

The art inside an architecture". Generative design system as a tool, and local architecture, as an inspiration in the shaping of the contemporary meaning of architecture in a village landscape context.

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Premise

Generative design is a revolutionary new method of creating artwork, models, and animation from sets of rules, or algorithms. By using accessible programming languages, artists, and designers are producing extravagant structures that form the basis for everything from patterned textiles to sculptures, art installations, films, architecture [1]. Generative design and generative art are a fact today. Rooted in the idea of conceptual thinking, it releases new methodological and aesthetic views of architecture and art.

The paper describes the process of designing a single-family housing estate in the suburbs of Bialystok – a city in north-eastern Poland. The article point to the issue of forming a contemporary architecture form from the traditional architecture existing in this area. Generative methods in architecture design can support the revitalization of such areas and be a tool to restore lost heritage and the spirit of the place. Additionally, the generative design method joined with the architectural code of local architecture gives us an outstanding opportunity to discover new shapes of contemporary

architecture according to culture, history, and landscape aspects of a project place. The designed housing estate, in its final shape, is a model of transformation of the features of traditional Podlasie country house. This approach to design is a generative approach to architecture in general. The effect of the designed architecture of the private estate, next to the purely economic goal, is an attempt to build, or actually, resurrect the said identity of the place.

The series of graphic artworks inspired by the generative design process of the described architecture complements the paper. The resulting works have artistic and graphics significance, but they relate directly to a specific place and the architecture designed. The graphics present abstract artworks that draw inspiration from Podlasie's local landscape, local architecture, and culture.

1. Introduction

The generative design method is a multi-criteria and basic understanding of the design process. The architect creates a system of activities based on the set goals of the project through parameters,

restrictions, and relationships [2]. Generative design as a method defines new patterns of architectural forms that constitute the avant-garde in the art of architecture and would be difficult to develop using other techniques, especially traditional ones [3]. Besides, the generative design supports the processes of sustainable thinking about architecture. In this case, all aspects of architecture are taken into account, such as economics, construction, location, geography. The generative support makes designing sustainable, advanced, and allows achieving a more measurable effect. Thus, the resultant solution is well adapted to the design place context. In the article, the author presents the possibilities of using generative design elements in the design of suburban housing architecture at the interface of the city and the village. The method was used to examine the existing spatial, architectural and cultural context necessary to obtain the best possible, fitting in place of architecture, using the archetypal features of the place, while introducing new values into the existing space. The generative method used here allowed to organize the features of residential development in the Eastern Podlasie region of Poland, and then transform them into forms of contemporary, individual and own language architecture. The collection of these features further contributed to the development of a set of designed architecture rules, which, in combination with the relations and limitations, determined the generating of the architectural form direction in this particular location. As a result, a coherent and resulting space of a contemporary home for a middle-class inhabitant of north-eastern Poland was created, respecting and creative reinterpreting the historical context, tradition, and village landscape. This approach seems particularly valuable because in the described region exist the problem of

identifying architecture in the context of the place and its tradition. Lack of understanding architecture as a space related to both the landscape and a given tradition causes a significant impairment of this space. As a result, the landscape of many places becomes devoid of its identity. Being detached from it contributes to the degradation of the countryside landscape. This phenomenon is particularly noticeable in the latest suburban projects in the Podlasie region in Poland. This regression provokes once again defining knowledge about the space in which we live and mastering such methods of architecture design that will enrich the existing space and consolidate its sense, both historical and contemporary. Creating architecture based on defining and reconstructing "elementary codes" for a given space should be one of the design methods. In this sense, the use of generative design methods allows for a high degree of precision, which guarantees architecture that is sustainable in terms of energy, ecology, materials, and economy, but also shaping the local landscape concerning nature and tradition. In this way, the belonging of the new architecture to the place where it arises is consolidated. Let us try to trace the individual design processes of a local housing estate in Niewodnica Nargilewska in the Podlasie province in north-eastern Poland.

