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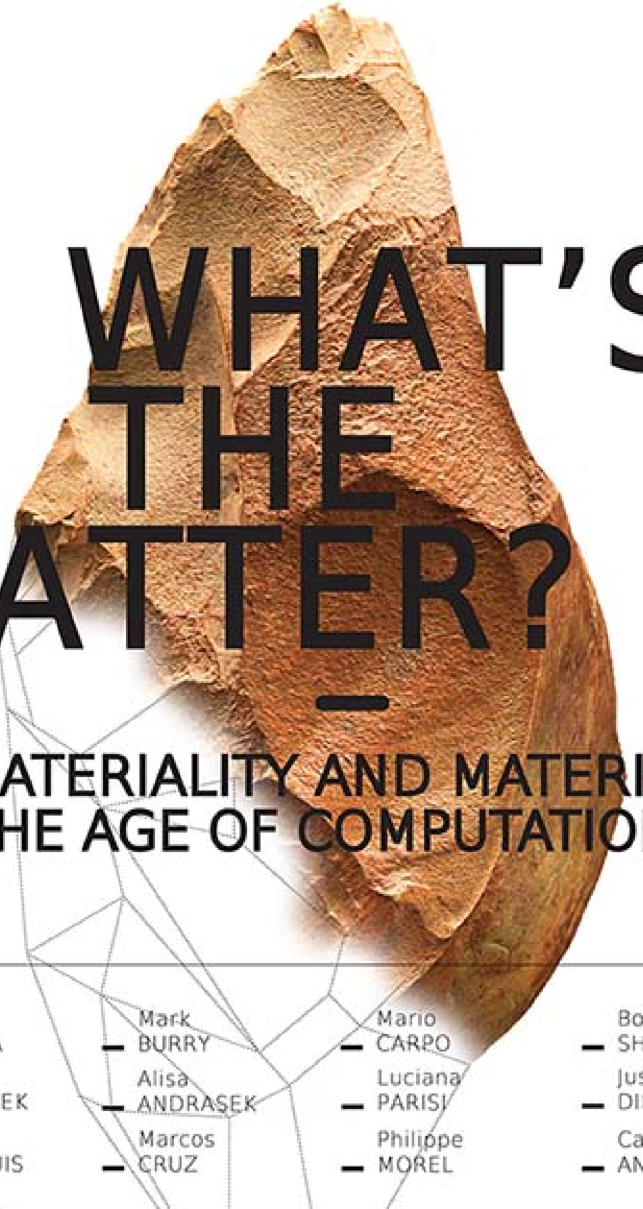

WHAT'S THE MATTER?

—

MATERIALITY AND MATERIALISM AT THE AGE OF COMPUTATION

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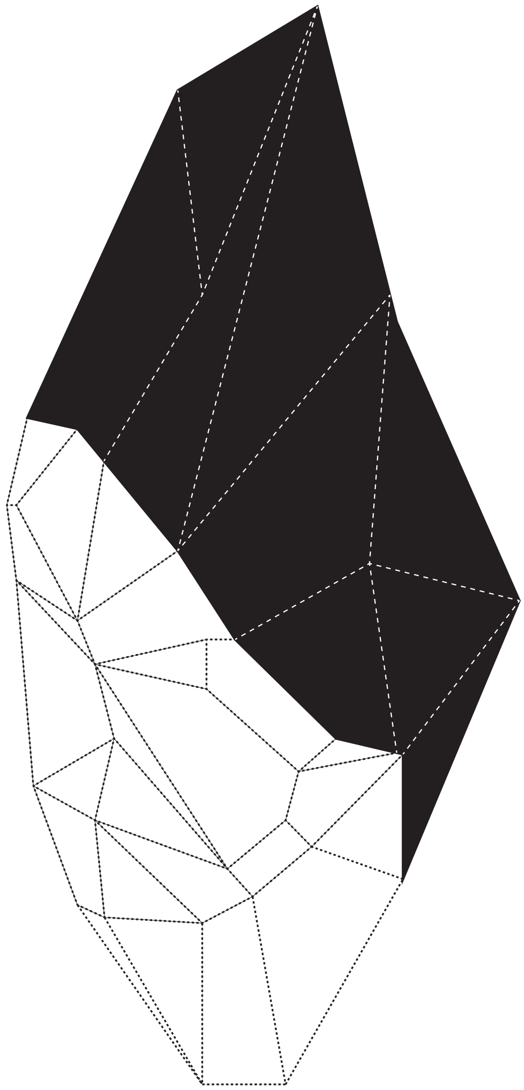

