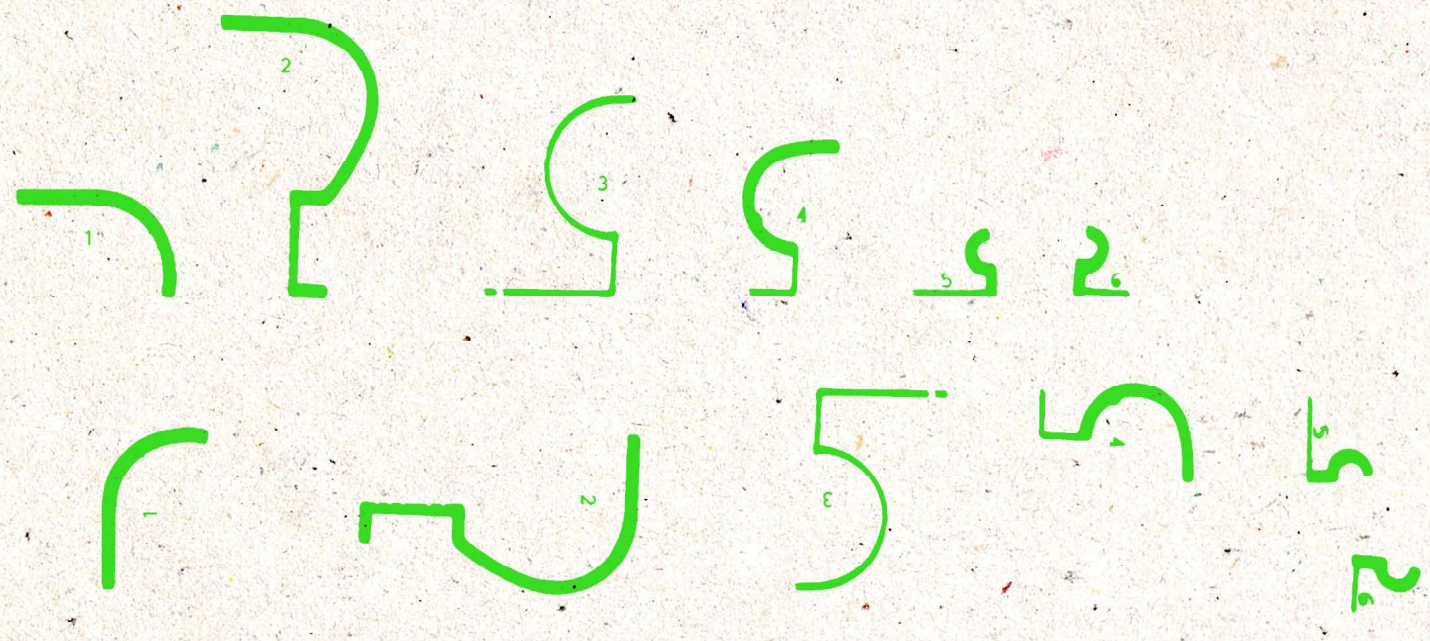
ALEKSANDRA PROKOPSKA



METHODOLOGY OF ARCHITECTURAL DESIGN

PRELIMINARY PHASES OF THE ARCHITECTURAL PROCESS

OFICYNA WYDAWNICZA
POLITECHNIKI RZESZOWSKIEJ

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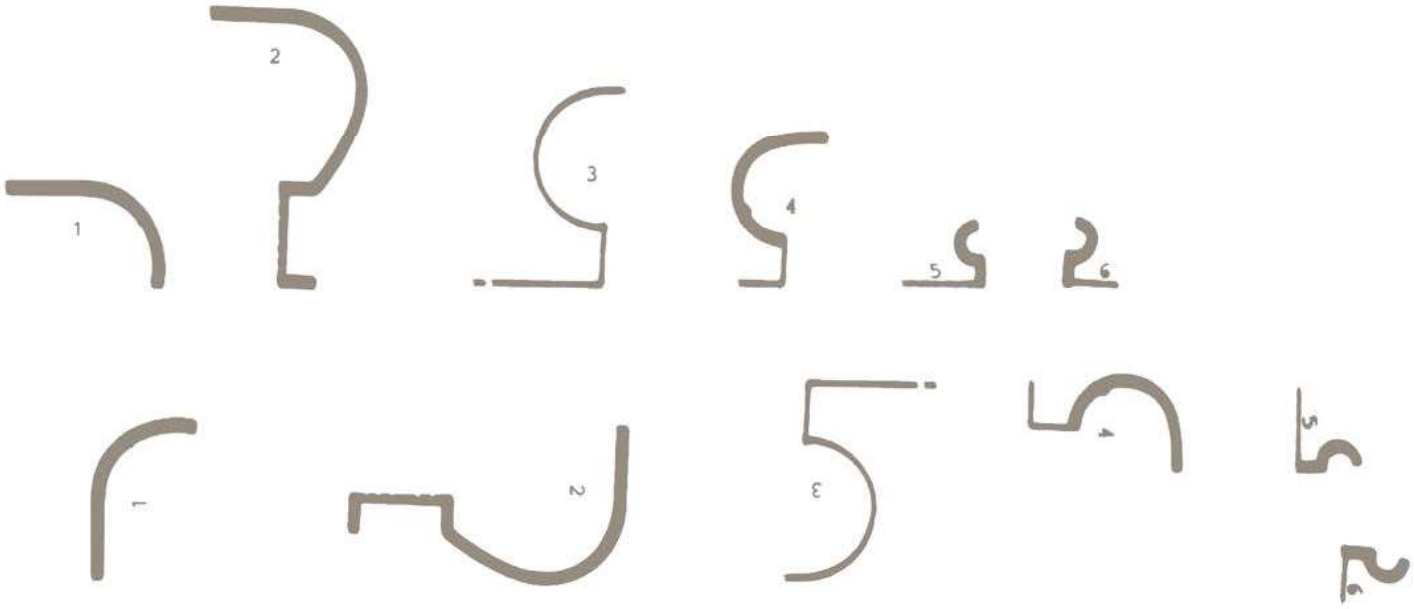

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PREFACE

The presented inquires, analyses and considerations, as being investigation activities, concern fundamental research in the domain of architecture. As accepting the position of a researcher of the phenomenon of human designing, the Authoress of this work analyzes the knowledge and science concerning design, including the architectural design, as being science concerning the design of the space of the life of the human being. She performs scientific, methodical and architectural analyses of processes and forms in the activity of certain, chosen architects.

Albert Einstein [25, 26] stated that the mind of the man has great, being yet not detected and in great measure not fully applied intellectual capacities. It appeared a difficult, nearly impossible task to be accomplished during decades of years for generalizing design-based decision-making activities of designers as well as of design teams in many domains of knowledge [97]. The modern development of knowledge, including architectural knowledge and art, technology, design methodology, architectural design theory, ecology and praxeology, systems theory and informatics creates such a chance [1-10, 13, 15-21, 30, 38, 40-42, 116].

The architectural knowledge is discussed in the monograph as being partially of know-how type knowledge (I know how, but I cannot say/explain that) and partially of know-that type (I know that). The know-how knowledge is presented as knowledge being connected with architectural handicraft and with acquiring experience in designing as well as with relation of designing with substantial problems of architecture realizations, i.e. with designing practice. These problems are completed with an analytical-reflexive and methodological look on the being difficult to be univocally formulated processes and procedures of creative architectural designing, especially in cognitive, spatial, culture-oriented, and time-based aspects.

The presented contribution discusses problems of theory and practice of architectural design, with particularly taking into consideration the preliminary phase of the architectural process. It presents ways and methods that often intuitively do accompany the architectural design process. The aim of the undertaken methodological considerations of the preliminary

architectural phase is the analysis of differentiated and conditioned in a many-sided way design decisions as well as of the creative design activity of the architect [90, 91]. Methodical analyses being cited or/and carried out on examples of outstanding creators of modern architecture serve that purpose.

Trials of an analysis of the design and creative activity[1] of the architect [90, 97] concern mainly the preliminary phase of the process. Such trials were undertaken according to the existing architectural, technical, ecological, methodological and systems-oriented knowledge.