2. Project location issues – input data

The project is located in the village of Niewodnica Nargilewska in the Podlaskie State in Poland. Economic transformations in Poland since the 1990s have changed the image of a traditional village. Thus, we are witnessing transformations where traditional agriculture in such areas is disappearing, and it is replaced by urbanization of the village, which often makes it a suburb of the city. On the one hand, the village

landscape is formerly quite random and highly distorted traditional and historic buildings, on the other hand, new housing investments of a rural character are becoming more frequent. The goal is to build a complex of several houses of high architectural and landscape value, whose quality is to result from the once existing traditions and architectural patterns. The second goal is economic. The design and construction study carried out in such a way as not to generate significant construction costs and to dedicate the offer of housing for the average middle class of a Podlasie inhabitant. The economic aspect of the investment throughout the case study correlates with the qualitative assessment of architecture. The facility is to be implemented according to the "know-how" principle - designed and subsequently implemented by one entity. The plot of the project is in an area of 4000 m². This short introduction is the starting material, which was then subjected to design work. Summarizing:

1. The surface of the plot with a rectangular layout adjacent to the street with a shorter line and the opposite line opening onto the river landscape imposes the best direction of the location of houses optimally
2. In this place, we can design a maximum of four houses - which results from the decisions of the communes legal
3. The existing landscape of the village becomes a reference in building the structural relationship between the form of modern architecture, the economics of construction implementation, and the typology of a historic village house in this region.

3. Generative design in shaping the architectural form of a single-family suburban building

In the architectural design approach, it is necessary to correlate the function of the building with its architectural form and to connect the internal function with the external function of the house in the form of a garden, driveways, and economic zones. In the further part, the construction of the building and its detail determines further relations. "Form follow function," as Mies Van de Rohe used to say, creates relationships and structures between the function, form of the object, and its impact on the external space.

Hence, taking a design strategy, consisting of recognizing the essential features of the place and transferring them to a design solution that will allow maintaining the integrity of architecture with the environment, as it was inscribed in the landscape. Design work based on the BIM model was used for this purpose.

4. Generative design

Generative design is not a new phenomenon. To a large extent, it is associated with the implementation of the latest IT technology achievements in design tools used in architecture. In many cases, this method supports and accelerates the design process of complex geometry characteristic of algorithmic aesthetics introduced into architecture. Recognized international design studios such as Morphosis, Un studio, Zaha Hadid architects, and Foster architects exceed the boundaries of architectural forms of expression and composition potentials unknown until now. Without the use of algorithmic programs such as Rhino, achieving such a style

would be difficult. Today, producers of software supporting architecture design are increasingly combining BIM technologies with GDS technologies [4]. Generative design is not only a tool that promotes a particular noticeable style of architecture today. Generative design is also a way of thinking that helps objectively organize individual design processes, connect individual project goals into a system of dependencies and relationships that, in consequence, give reliable architecture solutions. The definition of generative architecture is therefore not a homogeneous definition. Its primary assumption evolves along with the application and development of computer techniques in design because it is from this environment that the concept itself originates. However, the term goes beyond the scope of computer-aided design. It can be seen as an organizing process and argumentation in shaping the principles of the project as well as the meanings of its spatial layer.

The basic definitions of generative art and generative design say:

1. Generative art is an artistic practice in which the artist creates a system described, for example, using a natural language, computer program, or machine design, which has complete or partial autonomy affecting the final shape of the work [5].
2. Other definitions speak of generative design as systems for synthesizing design processes in the form of mechanisms capable of producing alternative solutions. The method of doing so is to define procedures (algorithms) as parameters and relationships and to test systems in the form of analysis [6].

Generative design is the use of algorithmic processes or rules and principles to receive design solutions.

Using generative tools in designing requires an architect's approach to the creative process from a different angle. The theory and practice of architecture have so far focused primarily on a form, not on the process of emerging form. Currently, architects wanting to study the impact of various factors on a form, reach for digital generative systems and tools. They borrow them from other disciplines and use them to design buildings and building materials. The most popular are Voronoi diagrams, L-Systems, cellular automata, fractals, shape grammars, and genetic algorithms [7].

Instead, for the vast majority of "generative architecture" projects, we should be talking about "using generative design methods." This formulation is more accurate because it leaves room for non-generative methods, i.e., traditional 3d or 2d modeling, that interferes with forms generated by a computer program. So if we want to learn what generative architecture is, we must first answer the question: what are generative design methods? Their use causes a fundamental change in the architect's relationship to the virtual computer form. In generative methods, the architect no longer models the form directly, building subsequent planes in virtual space. Instead, the form is generated by a computer, and the architect controls it with code or a script. The work of a designer is starting to resemble the work of a programmer in "Scripting language." Unlike classic programming languages (so-called algorithmic and object-oriented), the scripting language is usually built into the ready application. That is why it is invaluable for architects.