WHAT'S THE MATTER?

materiality and materialism at the age of computation

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The dark side of the shape
A method for the generation of alternative architectural organism under the constraint of morphogenesis

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Theoretical premises and research framing

This work is part of a larger research project started in 2009 with the aim of pointing out existing links among form, geometry and structure through the analytic study of the main developments of international architectonic culture in the period lasting from 2009 to present. The work is divided into two sections.

The first analyses the relation between the built architecture and its shape, the second goes on the reverse path, which is the way new architecture is defined through parametric architecture. Previous publications have explained in detail the first section [1,2,3]. A library of shapes has been created as a catalogue of a certain numbers of families and sub-families, where buildings can be identified by common features. The first sub-family of shapes developed in a previous work was the dome, where the general definition of dome was extended to the *hyperdome* architectures [4]. It is evident that a parametric library of geometries cannot be limited to the creation of an illustrated atlas of architectonical features, but it should deepen the relations between different families composed by different issues. The analysis of the relations through groups of features is tied to the study of meaningful paths of the contemporary design culture in the plurality of tendencies and transformations of the tools under the lights of professional activity. This relation is actuated through a continuous dialectic between architectures, cities and landscape, which creates a specific and distinctive shape. It is fundamental to locate single buildings into their own historical-architectural contexts, by examining specific key case studies in the wholeness of their architectural features. The second section embraces the parametric architecture using the computational tools that give the possibility to understand and manage complex architectures in an innovative way. The target of this research is to explore a method for creating multiplicity in architecture, through the use of generative design. It is possible to produce a computational alternative to a building by understanding its design. The process of understanding is strictly connected with the morphogenesis; the comprehension of the design process is based on the layout of algorithm, which generates the final architectural shape. The paramount elements of the algorithm are the definitions of key geometries of the building, as studied in the first section.

Method

The method used to achieve multiplicity in architecture is based on two steps, the analysis of morphogenesis and the parametric design. The comprehension of the design process is essential to drive the parametric design into a coherent direction. Morphogenesis [5], from the Greek *morphê* (shape) and *genesis* creation, literally, "beginning of the shape" is the biological process that causes an organism to develop its shape ; when it is applied in architecture, morphogenesis is referred to the creation process of the perceived image of the building. It is reached through the links between form, geometry and structures [6]. The morphogenesis process itself is studied in three different issues. The first is the analysis of the perceived shape of the building, which is the base of the process, and the check of final results. Subsequently there is the knowledge of the geometry and the structure, which limits the shape into the boundaries of perception. The recognition of key elements in buildings perfects the understanding process. These element are called *shape drivers* [6] , because they drive the main features of the form. Without them the shape would not be perceivable, so that they imply the parsimony and the necessity.

Once the shape understanding process has been completed, the next trail is the design of multiplicity, which is achieved by using the generative design tools to write a code. The tool used to lay down the algorithm is Grasshopper for Rhinoceros, which is a widely spread generative design software. Due to the input/output structure of digital tools it is important to define a specific input, that works out with geometric features to give forecasted results. The specific inputs are parameters, which may be external, or internal. External parameters are all of the features which do not belong to the building, but are connected with it. Examples of external parameters are proximity buildings, city skyline, environment features and physic features of the area. Therefore these are fixed parameters, so they cannot be modified. For the purpose of this research, the stress has been put on internal parameters, which are part of the building and they are subjected to modifications in design process. These kind of parameters are direct expression of morphogenetic analysis converted into algorithmic constraints, digital bonds among parts of the building. The final definition of the building (through its real perceptive appearance) becomes one of the multiple variants of a dynamic evolution of an architecture. These variants are driven by the modification of the internal parameters under the constraints of the geometry (driven by algorithm) under the influence of the external parameters.

