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Architecture

Architectural Term: Self – Similarity

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Key words: Fractal geometry; Complexity; Self-similarity; Vocabulary

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Abstract

Architecture, as one of the oldest areas of human activity, describes several categories that seem to be effective today: firmitas, utilities, venustas. But on the other hand, almost every period re-examines and reinterprets these terms. What is happening today? Are there old provisions still? Can we create new ones or expand, modify or re-create them? This paper evaluates the term of the architectural theme to contribute to the creation of a kind of critical vocabulary of contemporary architecture in the context of understanding architectural thought. Different ways of understanding/interpreting an architectural term can lead us to a new and different way of understanding and comprehending architecture itself in a modern changing world. This paper considers the relationship between fractal geometry and architecture as they respond to complexity and order, through the architectural term “self-similarity”.

Introduction

Today, architecture is becoming an extensible phenomenon in both thought and practice, the old paradigms are being abandoned or dismantled, but we still do not see a new position in architecture. On the one hand, architecture remains marked by its historical giving; on the other hand, modern practices relativizing, fragmenting, and deforming it. Architecture is increasingly recording the extremes of extreme scenarios and less and less a self-conscious stream. However, in the ambivalence of its appearances, we should also mark, to mapping the multiplicity of presence. No matter how much we ask about the validity of the reality of certainty through, *firmness, beauty and usefulness*, we need new words to cover its properties, activities, complexity, contradiction, intensity. What are the new words that refer to the current position of architecture? We understand the keywords of architecture as a critical vocabulary of architecture in the contemporary world. They can denote a particular phenomenon, anticipate it, otherwise explain it, and they can refer to the central flow but also the speculative margins of the architectural presence. Besides, we will follow a word, a notion and evaluate it through its etymology and its meaning as an architectural theme nowadays.

Self – Similarity

A term is a coinage made up of two words Self + Similarity. The etymological meaning of the word "self" comes from Old English; related to the old German Selb. The function of the word as a noun: a person's essential being that distinguishes them from others, especially considered as the object of introspection or reflexive action; as a pronoun: myself, himself, herself; as an adjective: identical, same; as a

combining form: oneself or itself. The etymological meaning of the word "similarity" comes from similar + -ity, or from French "similarité" that means "state to be similar". The function of the word as a noun: the quality or state of having many qualities in common; a point which two or more things share in common; not differing in shape but only in size or position.

The function of coinage Self-Similarity as a noun: the quality or state of having an appearance that is invariant upon being scaled larger or smaller. In architectural language, the coinage Self-similarity can be interpreted as a geometric similarity or physical correspondence between the parts in the building and the building as a whole.

Self-similarity is one of the main features of fractal geometry. It is a new geometric system that describes the complex shapes in nature that cannot be explained by classical Euclidean geometry. These shapes are too irregular, or too broken or fragmented, to be examined at any scale: *"Clouds are not spheres, mountains are not cones, coastlines are not circles, and bark is not smooth, nor does lightning travel in a straight line. . . . Nature exhibits not simply a higher degree but an altogether different level of complexity. The number of distinct scales of the length of natural patterns is for all practical purposes, infinite."* Benoit Mandelbrot [1].

Complex forms that have the properties of self-similarity are called fractals. The name "*fractal*" was first used by mathematician Benoit Mandelbrot in 1975 and had its roots in the Latin word "*fractus*", which means broken. Fractal objects have two fundamental characteristics: an unfinished detail at each point and a degree of self-similarity between the parts and global features (the whole). "*We can know to assert the existence of the conception of a fractal geometry of nature. Essentially, these are based on the concept of self-similarity, a property is shown by those evolutionary systems in which the structures remain constant while the scale of observation varies; in the other words, when the parts, no matter how small they might be, resemble the whole.*" [2].

Fractals do not have dimensions that can be measured in integers. Their size is a fraction expressed by the degree of irregularity "D" that remains constant in different ratios, represented by the formula: D = log N / log r, where "N" is the number of generator segments and "r" is the scaling factor from the initiator to the generator. The same can be illustrated by iterating (repeating) the Koch curve where each part of the curve is a copy of one iteration (Figure 1).

Figure 1: Koch Curve

In addition to iteration (repetition), the methods of transformation, scaling, rotation, reflection and duplication are used to generate complex shapes, which will be followed through examples in architecture.