After this introduction, we can now return to defining the terms "generative architecture" and "generative design methods." Let us take a look at the design of the civil court building in Madrid by Zaha Hadid (Fig. 1). Rhythmical enlargement and reduction of openings on

the facade suggest using some generative

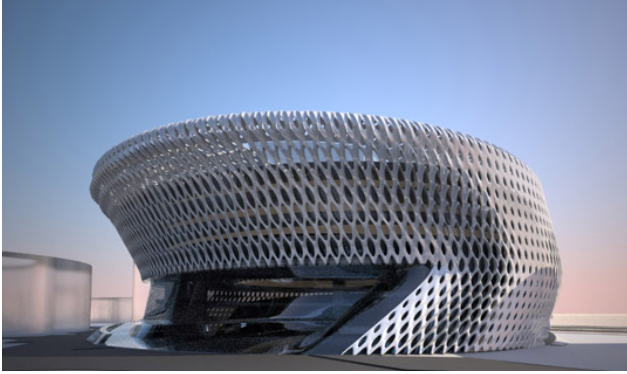


Fig.1 Civil Court Building in Madrid.
Architect: Zaha Hadid

Patrik Schumacher, Zaha Hadid's right hand in the studio, however, reveals the details of their design process in the book "Digital Hadid. [8] " Well, the pre-generated form is usually arbitrarily modified until it becomes satisfactory for the person working on it. Hence, for most of the work that had emerged from Hadid's studio in the last few years, the form "generative design methods" should have been used. The architect here interferes directly in the forms generated by the program. An example of a real "generative architecture" would be the project submitted by United Visual Artists for Darwin's Canopy competition at the Natural History Museum in London. It is a competition for installation on the occasion of Karol Darwin's 200th birthday, hence the architects from UVA decided to simulate the natural selection process by computer. With the use of "Genetic algorithms," architects have created generations of "virtual plants" competing with each other for survival, and therefore for access to the sun - also virtual, of course. The final form of the installation is, therefore, the effect of the simulation of the evolution process. This form is entirely derived from code written by architects and was not later subject to any "manual" modification. Hence the UVA project is entirely generative architecture. To finally receive a given design solution, the issue of generative design should be supplemented with an analysis system

method.

that would assess the accuracy of given solutions. The generative design seems to be excellent support for architects today. The following example may not use full algorithmic systems in the process of evolution of the form, but an attempt to create a system of principles, relationships and limitations and subjecting the resulting forms to an evaluation using the analysis system determines the architectural form, which is the result of a strict process, allowing the creator to learn new, unknown areas of searching for content and form in architecture.

5. The project of single-family houses district in Niewodnica Nargilewska

The design process has been closely linked to the determinants of the building's form and function. In this way, several variants of housing facilities were developed to choose the most suitable for implementation ultimately. The arrangement of the functions of the facilities was developed following typical interior design solutions in this category of single-family residential buildings implemented for the middle class in Poland in Podlasie. The diagram below shows the individual activities of the project (fig.2).

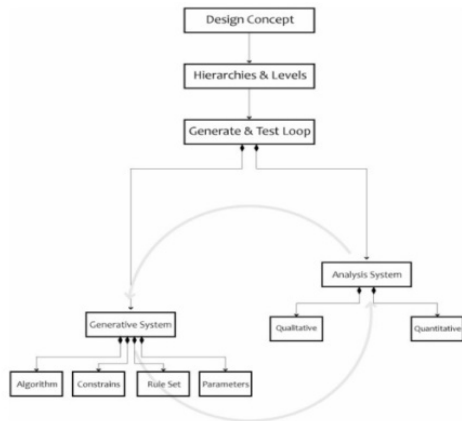


Fig.2. diagram activities of the project
The concept in the form of sketches is the fastest record of the designer's thoughts and the first attempt to link the essential components of a project venture into a mutual dependence network. These dependencies were to correspond to the following parameters:

1. The layout of buildings located in such a way as to create a maximally intimate space solution with relatively high building intensity and a limited budget for construction
2. The rationalized layout of the building's functions associated with the individual zones of the plot, such as the garden, driveway, utility part.
3. Form of architecture resulting from the tradition of local architecture, and then processed in the direction of optimization and demonstration of archetypal features using the resulting language of architecture and detail. The designed architecture was to imitate or at least draw the essence of the historical traditions of single-family housing in this area, but in itself be a carrier of new values.