Once the method has been undertaken, first along morphogenetic understanding, then with generative design, the result is the set of two elements. First component is the algorithm, which recalls all the rules that create the shape; the second is the 3d model of the building itself. This model is a transitive state of the architectural shape, strictly connected with the algorithm itself. With the scheme of elements built in the explained way, the real building is one of the possible solutions of the code, maybe not the best, maybe not the most functional.

Case studies

For the purpose of better understanding the whole process, two case studies have been explained in detail. The case studies were made starting from the final works in the courses of Digital Drawing in the Bachelor Degree in Architecture of Politecnico di Milano. Case studies are:

1. Turning Torso, by Santiago Calatrava – works by Stefano Moraschi and Ayca Ozmen
2. Serpentine Gallery Pavilion 2002 by Toyo Ito and Cecil Balmond – work by Paolo Tomelleri

The choice of these buildings has been guided by the clearness of the design process, which makes the method easier to comprehend.

Turning Torso

The skyscraper known as Turning Torso, designed by Santiago Calatrava, has been built in Malmo in the south of the Sweden in 2005. Its name is given because its shape is generated by the resemblance of the building with a rotating human torso. On a preliminary analysis it is evident that the shape is created by the rotation of a single element around a central core, which is the main bearing structure of the building.

The rotational element is a block of 5 floors, which bends itself; the full rotation, from bottom to the top of the building is 90 degrees (Fig. 1), but inside each block, one floor rotates 1.6 degrees relative to the floor below. It is clear that the rotation of the block is the first shape driver of this process; parameters used are all internal, because the skyscraper is an urban emergence, which has very few connections with surrounding environment. Going deeper into the analysis, the very first step of the generative design process is the definition of the plan of the single floor, which replicates itself rotating and moving through all of the building.

The starting form is the square, which edges are divided into quarter portions, then the connecting lines are extended and trimmed as shown in Fig. 2. Once some work of smoothing has been done, the edges of the actual plan is drawn. The algorithm could be fed directly with the final edge curve, but it has been written starting from the very beginning of square divisions, for didactic purpose. The algorithm works considering elements as a part of the whole. The array that generates floors and blocks is dependent from specific control parameters: floor height, floor distance, storeys per module,

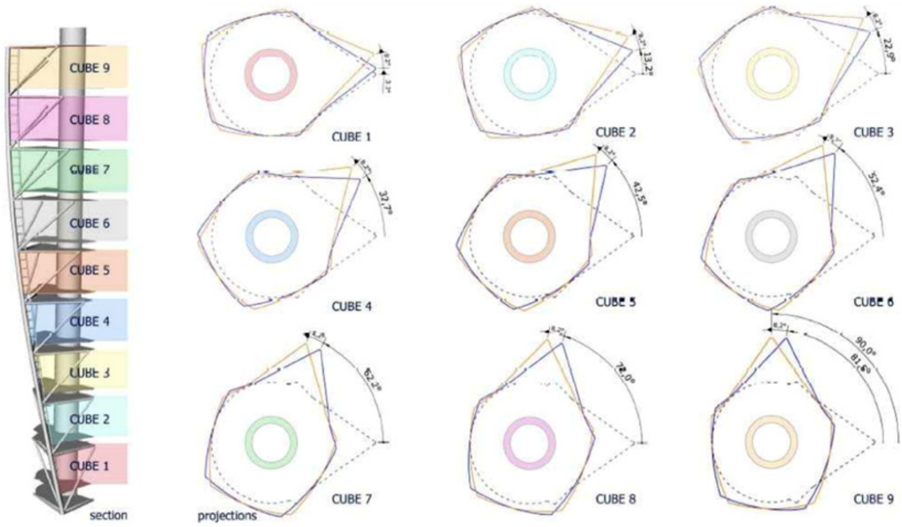

Fig. 1

Rotation of level in a single cube - Turning Torso. S. Calatrava – (course of Representation – prof. Domenico D'Uva, student Ayca Ozmen).