Architectural Meaning of the Term Self-Similarity

In an attempt to distinguish Euclidean from Fractal geometry, considering architectural styles, Mandelbrot will point out the following: "In an architectural context, the Ludwig Mies Van Der Rohe building, Farnsworth House, is an example that takes us back to Euclid, while the fractal aspect of architecture can be seen in the buildings of the Beaux-Arts." [1]. That confirms that the features of fractal geometry have been used continuously throughout architectural history, which can be read through the examples of ancient temples, various medieval castles, Gothic cathedrals, baroque churches, Hindu temples, until the Modernism in Frank Lloyd's works (Figure 2). All of this suggests that conscious fractal architecture could not have occurred before Mandelbrot formulated fractal geometry in the late 1970s.

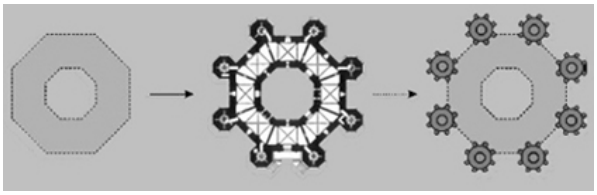

Figure 2: Castel del Monte (1240-1250)

Case Study

Architectural example 1: Sarphatistraat office - Amsterdam (1999), Steven Holl

The new socialist housing developer accessory, located in Amsterdam's Sigmel Grecht, has been completely renovated and expanded, where through the design process the architect has used the "Sierpinsky sponge" principle of openings continuously cut in planes approaching zero volume. The planned design program which develops both in the plan and cross-section is placed between the perforated walls in the shape of a sponge (Figure 3). The "Sierpinsky sponge" can be explained as a three-dimensional analogy of the "Sierpinsky carpet" (two-dimensional). The basic shape of the square is divided into nine squares where only the middle one is removed, followed by the removal of the central squares from the other eight squares.

Figure 3: Detail of Facade, Sarphatistraat office – Amsterdam (1999), Steven Holl

The iterative process accounts for the rich forms that we associate with fractals. The procedure is repeated through the process of iteration to obtain a solid-looking body and infinitely large surface area, whose volume is equal to zero, principles that are in line with the self-similar fractal geometry (Figure 4).

The scale appears as an opportunity for relations, emphasizing its scalar ambiguity explained by J. Morales as A - Scalerity: a mechanism and action in architecture that does not distinguish boundaries, which is solvable. The whole space of this architecture is intermediate, a space between [3].

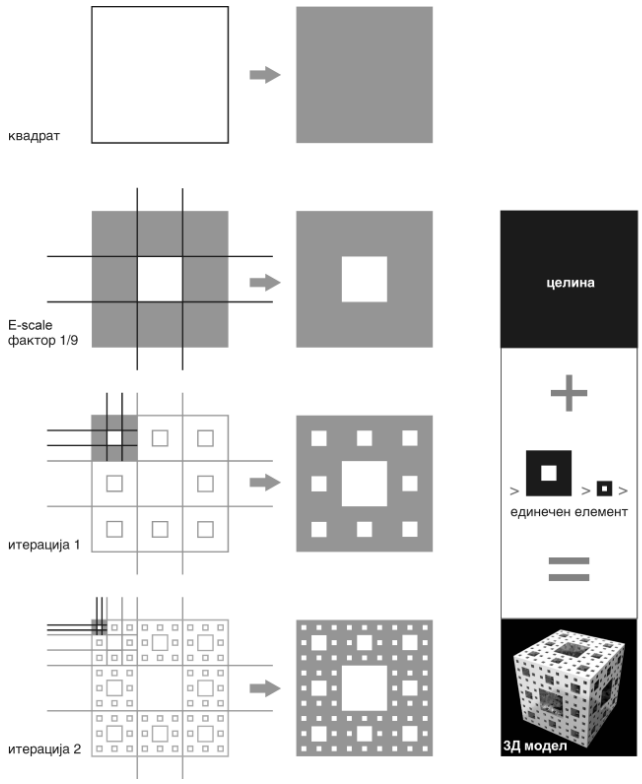

Figure 4: The first three steps of the construction of Sierpinsky carpet

Architectural example 2: House XI-a (1978), Peter Eisenman

Less than a year after the publication of the English version of "Fractals: Form, Probability and Dimension" by the famous mathematician Mandelbrot, architect Peter Eisenman exhibited his project for the first time for House XI (Figure 5). In it, the architect applied the concept of fractal geometry in a specific way - a process that he described as a search for three destabilising concepts: discontinuity, which is confronting with today's metaphysics; recurrence, which is facing the original; and self-similarity, which confronts the representation and aesthetics of the object [4].

