

## Architecture, Form, Expression. The Helicoidal Skyscrapers' Geometry

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### Abstract

The Expressionist utopia of an Architect imitating the rigorous and -at the same time- extremely bizarre formative principles of Nature, linked with the engineering "must" of a coherent and correct structure are apparent antithesis if only played as the manifestation of an irrational and uncontrolled freedom. We explore the ancient idea of Harmony and Beauty and the historical confidence in the **logarithmic spiral** as the symbol of perfection in an un-built project for a 565 m (1,854 ft) high skyscraper that was supposed to be built on the tip of Manhattan, NYC.

The role of geometry is no more exploited as an instrument for controlling architectural form, but for its liberation: the project for a helicoidal skyscraper consisted of a succession of warped wings developed on the layout of the logarithmic spiral. The helicoidal shape, works better than the others in splitting up the force of the wind in resistance, has a positive influence on the stability of the building and is the result of a strong design theory wondering about the power of invention, the power of geometry, the power of relationships among numbers, and finally the beauty of (deriving from) mathematics (in Architecture).

### Sergio Musmeci and Manfredi Nicoletti – Helicoidal Skyscraper, NY 1968, project



Figure 1: *New York Crescent Project - model*

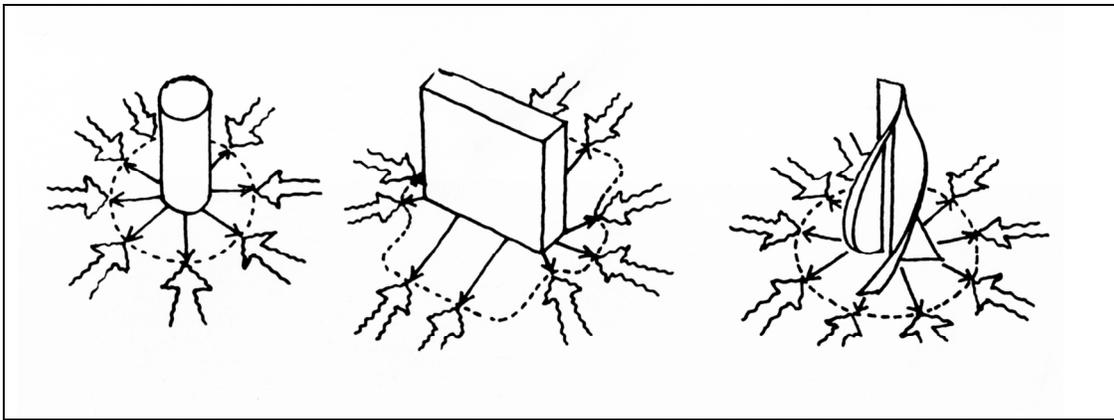
To revitalize the Downtown Manhattan area, at the end of the Sixties, Manfredi Nicoletti (architect, born in 1930) designed the “New York Crescent Project” a residential settlement mega tens-structural shaped for 80.000 inhabitants completed by an amazing **Helicoidal Skyscraper** as the business center of the complex, designed with Sergio Musmeci (1926-1981, one of the most daring and unconventional engineers born in the twentieth century). The two were involved in a research on organic architecture that in Italy had a very particular course. In a way referred to Frank Lloyd Wright, because of the exhibition Bruno Zevi did in his coming back to Italy after the stay in USA during the Second World War, but from another point of view, it was even more deriving from the tradition of architecture as metaphor of nature.

The Helicoidal Skyscraper has aerodynamic form and a structure inspired by stay-bridge technology and the limb of a mammal whose extremely effective endurance depends on the relationship between bone and muscle.

It is composed by a compressed central core and external tensioned fascias.

The central core, containing all the vertical systems, consists of three inter-connected hollow cylinders to each of these a sail - composed of a host of stay-cables - is anchored. These stays bear the floor structures, compressing them to the core. The floors do not therefore represent a dead load, but instead actively work with the static system of the structure.

The structural concept concurs to a shape that minimizes the weight and the dimensions of the load-bearing members. Three warped sails are anchored to three 565m-high mast elements.



**Figure 2:** *The whirlwind produced by rectangular sections have considerable whirlpool effects and mono-directional pressures. Cylindrical shapes produce lateral pulsation loads. The helicoidal shape dissipates wind forces.*

### Genesis. Forms Derived from Nature

*... something of the use and beauty of mathematics I think I am able to understand. I know that in the study of material things number, order, and position are the threefold clue to exact knowledge: and that these three, in the mathematician's hands, furnish the first outlines for a sketch of the Universe. [1] p. 778*

The paradigm is: building design as a result of organic growth.