Albert Einstein [25, 26] stated that, if we want to conserve sincerely and honestly the talents of all human beings and their unhampered development, we cannot abandon the methods that lead to that aim. What concerns the scientific language and the scientific method, he wrote also that the result of use of the scientific method as being a research instrument in the hands of the man depends entirely from the character of goals set by the mankind. If such goals exist, the scientific method creates ways of their obtaining, but the goals alone cannot be created by a method [25].The purpose of the presented scientific analyses and considerations is a full and innovative utilization in science, teaching and in design practice of the today's architect of methods or their elements as well as of the existing interdisciplinary knowledge.

An equally important aim of the work is to create, for didactic workers [12], possibilities of more efficient teaching of the design workshop of the architect. This monograph has been elaborated with the hope that it will allow students of architecture for understanding the nature of the profession of the architect, the many problem threads that characterize architecture, for easier acquiring the fundaments of the architect's workshop.

The methodological problem approach is treated as to be important from the point of view of further consequences concerning the design and realization of the being undertaken architectural activity. In the architectural preliminary phase often are made basic design decisions what concern, for instance, their correctness as well as the area of the proposed solutions.

The knowledge concerning the design workshop of the architect in the being proposed methodological, esthetic, ecological, praxeological and interdisciplinary aspects can appear to be helpful in designing and constructing future beautiful and expected creative architectural solutions, being in conformity with social wants.

In the contribution, architectural problems are discussed as being related to ecology, with the beauty of the nature, the nature of architecture and of its form. Problems are analyzed connected with the architectural usefulness in the broadest sense of the word of the being designed architecture. The discussed problems include also questions related to technical

[1] The notion of „design-creative activity" as innovative activity in the methodology of designing is used, in his scientific works, by the ethicist and methodologist Prof. Wojciech Gasparski, the Director of The Institute of Ethics of Business in Warsaw.

construction, with modern building materials and with technology types, e.g. ecological technologies.

Irrespective of the questions above, here methodic activities are discussed that were really carried out by outstanding architects, who had and have an undeniable influence on the development of and progress in architecture of the present time.

According of the opinions of Einstein [25] and many intellectuals our thinking is proceeding without the need of using words, and besides, in a great measure is of an unconscious character. That statement concerns also the complicated problems of designing and making decisions in architecture, now and in the past. And that statement concerns the creative design activities of the architect [90, 91]. The methodical analyses presented on examples of selected works of outstanding creators of modern architecture serve really the here being accepted and described goals.

The discussed research [62-107] of architectural creative processes are undertaken under the influence of the cited above and not cited intellectuals: Prof. eng. architect and ecologist Z Bać [2-10], the computer scientist and methodologist Prof. eng. M. Bazewicz [14-17, 20], the methodologist and mechanical engineer Prof. F. Przystupa [16, 108-110, 117], the praxeologist and methodologist Prof. eng. Gasparski [21, 30-32], and the ecologist Prof. eng. architect H Skibniewska.

Wojciech Gasparski wrote that when searching for generalizations one neglects the unity, and technocrats, bureaucrats, organizers try to not to deal with the unity, unless comprised in categories of types, mean cumulative quantities.

The undertaken by the Authoress methodological and systems-based investigations and analyses are documents of and confirm the use of methods or elements of methods as design ways in architectural processes, according to examples of the architectural creative activity, among others of Le Corbusier, J. Utzon, Santiago Calatrava. Methodological analyses are presented of the architectural mass structure of the Opera House of Sydney, realized by Utzon himself as well as of the Villa Savoye of Le Corbusier. These particular methodological investigations are compatible with the existing architectural, methodological, informatic, systems-based and geometrical knowledge.

New innovative possibilities comprising the use, in science, education and design practice of the architect of present time, of methods and their elements of the existing interdisciplinary knowledge are assured by the modern pro-ecological tendencies in the development of and progress in architecture. This development and progress aim at shaping energy-saving, ecological and intelligent architectural objects or/and human seats, e.g. of the habitat type, that improve the quality of the architectural milieu and of comfort of living [7, 8, 12, 63, 75, 77, 78]. The presented considerations are connected also with the concept of the house as machine for living of Le Corbusier and with the idea of the intelligent house. As the result of the undertaken and presented research a unique program of computer assisting of the creative architectural design process has been elaborated.

The submitted work has been constructed in the way as to appeal to the Reader and to persuade Him/Her of the presented rationality of methodological considerations as well as of the described architectural design activity and architectural art, independently of the order of precedence of reading the particular chapters.