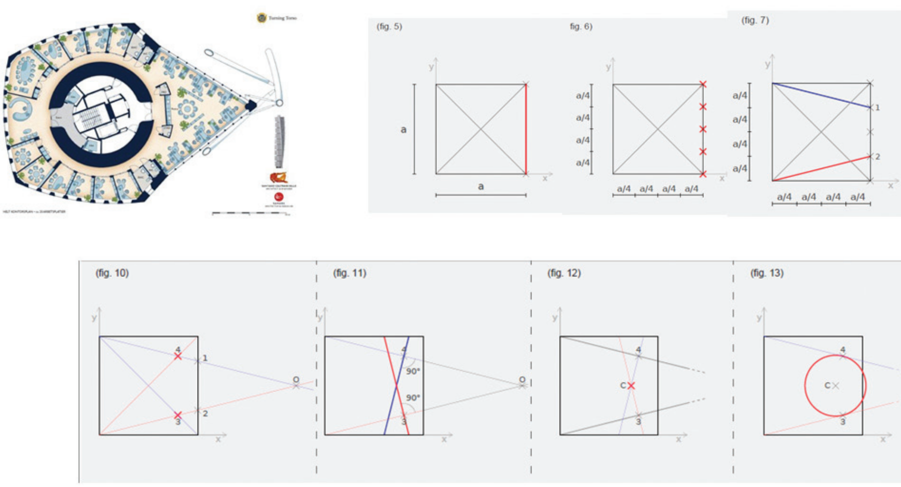

Fig. 2

Plan morphogenesis - Turning Torso. S. Calatrava – (course of Cad Parametric 3d drawing – prof. Domenico D'Uva, student Stefano Moraschi).

number of modules, panel width and panel numbers, as detailed in Fig. 3. Thinking in terms of perception the differences between the aforementioned parameters and the shape driver are evident. Modifications in generic parameters generate differences in small details. Variations in shape driver, the angle of rotation in the specific case, gen-

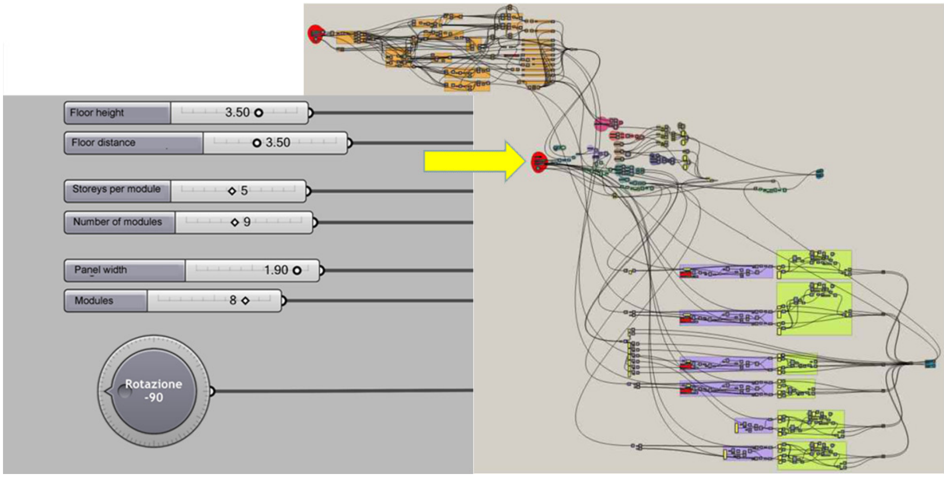

Fig. 3

The array that generates floors and blocks is dependent from specific control parameters: Turning Torso. S. Calatrava – (course of Cad Parametric 3d drawing – prof. Domenico D'Uva, student Stefano Moraschi).

erates a new form, different in its essential features. Compare Fig. 4 and Fig. 5. In this last figure the rotation, which is equal to 90 degrees is increased up to 180 degrees, generating a more slender silhouette, given by the different proportion ratio between the external upwind mast and the modules.