The philosophy on which is based the **Helicoidal Skyscraper** project and the general approach to the design concept in Musmeci and Nicoletti has as a main reference: Nature, whose forms have not to be simply imitated but understood in the context of their generation. *“We have to understand the genesis that brought to the creation and why that specific form determines the resistance and permanence of a living*

*being in that or in another environment*” [11]. There are organized forms in nature that are dominant, such as spiral organization, and even this reference cannot be considered without other principle reference, so to understand material and immaterial environments in which a designer operates. The desire for the future and the forces that bring to it represent this kind of immaterial environment, that in-between condition linking (not separating) the reminiscence of the past and the contemplation of the future. It is the form that they give to the building materials that summarizes the very essence of architecture made both of functionality and aesthetics.



**Figure 3:** *A composition of sketches and the model of the skyscraper as you can find in many presentation by the authors themselves ([5] – p. 122).*

The search for analogies and similarities in Art & Science, to make a parallel between “organic growth” in Nature and the “organic growth” in Architectural construction, dates back at least to the second half of XIX Century. Cornerstones were the work by Sir d’Arcy Thompson [1], as well as the later investigations of Matyla Ghyka, who developed a whole theory where the notions of “Mathematics of Art” and Mathematics of Life” are (to use his words) “*coincident [...] under a condensed form that we can call «The Geometry of Art & Life»*” (Ghyka, Introduction, pp. xi-xii). Ghyka remarks also ([2], p. 167) that at the beginning of XX Century “*Engineers and Architects united their efforts, the growth of animal and plants showed to be well compatible with that of Human constructions*”.

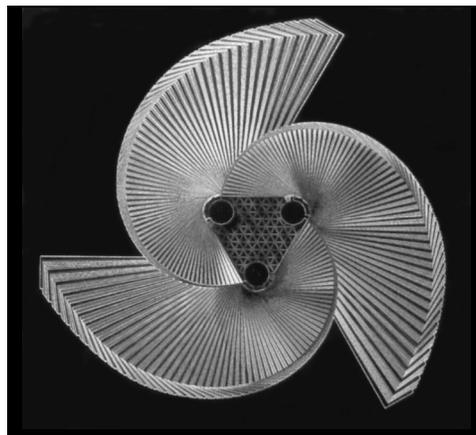


**Figure 4:** *Columns resemble Trees. The Museum of the Sagrada Família, photo by M. G. Lorenzi*

In a previous investigation of ours we have discussed the notion of “persistence of forms” in Art and Architecture in this perspective, we should remark that not only “geometrical forms” do persist, crossing Centuries and Ages, but also “natural forms”. [7] [8]

The Human endeavors, moreover, have not only imitated the “figures” and the “notions” of “natural geometrical forms” (a kind of “static imitation”) but have also set in action the strictly different (since “dynamic”) imitation of the “process of growth” in itself, constructing not only forms that “are natural”, but even trying “*to work as Nature would work*” in situations in which Nature has not yet attempted to act but Humans have had the courage to do it: as an emblematic example, no tree in Nature has reached elevations of several hundred meters, while human constructions have done it so to adopt to these “magnified scales” the same natural principles upon which a tall and slim object (like a tree) can grow vertically and remain stable against gravity and against the torsional stresses generated by natural forces like winds.

### **Geometries and other Disasters. The *Spira Mirabilis*, the Babel Tower and the Source of Knowledge**



**Figure 5:** *Top view of Musmeci-Nicoletti helicoidal skyscraper: the progression and rotation of the floors form three Golden Spirals with the origin coincident with the center of the hollow cylinders of the main structure.*

A tower and (nowadays) a skyscraper is at the same time a solution to a need (it can hold people, things and activities in great quantity) and a strong figurative symbol. It contains people, languages to decrypt and flows to organize. Skyscrapers are Tower of Babel and Babel represents the ultimate in imaginary architecture, a skyscraper of the mind.

The idea of Babel traces back to ancient Sumerian stories from the time of 5000 year old Mesopotamian Ziggurats, to the reinterpretation of these myths in the book of Genesis. In the 16th century painters in Lowland Europe, created the most well known imagery, evolved further with the un-built Palace of the Soviets and in the retro futuristic view of skyscraper cities of Fritz Lang’s Metropolis. Although in the book of Genesis is not mentioned how tall the Biblical tower was, the phrase used to describe the tower, “*its top in the sky*” is – beyond all doubt – an idiom for impressive height; on the contrary, according to other sources, the tower was wider than it was high, more like a mountain than a tower, and the spiral path was so wide that it contained lodgings for workers and animals. The fact is that the spiral itself was associated both to good and bad. Reaching for the sky is perceived as either getting closer to God or an act of unforgivable hubris. Architects anyway have used it to celebrate a workers’ utopia and a faithful believing in human capacities.