The main purpose of the work is to methodically and technically perfect and improve the real creative processes of designing and teaching architecture, thus, as a consequence, to construct a more beautiful, healthy, and perfect architectural environment, also habitats, according to a compensated, well-balanced development approach.

CHAPTER I

The role of the architect who deals with designing and harmoniously shaping the architectural environment

The Architect as engineer and as esthete dealing with shaping the space of the constantly increasing built environment. The present-day development of architecture allows us to hope that the architecture of the 21st century, designed as innovative pro-ecological architecture and based upon modern achievements of knowledge, art, science and technique can be realized in interdisciplinary teams in harmony with the natural environment and with the nature of the human being.

The architectural environment, being a built environment, enters in a ruthless manner into the natural environment. Therefore, a harmonious coexistence of the natural environment and an artificial environment being a designed and built environment needs the realization of complex and difficult tasks.

At present, planning and realizing a sustainable development is generally accepted and implemented in the planning and designing activity of many countries. Such activity anticipates the consequences of reaction of investment objects upon the environment and on the planet; and that is one of the objectives of the present-day architecture.

Realization processes in architecture and building engineering are preceded by complex, design processes performed by individual design engineers or/and design teams. The architectural process, being a complex design process, conditioned in a many-sided way, concerns art, technology and many other domains of knowledge, thus it is an intellectual process.

The process of architectural design is composed of several phases: the preliminary phase, the phase of the architectural design project, the phase of the architectural building project and the phase of realization design project as the goal of design activity.

In order to fulfill this complex goal we use, within a limited or broader scope, achievements of knowledge and science of other domains, namely knowledge of art, technical knowledge, logistic knowledge, systems-based knowledge, often also intuitively applied knowledge concerning methodology of design [24, 53,54,62-67], or being a part thereof. As an effect, the modern language of architectural design refers to many domains of knowledge and technique.

In this work a description is presented of analyzed from the methodical point of view preliminary phases of exemplary design processes in architecture, with particularly taken into consideration artistic creations of outstanding designers-architects who influenced greatly the development of modern architecture. In science it is accepted that, according to principles of the contemporary knowledge of design methodology, that the kind of process being used in designing deeply influences the obtained results and achievements. This concerns especially the preliminary process of architectural design. Esthetical qualities of buildings concern the elegance of form being in a never ceasing context of space of place, and the creation of the whole complex of the architectural object through using every, even smallest detail. At present, the quality of architecture is perceived on the level of particular elements of equipment or technical systems. That signifies the need for an earlier performed suitable design choice in conformity with the destination, what assures an appropriate service life as well as esthetic values. That means, for the architect, the necessity of fulfillment of the assumed technical parameters, material parameters and ergonomic parameters (among others standard adaptation of the building for handicapped persons).

Legal acts are in force on international level in many domains of knowledge, and in architecture, in the domain of protection and management of architectural, natural and cultural heritage, in the domain of town, country and regional planning, in the domain of cooperation of autonomous local institutions as well as in the domain of local transfrontier cooperation [3-5]. Particularly the following acts have to be mentioned:

– Convention concerning protection of the world culture and natural heritage, Paris, 16 November 1972;

– Convention concerning access to information, public participation in decision-making processes and access to justice in matters of environment, Arhus, 25 June 1998;

– Convention concerning protection, of European wild fauna and flora and of their natural seats, Bern, 19 September 1979,

– European convention concerning protection of archeological heritage (with changes and addenda), Valetta, 16 January 1992,

– European general convention concerning transfrontier cooperation between communities or territorial organs, and their complementary protocols, Madrid 21 May 1980,

– European Chart of Local Autonomy, Strasburg, 15 November 1985,

When designing and materially realizing our being constructed architectural environment as a user-friendly environment, we are collectively searching for new solutions and for a new

level of achievements. In this scope can be helpful, beside ecological consciousness, the awareness of using by many designers-architects methods improving the activity of the architect or elements of methodical activity.

In the preliminary architectural design process, according to the existing at present knowledge, buildings can be considered ad can be fashioned with treating them as whole objects composed of systems or arrangements, among others of spatial arrangements, construction systems, functional systems, installation systems or/and, to some extent, as design ”organisms”. This approach is evident in objects of modern architecture, particularly in buildings of organic architecture.