Serpentine Gallery Pavilion 2002

The Serpentine Gallery is a temporary pavilion located inside Hyde Park in London. The pavilion is rebuilt every year but the specific case study is related to 2002 building, designed by Toyo Ito and Cecil Balmond , come into being from 12 Jul 2002 to 29 Sep 2002. As in Turning Torso the starting geometrical entity is the square. The morphogenetic analysis (Fig. 6), has pushed the research on the relationship between edges. The peculiarity of the square splitting is the contrast between the inner symmetry of the shape and the dividing ratio. In fact the square is divided on one edge by its half (1/2), on the adjoining edge it is divided in three parts (1/3). Then the division points of the edges are connected through lines. The process of point joining and lines chamfering is repeated creating a certain degree of complexity (Fig. 7). This extension process is present on the elevations too, as shown on the lower row of Fig. 7; the facades have been flattened and included in this procedure. Once all the network of lines has been laid up, they are used to cut the surface that wrap the box. Part of the cladding can be removed, the rest will be extruded to make the structure of the building. The splitting and extension process can be repeated in an infinite loop, but a real construction require finite pieces of finite dimension, not too small to be unmanageable. As explained

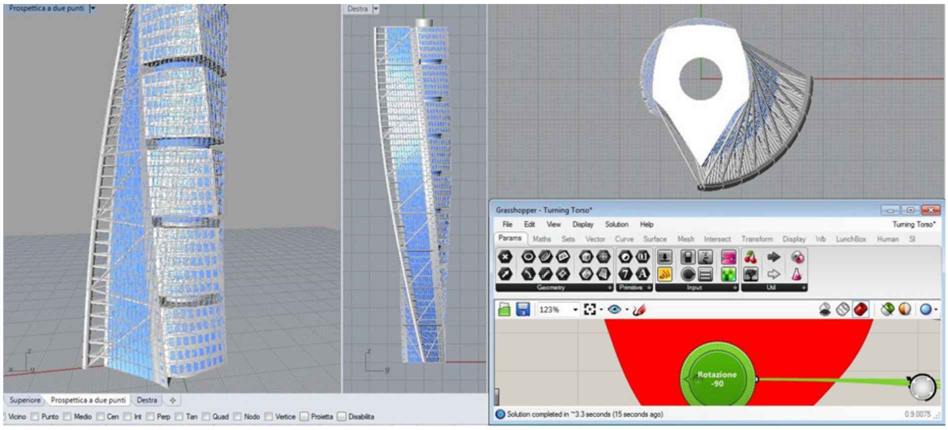

Fig. 4

Shape driver. Angle or rotation of 90° generates actual building Turning Torso. S. Calatrava – (course of Cad Parametric 3d drawing – prof. Domenico D'Uva, student Stefano Moraschi).

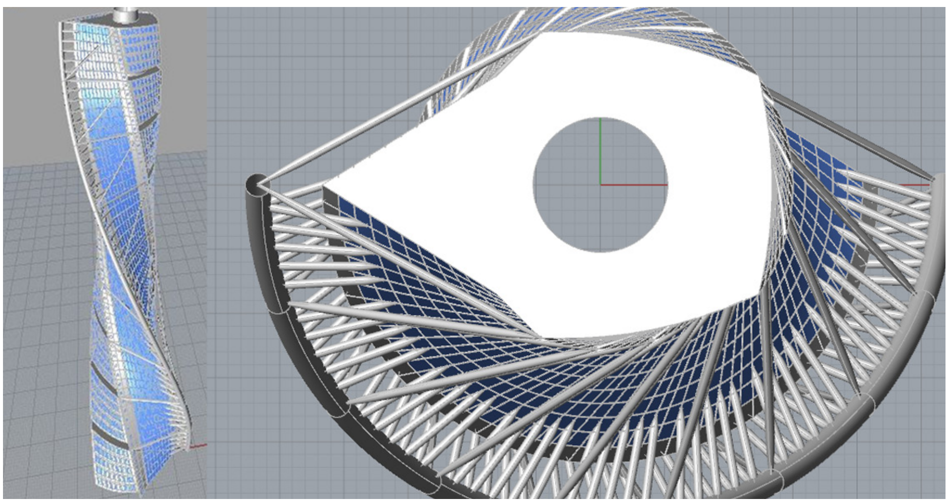

Fig. 5

Shape driver variation. Angle or rotation of 180° generates an original building - Turning Torso. S. Calatrava – (course of Cad Parametric 3d drawing – prof. Domenico D'Uva, student Stefano Moraschi).

in the previous case studies, the process is transformed into a Grasshopper code, which is designed into a finite number of steps, given by the same number of steps taken by the designer in the actual building. The built structure, however, is not the exact product of the process, because some elements had to be changed, without following the general explained scheme, but simply removed. Doors and openings have