The layout of the building function had a direct impact on the body, while the building body was to be implemented in such a way as to ensure the economics of construction and to support the solution of the plan. Thus, already at the concept

sketching stage, a system of rules was created that were to be applied to the project and decide on its solution. The rule set is described in the diagram below (fig.3).

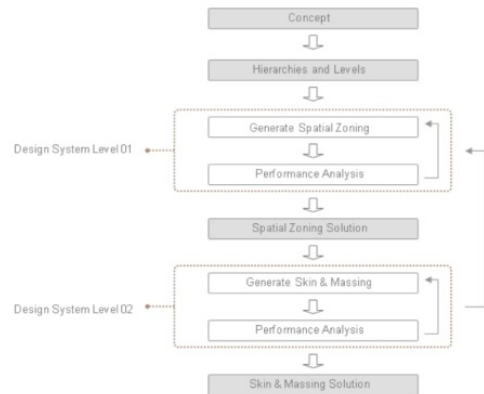


Fig.3. Rulesets diagram of the project.

In this way, the most suitable solutions for building plans were generated, and the architectural form itself was developed. Further rules were introduced that were to have a decisive impact on the final solution of the architecture form. These rules are:

1. The roof layout of the building as a gable roof - it is the most characteristic of the existing architecture of this region and the tradition of constructing the truss of the Podlasie region. The roof span cannot exceed 7- 8m.
2. Roof carpentry systems dominating in this region are bar-tack systems. The roof span in a traditional building did not exceed 7-8 meters. Moreover, such a module was to be preserved for the roof span.
3. Roofed part of the terrace - protection against sun rays, rain, and snow.
4. The windows in the living room should be extensive glazing that opens onto the garden zone and impressive views.

5. Preparation of window openings so that they do not overlook the neighbors' plots or interfere with the neighboring plots to a small extent.
6. Using architectural detail and material properties of facade finishes as a carrier of architectural language.
7. The varied nature of the buildings adequate to the size of the plot.
8. Two-story building - day zone on the ground floor and night zone on the first floor.

The economics of construction was to be an essential factor in the form generation process. Implementation costs were an essential component in the assessment and acceptance of the final solution. The division of the investment area into smaller plots, as well as clean and geotechnical conditions, allowed the location of two semi-detacheds and two detached houses. Moreover, here again, it was decided that due to the more impoverished location and smaller plot areas, the twin buildings as design and implementation must be developed as easy and cheap to implement, without losing any of the individuality and quality of creative architecture. The last two plots, due to their better location and area, were laid out with different forms of expression potential. In this way created two forms of the building:

1. twin buildings,
2. free-standing buildings.

Designed according to generative rules, they retained similarities and differences.

6. House one. Twin buildings – the evolution of form

The developed building scheme presents the following features of a building form:

1. Roof to wall body proportions 2:1
2. Roof span in purlin-tick construction 7m
3. hoods and porches
4. Wooden elements as a detail

The photo below shows the shape of the house, which, in this case, is an archetype necessary to build a new expression of the form (fig.4).



Fig. 4 Traditional house in Podlasie in Poland - the archetype of architectural form in search of expression of new forms of residential architecture in a given place

The simplified model is a record of the structure of the house reduced to its most crucial recognition features. At this level, the process of evolution of the solid took place to generate its form rooted in archetype, but which is already a modern form. It was mentioned that for the design of semi-detached houses, the priority was the extent of the craft and the economic factor. How to design and then realize a building that was uncomplicated in implementation and optimally cheap while maintaining the nature of the archetype - a Podlasie country cottage, a functional program of the house, and having architecture-valuing features? The architectural structure of the design was to

mean that the roof not exceeding 7m span was to remain about the wall. The walls were to keep the 2:1 aspect ratio. The glazing on the ground floor was to open onto the garden; the terrace should be roofed. The first generated family of forms met the established rules of the project. The next transformation process excluded all elements that generated additional costs from the project. The building has been simplified to the minimum necessary while maintaining the same user comfort. Economic and performance expectations were completely met, while the archetypal model was lost. The building's proportions, mainly in maintaining the size of the body walls to the roof, have been violated (Fig .5).