In this contribution, a trial is presented of description and methodical analysis of creative design of the architect, i.e. the decision-making activity of the designer-architect is discussed. In the work, the decision-making activity of the architect is described as a methodical and pragmatic description of successive designing steps in the complex process of architectural design. Descriptions of such activity appeared on the base of architectural, methodological, systems-based and praxeological knowledge as well as of the practice of architectural design.

Social, cultural, technical, technological and organizational transformations that appeared in the last decades show that beauty and usefulness are essential factors in shaping the human environment. It happens that buildings being realized as objects that „stick” in the natural landscape create a new quality and become an integral part of the natural landscape. Undoubtedly, our environment involuntarily is subject to our estimation, also esthetic estimation. It is possible that we are observing contemporaneously the integration of many domains of knowledge, technique, technology, art, also architectural art, into one functional wholeness, i.e. into the sustainable architectural environment. Deciders, architects and builders face always the task how to subdue forces of the nature in such a way as not to disturb the equilibrium of the environment.In the architectural environment as environment of the human being, art is an element that, in practice, is characterized by its omnipresence and is non-transferable in social sense and feeling.

CHAPTER II

Definition and selected problems of the modern architecture

At present architecture is more and more often defined as a science and art of organizing and shaping the space of environment of human life e.g. of the urban environment and suburban environment. In scientific analyses of practical architectural problems it is worth to return to the question that can be found in considerations of the Polish great philosopher[2] Władysław Tatarkiewicz [120]:"What is the difference between science and skill?" First, stated Tatarkiewicz, a separated correct observation and single true theorem does not yet constitute a science. Further, W. Tatarkiewicz stated, that a generalized, vague consciousness that things are so and so, does not make a science too. Such consciousness should be analyzed and expressed in the form of theorems by means of notions. Finally, it is not enough to know a thing, but one has to demonstrate or prove that it is really so. In other words, if we want to declare the knowledge/information we possess to be of scientific character, such knowledge/information has to be ordered, analyzed and proved. Without these properties, it is at most merely skill and not science.

In general, science requires not only "knowing" but also "understanding". The aim of science is different from the aim of skills. The aim of science includes also truths that are interesting as themselves, and in skills the question is to have truths that are practically valuable [73, 74, 88, 94, 97, 131]. Skills play an important role in the process of architecture design, independently of knowledge.

[2] Philosophy is the knowledge tending to recognize the essence, structure, principles of existence and of thinking as well as the most general laws that govern the human being, the society and the nature; critical analysis of methods and notions of a determined discipline of knowledge; colloquially, it is the aim at recognizing general truths; world outlook. (...) gr. philosophia. 'rational knowledge, science'.- fil(o) – in compositions liking; friend, amateur; inclined (to); predilection, fancy, inclination, gr. philein to like – sophia, wisdom.

Vitruvius, the author of the oldest book on architecture and building construction [125] states that builders who do not possess theoretical knowledge, are capable only to obtain mechanical achievements and that they, by their works, do not exert any inspiring influence on other people. On the other hand, builders who do base themselves only on exact science, proceed as if they follow a shadow, and not the reality. Only those who have mastered exactly both theory and practice – possess efficient arms in order to achieve the aim they have traced out for themselves, with fullness of universal acknowledgment.

Architecture, being a complex domain of knowledge, has timeless values concerning particularly the art of creating beauty and broadly accepted usefulness. Architecture is the art and science on construction engineering and it deals with constructed things, as well as concerns the form, the material, the style of building and constructing. The principles of classical esthetics are source and base of our culture. The considerations of Leone B. Alberti[3] are a reflection of classical opinions and views that proclaim beauty to consist in order, harmony, proportions and conformity of parts. Esthetical principles in the history of development of architecture were connected with the development of the esthetical idea and with universal values that cause we accept some achievements of architecture to be remarkable.

Classical opinions concerning esthetics proclaimed that the mentioned here conformity of parts composing the whole of the architectural work consists in tending to create, in the framework of composition of the form, a certain order being determined at present as consistence or unity of architectural form. Such consistence concerns the unity of architectural form and construction. Engineering and technique of building are instruments in creating architecture and exert thereon an uncontested influence.Architecture, as skill resulting from handicraft, concerns simultaneously art, science and technique.