**Figure 6:** *Roelant Savery, Tower of Babel, 1602, Germanisches Nationalmuseum Norimberga*

While the Bible doesn't specify what the Tower of Babel looked like, we get a hint from the extraordinary paintings of 16th Century painter Pieter Bruegel the Elder and even other less known Flemish painters. They portrayed the tower as a spiraling mountain of masonry -- with a pathway twisting around its tapering exterior.

In 440 B.C. Herodotus wrote a description of Babylon and its tower in the first book of his "History": *"It has a solid central tower, one furlong square, with a second erected on top of it and then a third, and so on up to eight. All eight towers can be climbed by a spiral way running around the outside, and about halfway up there are seats for those who make the journey to rest on."*



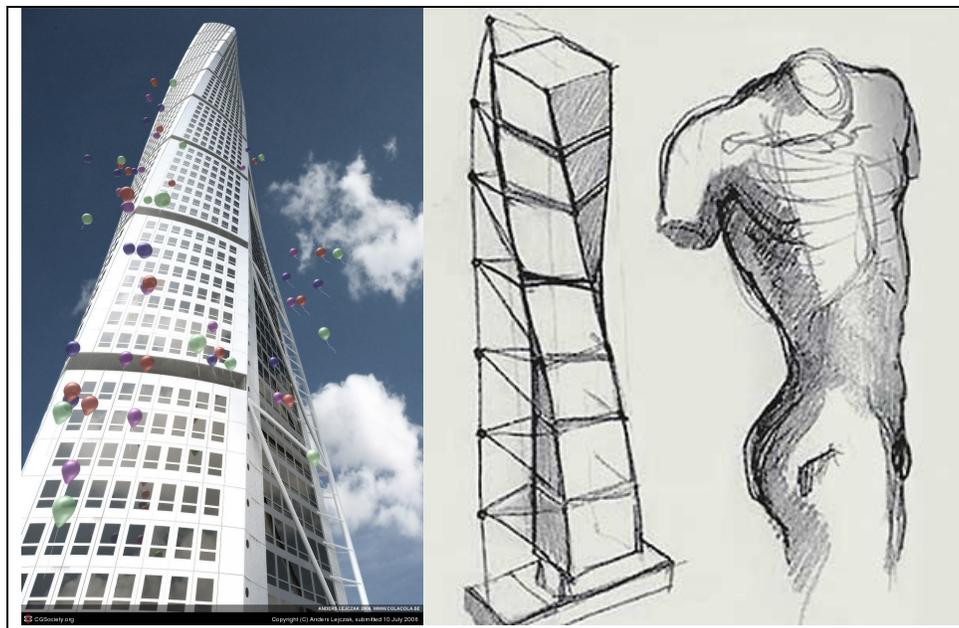
**Figure 7:** *Bruce Alonzo Goff – Bavinger House, Norman, Oklahoma 1950*

**Figure 8:** *Vladimir Y. Tatlin - Monument to the Third International 1920: model erected in the courtyard of Royal Academy of Arts, London 29 October 2011—22 January 2012.*

And Jacob Bernoulli was so fascinated by the mathematical beauty of the curve that he asked that it might be engraved on his tombstone with the phrase "*Eadem mutata resurgo*" ("I shall arise the same, though changed.") , so the spiral becoming the symbol of resurrection. Moreover following the musicological tradition that states that, 'As one stroked the strings upward, the tones descended to earth through E-D-C-B-A-G-F.' and that the scale would be ritually strummed by priests in order to call angels down from Heaven! so the Tower of Babel, seen as a 3d logarithmic spiral, with the vertex pointed to the sky brings to Heaven, down to the Hell.

Frank Lloyd Wright turned this ziggurat upside down in the great white spiral of his Guggenheim Museum in New York and Vladimir Tatlin designed an inclined tower (the slope corresponding to the earth's axis slope) 400 meters-high (that would have dwarfed the Eiffel Tower in Paris) and interpreted the complexity of Babel because of the composite inside. In the iron-and-steel structure of twin spirals he thought to locate three glass building blocks, housing libraries, conference halls and an information center, which would rotate at different speeds (the first one, a cube, once a year; the second one, a pyramid, once a month; the third one, a cylinder, once a day).