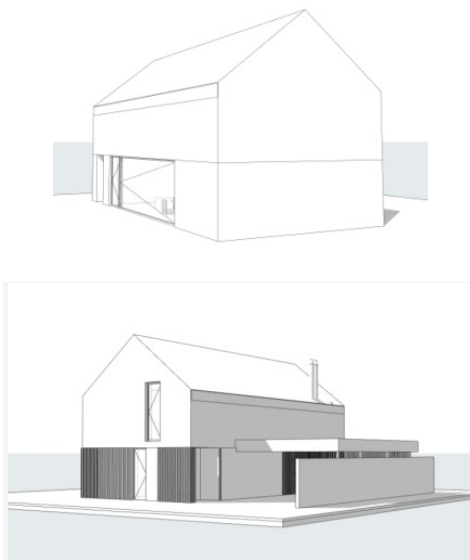


Fig. 5 Proposal of the generated form of a new typology of design architecture according to the traditional house pattern and its transformation to find harmony and proportion of final contemporary architecture

Another process of the body's evolution was the use of such detail and such finishing materials that would restore the relationship of the designed body with the established archetypal model (i.e., the typology of a traditional country cottage). The floors and roof structure were made of one homogeneous material, and the

bodies of the ground floor walls from another in this way with little effort, the basic rule guiding the project was restored - this is a reference to the archetype. In space, the noticeable material division of the story of the building expressed these archetypal features and the perception of proportions. Another activity aimed at maintaining the diversity of any similar architecture was changing the material color parameter. Thus, the upper part of one of the buildings made of black sheet metal, and the upper part of the next building is made of white with a membrane - emitting the nature of another natural material which is concrete (fig.6).

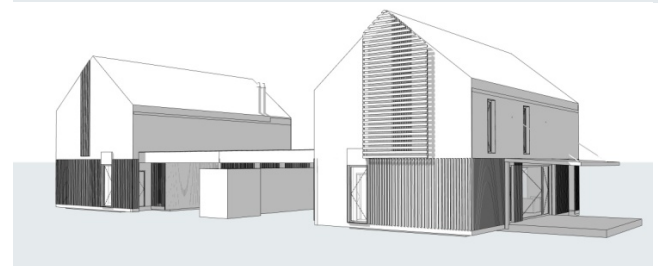
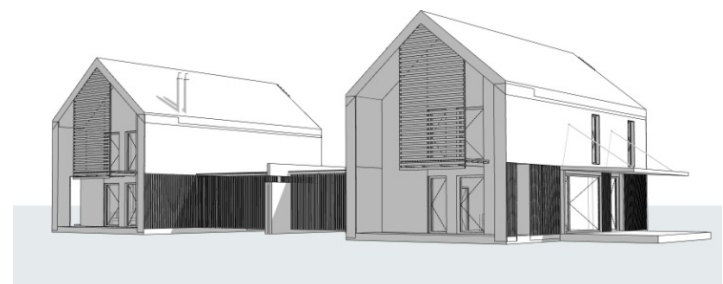
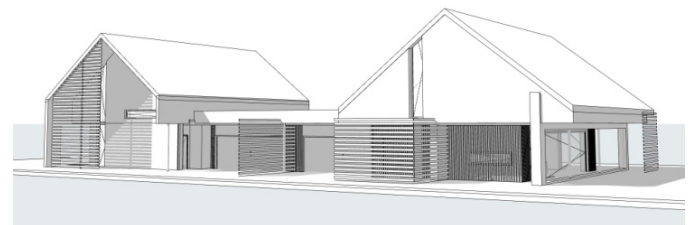




Fig.6 House 1 – the evolution of form

Additional activity in the design of this architecture consisted of hiding all building installation elements, mainly drains draining rainwater. As a result, a two-story building finished with a sloping roof in space looks as if it consisted of two independent modules.

The developed objects present the language of architecture, whose spatial and architectural solution is the result of the transformation of the house form that has always existed in this area. The generative method and structural thinking greatly assisted the design process. The system of analysis in the assessment of the imposed relationships between individual elements of architecture has allowed obtaining a cheap and easy to implement a solution that is also distinctive architecture - complementing the tectonics of the village and indicating the almost genetic relationship of modernity with tradition. Working on the BIM model and using generative design elements gave satisfactory, balanced, and measurable effects. At each stage of conceptual design, the project was subject to evaluation and activities that allowed for obtaining a completely satisfactory new form of native architecture.