Architectural design is understood to be the skill and art of shaping the space of our environment; it is issued from assumptions of integration and interactivity of contradictory factors, and is functioning as a multi-criterion system. Contemporaneously, the quality of architecture is perceived on the level of particular elements of equipment or technical systems. Architecture is the image of the epoch wherein it is coming into being as it is conditioned by a concrete phase of technical, social and civilizational development.

This domain of knowledge is also conditioned by the environment where it appears, and by the natural environment as well as by its resources, by the broadly conceived building tradition and by the search by the human being for his/her identity.The development of science, technique/technology and organization of work conduces to the phenomenon of collective rising of works and achievements of architecture.

The above presented opinions are in conformity with contemporary engineering, architectural science and knowledge, with design methodology, with praxeology and ecology, for instance ecology of the town. At present, the notion of architecture as skill appears more and

[3] Leone Battista Alberti (Italy, 1404-1407 *en.wikipedia.org/wiki/Leon_Battista_Alberti).*

more frequently in analyses as well as in the context of science. Architecture accepts technical solutions, i.e. construction solutions and material solutions. At the same time, as architectural art, it transcends these solutions in a natural way, and sometimes is in advance of our possibilities of performing objectively made analyses.

The contemporary theory and practice of architectural design and constructional design allows to a more and more extent to understand the processes occurring in the architectural space, understood as a space experienced by the human being. Theory and practice of architectural design allows for selecting tools of forming and managing the architectural environment in a way that lead, by assumption, to fulfill determined individual and social needs as well as to reach the assumed design aim. According to opinions of many intellectuals, the statement of Albert Einstein [12, 13, 14] that our way of thinking mainly is carried on without the use of words, and, besides, to a great extent has an unconscious character, can be referred directly to the architectural process as a complex process being conditioned in a many-sided way.

The process of designing the architectural form is a complex intellectual, artistic and, at the same time, a technical and logical process. It is a thinking sequence being carried on especially in the preliminary phase, partially in the subconsciousness of the architect. This process occurs according to the engineering and architectural knowledge and the geometrical record as well as to technical standards, i.e. also building standards. Each architectural solution is a synthesis of many factors. In architecture, such synthesis leads to unity of form, function and construction. From the architectural and constructional point of view, conceptually shaping the building in the preliminary phase (e.g. of a building or bridge) is the art of synthesis of many factors. Fulfillment of many requirements had and has an essential influence on the obtained by the designer form and construction of the being designed building [80, 81] what is always connected with the environment wherein it comes into being.

In the first preliminary phase of the design process subjective aspects connected with art and tradition as well as objective aspects connected with technology, usefulness and construction appear. According to the opinions of the design engineer, Prof. Zalewski [127], the ability of constructing can result from the artistic creative vision , however on condition that the architect gets to know and appreciates structural analysis, functioning of forces in the building and features of material from which the building has to be executed.

The fundamental requirements what concerns each structure, also, for instance, structure of a bridge, can be determined in a simple way: the structure should fulfill its own function without any danger of destruction. However, economics requires the structure to have such strength as to function with an appropriate safety margin and to assure its strength under the most unfavorable system of load that rationally can be imagined. The ability of constructing has to base upon strong foundations of statics and structural analysis. This knowledge and the connected therewith skills can aid the designer when selecting the appropriate structure, and rationally foreseeing its probable behavior.

The presented here considerations confirm the conviction of many architects that the preliminary phase of the design process is always the most difficult moment for the architect-designer [118]. That phase required and requires skills for performing a synthesis of all the earlier or/and presently considered architectural conditions. This synthesis is generally expressed in the form of drawings.

The most outstanding architects of the 20th century had often recourse in their creative activity to creative and innovative ways and manners. During the 20th century, it is philosophy of structuralism that predominates in architecture and construction. In architecture, a conflict until now takes place between architecture of sculpture and architecture of structure. If we acknowledge the architect to be the only humanist working among technicians, we can consider architecture to be an art and a science concerning building engineering and built things. In such a context, it is possible to approach problems of sustainable development and of improvement of the architectural environment composed, at present, of objects that are more and more energy-efficient and pro-ecological [21]. However, when considering many problems of the contemporary development, the following, unchanged question is arising: What can happen without social motives and in connection therewith without possibilities of realization of maintaining the ecological equilibrium of the natural environment and of the designed, thus constructed environment that means architectural environment?