### **I Want to Touch the Sky. Musmeci's and Nicoletti's Helicoidal Skyscraper as the Seed of Chicago Spire, Malmö Turning Torso and Dubai Infinity Tower**



**Figure 9:** *Santiago Calatrava, Malmö Turning Torso, 2005.*

**Turning Torso** is mixed-use residential tower in Malmö's Western Harbor, that serves as a landmark for the new development of the city, and as a symbol of revitalization of an important urban area from a decay industrial zone into a thriving seaside neighborhood [12] (spiral as metaphor of resurrection). The idea originates from the Turning Torso sculpture Calatrava himself did years prior. The building consists of nine cube units with triangular tips. Each unit, twisting towards the waterfront, houses five floors and works as a sub-building.



**Figure 10:** 1-Santiago Calatrava , *Chicago Spire*; 2-Skidmore, Owings & Merrill, *Dubai Infinity Tower*; 3-David Fisher, *Rotating Towers* (to be built in Dubai, Moscow, New York)

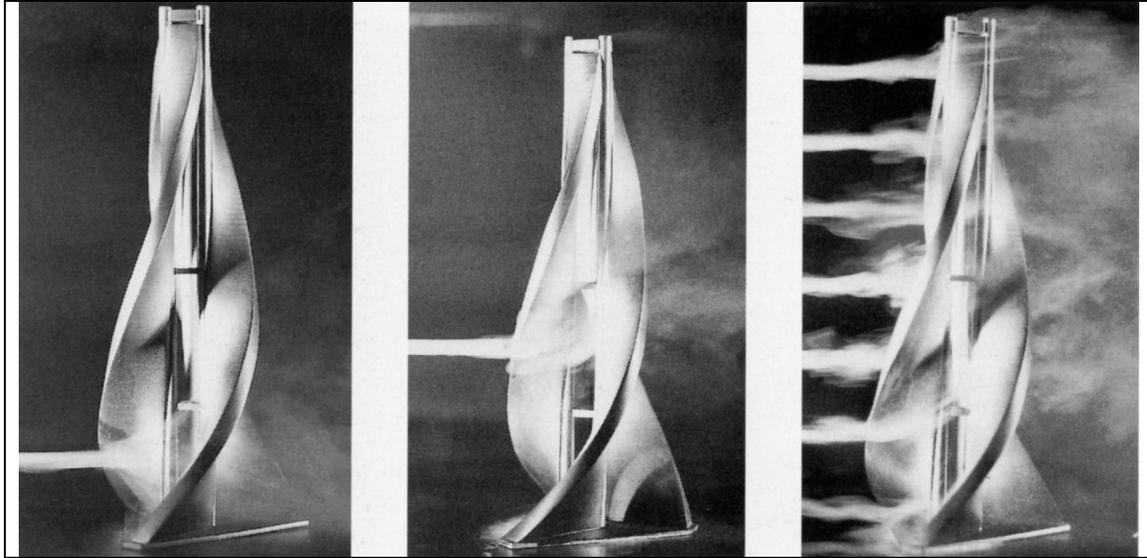
**Chicago Spire** is a proposal for a 2,000-foot-tall twisting tower in Chicago, Illinois, which was abandoned in 2008 with only its foundation work completed. As with many of his designs, Calatrava was inspired by themes taken from some images of nature or reality and for this twisting skyscraper he likened the structure to an imaginary smoke spiral coming from a campfire near the Chicago River lit by Native Americans indigenous to the area. The curved design, similar to that of Turning Torso in Sweden, may provide the same two major benefits of Musmeci's and Nicoletti's skyscraper: curved floors designs have a tendency of adding to the strength of a structure and the curved face of the exterior will minimize wind forces.

Each floor is rotated by 1.2 degrees to achieve the full 90° spiral, creating the shape of a helix.

**Dubai Infinity Tower** The structure gradually twists 90 degrees; the floors, which are rectangular, surround a cylindrical shaft that contains the lifts; the formwork is simply rotated about one degree at each successive floor level. Exactly each storey rotates 1.08 degrees around a fixed cylinder core, so that, once the tower is complete, the 73 floors will make a cumulative 90 degree turn.

*"It is a piece of sculpture that is unusually large and that is the effect that we were really after ... a large piece of sculpture that had this dynamic form,"* says Ross Wimer, a design partner at SOM (Skidmore, Owings & Merrill), *"...one thing we discovered in the testing is that the twisted shape performs better in the wind than a rectangular extrusion of the same proportions."*

Once again the figurative goal coincides with all the structural needs Musmeci analyzed 40 years ago.



**Figure 11:** preliminary aerodynamic analyses on Musmeci-Nicoletti skyscraper model. Institute of Aerodynamics and Aircraft Design Institute at Engineering Faculty of the University. of Naples 1971.

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