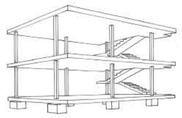
Metamorphosis – to create a specific form in relation to its specific requirements for given purposes
To apply an analysis to mold a fluid to form a solid. To perfect a specific man-made rock, optimized to his specific characteristics concerning structural performances, architectural aspirations and/or meticulous tectonics.

From the first roman concrete (opus caementicium) to the revival in the 19th an 20th century by the invention of Portland cement and introduction of reinforcement components to resist tensile stresses, it has had an enormous impact to architecture, structural design and a broad spectra of industries. The process of designing concrete has been undergoing a lot of change due to divers and upgraded material components, insight about the characteristics and artistic explorations.

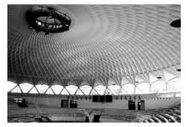
The manifestation of concrete in the architectural and structural practice has known different kinds of architypes.
A subjective enumeration:

Modern use (example Le Corbusier, Dom-ino, 1914)



Pre-fabricated elements (example Mark West,NYC, USA) Photo: Anne-Mette Manelius

Cantilevering entities (example 'La Flèche', Genie Civil, Expo 1958, Brussels, Belgium)



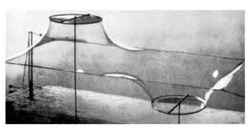
Grid structure (example Luigi nervi, Pallazetto dello Sport, 1957, Rome, Italy

Shell construction (example Heinz Isler, Highway Station,1968, Deitingen, Switserland)

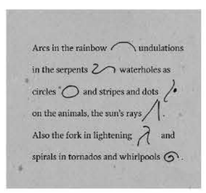
Recently the fast technological evolution allows to increase complexity by increasing the quantity of relevant information (environmental, artistic, management, financial, durable,…) parametrically and provides advanced designing tools. These tools, in return, has changed the design process, the concrete manifestations and thus enrich the intuitive sensitivity towards the material itself.

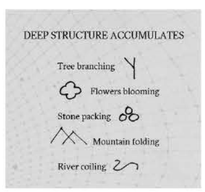
Catenary arches result from hanging models. Antonio Gaudi used this method to make compression structures. This relation converting one catenary, or combination of tensional elements, into a series of compression elements was a prelude for architects, engineers and designers of the 20th century.

Minimal surfaces in tension-only structures (or the inverted catenary compression-only structures) are biomimic examples of an evolutionary progress of a building system. Because they derive from examples we observe in nature, we intuitively regard them as elegant and fascinating. The minimal surface allows to divide the stresses optimally and thus requires a minimum of materiality.



Deep structure is felt in all of us, informing our everyday interactions and acts of creation. These primal memories are ancient, and as Cecil Balmond explains, inescapable. Here he contemplates how we came to make sense our world and the mysterious power of these very first archetypes.
Deep structure is a drum that beats behind organization – a primal memory of the algorithms that paved the way for survival.
(reference: 'Deep Structure' Cecil Balmond, 2015) http://tip.balmondstudio.com/tip/deep-structure/



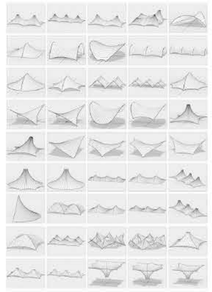


Due to high costs of scaffolding, environmental issue concerning non-reusable components of scaffolding and a possible lack of research and interest, shell structures became rare.

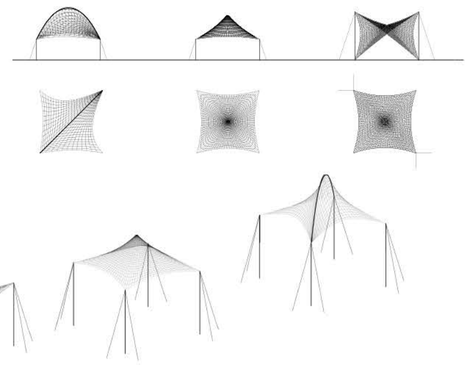
This project (re-)introduces the concept of the membrane-shell structure. A minimal surface based tensional component with internal cables for support which works as a mold and as an active structural member. A concrete shell is sprayed upon a mesh membrane to imitate the shape and over time gives structural compressional support. (Anhalt Universität, IMS, Henning Dürer, Dessau)

This allows for a synergetic system (ref: Buckminster Fuller, Synergetics, 1975) where both tension and compression members are necessary and provide more than there qualities separately. There has been done research about this method (VUB, Brussels and Anhalt Universität, Dessau) but there has been little response in practice. This project is an attempt to revitalize and expand this system in order to contribute to a more natural formal architectural language, a structural synergetic system which optimises material form in relation to its respective properties. A parametrical system to find optimized concrete shape due to its properties. A Metamorphosis...

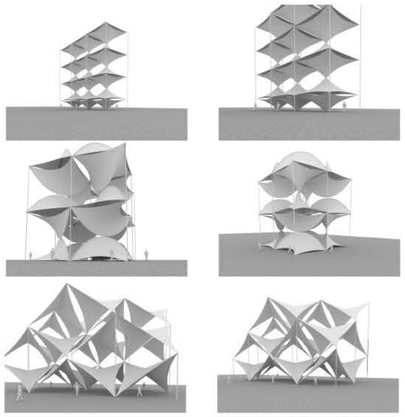
1. One simple element I shell elements based on common membrane typologies



Fabrication - Shotcrete is sprayed on the mesh. To prevent the concrete from dripping off the mesh, the edges could have a stiff profile (as in the image above (HEB100) or a flexible welded edge normally used to guide water towards the lower corner of a common PVC membrane. Depending on the shape and structural analysis, the edge cables, the tie-downcables and stabilizing cables inside the mesh could take tensile stresses after the shell is formed. In this way we optimize the structure to the corresponding material properties. The beams and rings (example arch and highpoint membrane) could be left out depending on the structural analysis. The vertical 'masts' could be left out if the cables are abundant and of the compression could be fully transferred to the shell.

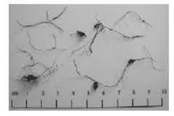


2. Combining elements I The precasted element combination



By making combination of the elements we can make all sorts of 3 dimensional structural configurations.
A metamorphosis of a normally rigid pre-cast element.

To reinforce the concrete flexible fibers are used.



Recycled steel fbers

Concrete with fiberglass fibers

Carbon fbers

3. Complex minimal surface membrane shells