion, by Danish Architects BIG (Bjarke Ingels Group), is an architectural project where design, fabrication, construction and materiality are optimised through

Figure 7.20 The Serpentine Pavilion by Bjarke Ingels © George Rex