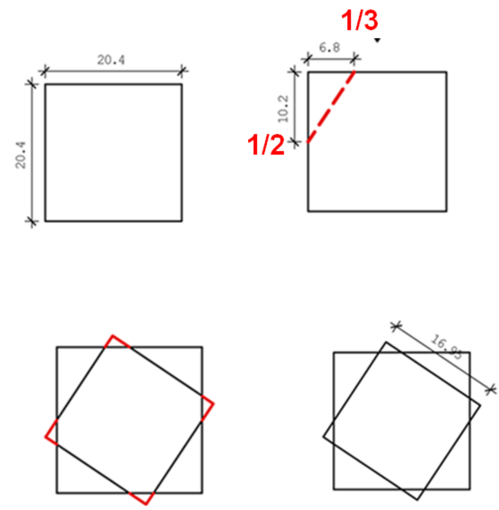

Fig. 6

Plan morphogenesis - Serpentine Pavilion, Toyo Ito – (course of Cad Parametric 3d drawing – prof. Domenico D'Uva, student Paolo Tomelleri).

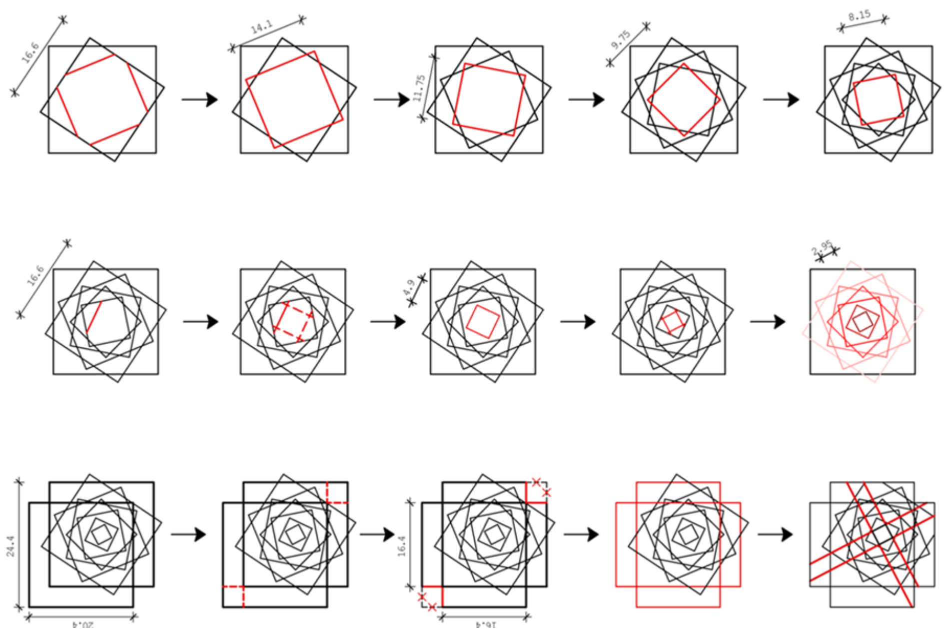

Fig. 7

Plan and elevation morphogenesis; This extension process is present on the elevations too, as shown on the lower row - Serpentine Pavilion, Toyo Ito – (course of Cad Parametric 3d drawing – prof. Domenico D'Uva, student Paolo Tomelleri).

been obtained by removing significant parts and corner subdivisions are sometimes changed. These emergences from the general scheme are detailed in Fig. 8. One of the possible shape drivers for this building is the division factor, which is 1/2 and 1/3 for adjoining edges. Once this parameters have been worked out with the algorithm, they produce the actual building. Creating the building multiplicity is much more interesting. Variation in splitting of 1/2 and 1/3 for all edges have been experimented without significant variations. A single case has been interesting, the division of edges in 1/4, as shown in Fig. 9 has created something completely unexpected. The whole building is made of linear edges, so all the elements are expected to be polygonal. In this case of edge division, instead there is the creation of three curves on the top of the roof. Increased divisions, as 1/4 and 1/16 create less interesting solutions, moving the filled elements of the roof toward the edges.