7. House two. Detached single-family housing

According to the same principles has been designed detached single-family

houses. The location on the plot was the result of an optimal location to the directions of the world, urban layout, ground conditions in the designed area. In a spatial sense, it became essential to connect buildings with the river adjacent to the plot, i.e., directly linking the recreational zones of the house with water as the greatest asset of this location. Another goal in shaping the form was the transformation of the "archetype" existing traditional house to maintain the ratio between the roof and the body of the walls in proportion 2:1. This system of proportions was to be immutable and not subject to transformation. Another factor of transformation was the use of light as an element shaping the space of the solid. The arcades were designed to protect against excessive light and precipitation. On the other hand, they highlighted the relationship between the play of light and the solid structure. The factor determining the functional and spatial layout was a sense of security. From the side of the river, the buildings were supposed to open maximally towards the river. From the driveway side - the principle of protecting residents from external stimuli was to be kept to the maximum. Therefore, in this part of the building, airtight partitions were used, and the potential windows openings were maximally reduced.

A structural layout of the building form was created based on the following relations and dependencies:

1. Linking the localized functional areas of the house with the water surface through maximum glazing and thus extending the recreation area of the house towards the water
2. Development of the driveway side of the building as a safe zone - reduction of possible openings to the necessary minimum, shaping of the walls of buildings ensuring a maximum sense of security and intimacy of the residents of houses
3. The solution of the roof form while

maintaining the "archetype of the house" proportion system at this point in a 2: 1 ratio

4. Light handling in shaping the building body

5. The use of detail referring to the characteristic wooden pedigree of architecture of this part of Poland, especially in the gable parts of the building

The design principles program constructed in this way was subjected to generation processes, from which two coherent and individualized forms of architecture were developed (Fig.7).

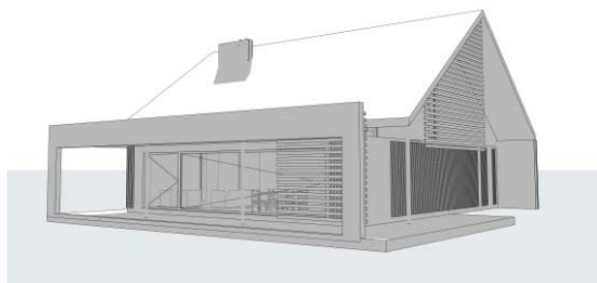
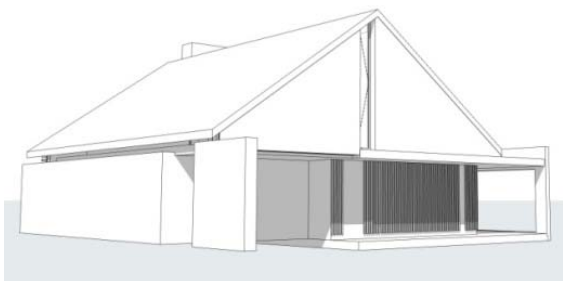
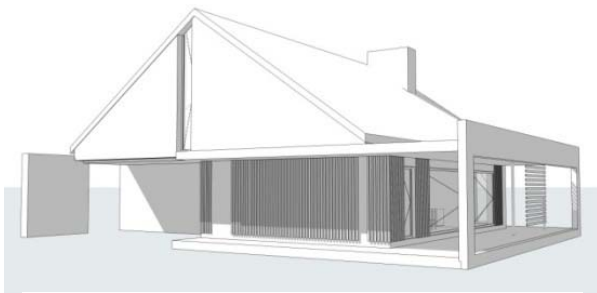


Fig.7 House 2 – the evolution of form

8. Conclusion

The designed housing estate in the context of the landscape of the village of Niewodnica Nargilewska in Poland is an example of architectural creativity resulting from conceptual processes thinking that follows the idea directly. In this case, the idea was to transform the "archetype" of a traditional home in this region of Poland. Designing architecture in the spirit of the "pure form" of conceptual art is the creative material of this architecture. This design method

eliminates our tastes in architectural design that could cover the real sense of architecture. The sincerity of the form of architecture generated in this way results from a consistent, structural path of design following only the idea. The generative method is conducive to conceptual design and makes architecture designed in this way art. The architecture designed in this way results from the transformation of the original form of architecture in the process of generative design.

Designing architecture always requires giving it an idea and then doing everything so that the spatial solution is a record of evolution and, ultimately, the development of that idea.

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