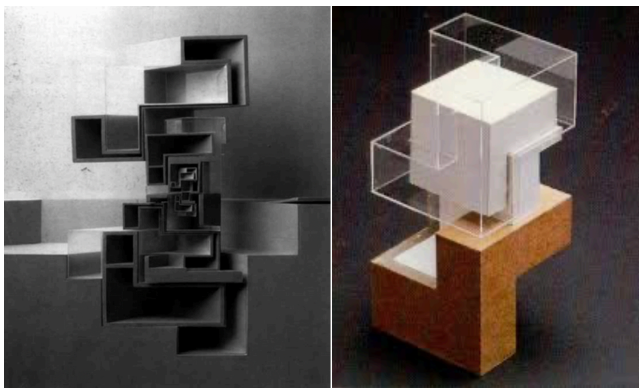

Figure 5: Structure of House XI-a (1978), Peter Eisenman

The "House XI-a" is a composition where the form is obtaining by combining the shape of the letter "L" through the principle of complex rotation and vertical symmetry. The basic concept is a square shape divided into four quarters, where one quarter is subtracted, considered by the architect as a symbol of an "unstable" or "in-between" state; neither a rectangle nor a square. The three-dimensional variant is a cubic octant subtracted from the cubic whole, representing the L-shape in three dimensions. Each "L" represents an inherently unstable geometry; a shape that oscillates between more stable, or complete, geometric figures. The eroded holes of the two original L forms collide in "House XI-a" producing a thoughtful scale-less object that can be generating in any size. The concept will try to apply to the Venice housing project. The architect places a series of such identical buildings in different sizes across the town square of Canareggio. Each of these objects is scaled, House XI-a. The presence of an object in an object is reminiscent of the original form, and their place overrides the role of the model and becomes an integral part of it, as well as a self-similar, self-referential architectural component. House XI is efficiently scaled an unlimited number of times, forming a fractal architecture.

Architectural example 3: Student Dormitory – Goce Delcev, Skopje (1969), Georgi Konstantinovski

The overall spatial formation of the student dormitory Goce Delchev is deriving from the essential constitutive element "student unit". The design procedure follows a line of geometric repetition of this element along the path of translational displacement, resulting in a student block. The same block, followed by a 90-degree rotation, is repeated three times around the courtyard. The geometric analysis shows that the "student unit" was used for generating the whole, which has the characteristics of self-similarity of the element with the whole. It confirms that the principles of fractal geometry are applying in the design process (Figure 6).

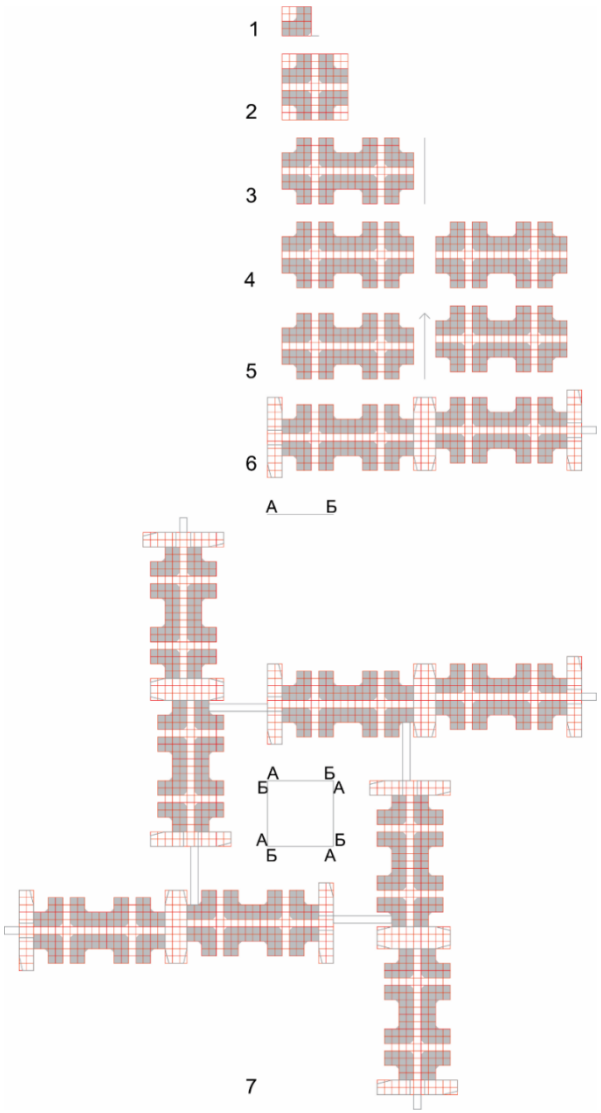

Figure 6: Geometric principles, Generic of Form, Student Dormitory – Goce Delcev, Skopje (1969), Georgi Konstantinovski; 1. The basic cluster of room unit; 2. Iteration with rotation; 3. Iteration with the translatory path; 4. Iteration with mirroring; 5. Iteration with one module displacement; 6. Student housing block 7. Iteration with rotation).

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