It has been experienced as a choice of space drivers the selection of different starting edges. The actual building is based on a low box, whose edges in contact with the

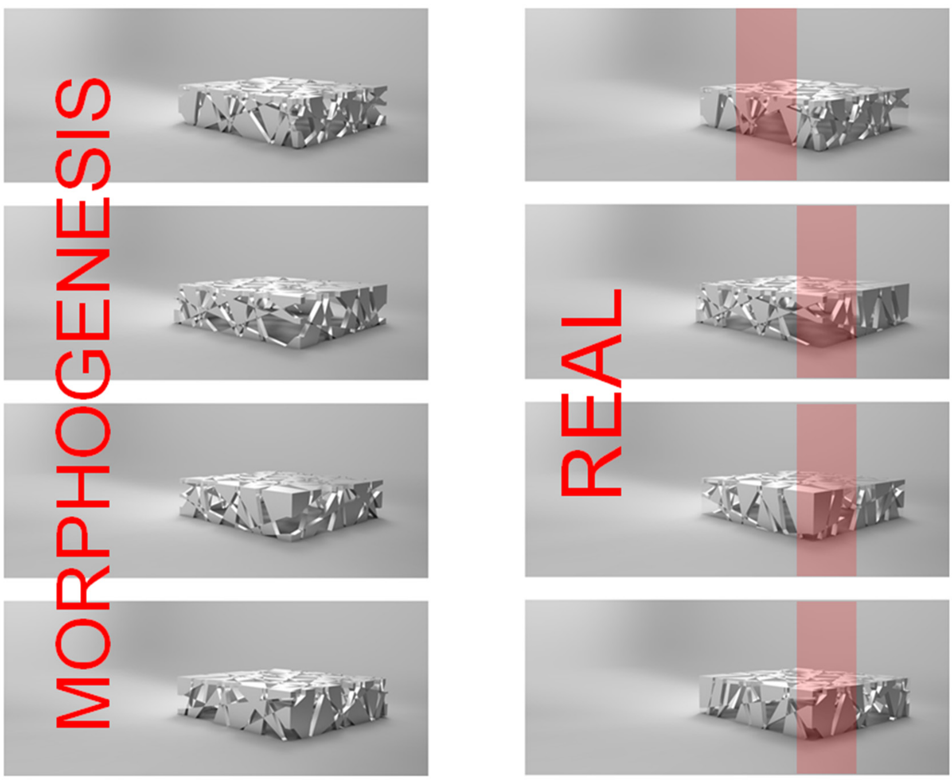

Fig. 8

Emergences from the general scheme; doors and openings have been obtained by removing significant parts and corner subdivisions are sometimes changed. Serpentine Pavilion, Toyo Ito – (course of Cad Parametric 3d drawing – prof. Domenico D'Uva, student Paolo Tomelleri).

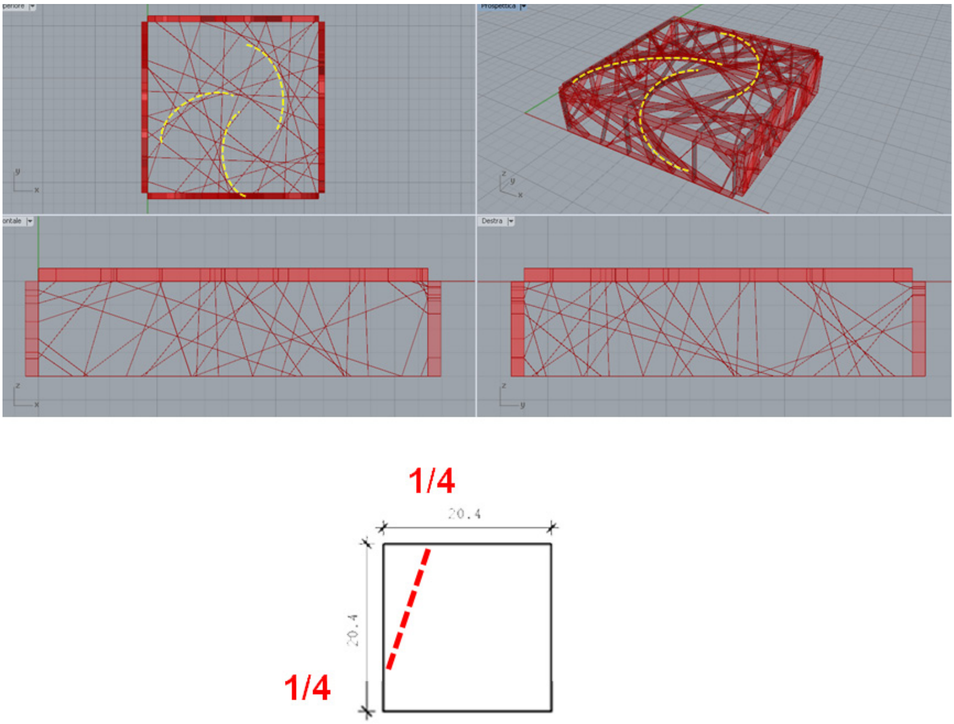

Fig. 9

Division of edges in ¼ created something unexpected (yellow). In this case of edge division, generated three curves on the top of the roof. Serpentine Pavilion, Toyo Ito – (course of Cad Parametric 3d drawing – prof. Domenico D'Uva, student Paolo Tomelleri).

ground have a dimension of around 20 metres, and the edges which mark the height is less than 4 metres. It was experimented to work out the actual edge division on a regular cube, which border was 20.4 metres, and the result for these operations are shown on Fig. 10.

Conclusions and future developments

The application of the explained method, produced basic outputs, but its potential is huge. The case studies experimented have themselves several ways of improvement. The shape driver for the first case study was the angle, but further research may imply the changing of the basic extrusion shape. Serpentine pavilion is a step forward the first case study, because it experimented the application of two shape drivers, which allows a good degree of multiplicity with basic parameter editing.

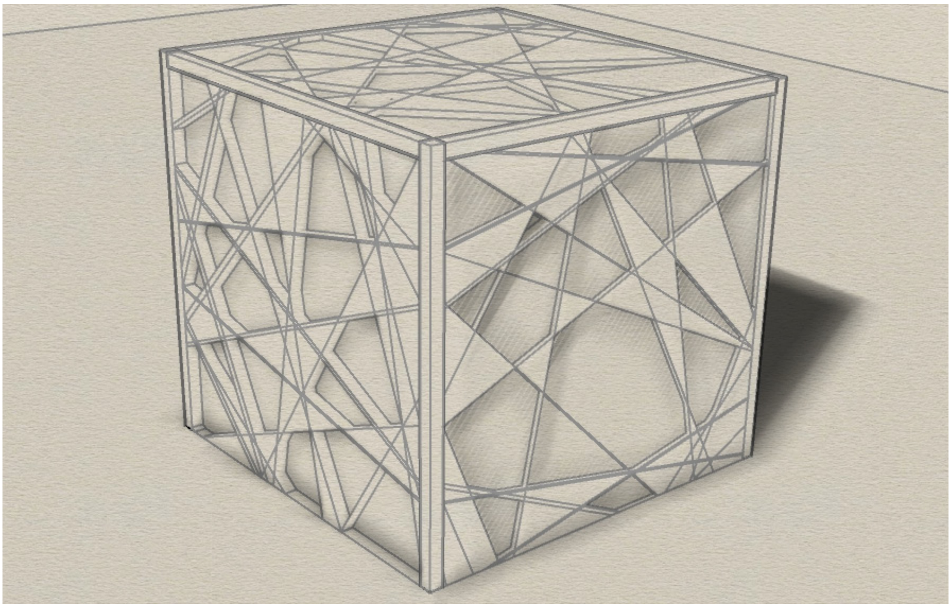

Fig. 10

Experimentation in working out the edge division on a regular cube, which border was 20.4 metres - Serpentine Pavilion, Toyo Ito – (course of Cad Parametric 3d drawing – prof. Domenico D'Uva, student Paolo Tomelleri).

A wide field of outcome for this kind of research is an experimentation done among different families of shape drivers or in different families of buildings with similar perceptive features, which can led to a greater control in the multiplicity of building.

Just like the universe which is made with 23% dark matter and of 72 % dark energy, and the 5% of ordinary matter is visible, so the perception of real-life building is limited only to the final design, but more shapes may be discovered from it once it has been fully understood.

Acknowledgement

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