At present, many definitions of architecture exist, of definitions that are simultaneously and in parallel accepted. In the Encyclopedia Britannica, one can find the statement that the type of architecture is not determined by the architect, but by the society because of the needs [22, 23]. The society, indeed, designates the objectives that are assigned to the architect in the form of tasks in order to find means for reaching the fulfillment of the aims. This definition enhances social and interdisciplinary aspects in the creative activity of architecture. Thus, the question can be asked concerning the contemporary possibilities assured by the progress in science and their influence upon the work of the architect and effects of that work, i.e. on architecture. As an effect of the present-day, many-sided development, the architect, being the only humanist working among technicians, faces the difficult task of realizing new architectural creations in the more and more conditioned, many-sided, thus interdisciplinary design process. The contemporarily more and more often realized pro-ecological architecture [24] can and should serve maintaining the old spatial order that serve the fulfillment of differentiated and more and more precisely recognized needs of the human being, and building new spatial solutions, e.g. based upon energy-efficient technologies. As a result, such process leads to the construction of a new spatial order through the continuation of the old order.

At present, the declared to be the oldest definition of architecture is the definition of Vitruvius, a Roman architect (about 70 B.C.). This definition is interpreted as the unity of function (utilitas), construction (venustas) and architectural form (firmitas) [25, 26]. This famous triad of notions: utilitas, venustas, firmitas, that means usefulness, durability/life, beauty, constituted through many centuries the basis of all theoretical considerations in architecture.

From this definition, the conviction was derived that unity and harmony of these three fundamental factors: form, function and construction constitutes the basis of value of the architectural achievement. This triad, despite of the passed time and existence of many parallel, used and accepted definitions of architecture, did not lose significance. Vitruvius, being the author of the oldest preserved work concerning building states that builders who do not have theoretical knowledge are capable to reach only mechanical achievements and do not exert any inspiring influence on other people. In addition, those, who lean only on exact science, behave as following a shadow, and not the reality. Only those who have mastered precisely theory and practice are in possession of arms that allow them to reach the aim they had traced out with perfect, full appreciation.

From the antiquity, through Vitruvius, the question was asked: who is called for elaborating architectural theories that, by nature, concern also construction – whether only a practitioner who deduces a general theory from practice, or a theoretician, who knows how to operate correctly notions and who applies his/her general theory to practice and, maybe a theoretician of art, an esthetician?

The definition that at present is well known and accepted as well as used for teaching in many countries during many years is the definition of architecture of Z. Giedion [2]. Gideon says in that definition: *architecture remains and will remain still for a long time the domain of knowledge that is suspended between two poles of human thinking (objective and subjective pole), between different types of exact sciences (where cognition progresses rapidly forwards) and the hitherto not yet really known and not fully objectively examined world of intuition and emotion (called until now intuition and artistic emotion).*

Intuition and artistic emotion of the designer-architect suggests the application of methods or of their elements as ways of creative architectural achievement. This definition includes the information that architecture is a processing function of subjective and objective information on the human nature, of used techniques and of the space of being analyzed and shaped architectural environment. Architecture illustrates complex needs of the human being as well as the existing in the given epoch possibilities of their fulfillment.

At present, one can define architecture as the art of organizing and shaping the space of the environment of the human life [28, 29, 30]. Architecture is the science and art of creating the environment for social life. During the last decades, the contemporary architecture ripened in the sense its outstanding creator, Le Corbusier, wrote. He wrote that the main objective of architecture is not the game of pure solid masses in the light, but the creation of a social space where people will have to life [31, 32]. According to the entry in the Athens Charter [31, 32], published in 1933, architecture requires continuity. That means that a building is not a finished whole, but an element of a greater whole. This statement is compatible with the Athens Charter prepared by CIAM (Congres Internationaux de l'Architecture Moderne 1931). The Athens Charter was published by Le Corbusier and corroborated by many most outstanding contemporary architects.

One should reckon, among the permanent values of the Athens Charter, a richer comprehension of space through perception and appreciation of its changes during time, and the enhancement of the interrelation of building and town as well as landscape. Such thesis is now enhanced by the architecture of landscape, according to the Landscape Convention and analogous conventions [28-30]. It happens so in the framework of the more and more generally realized sustainable development e.g. of the town, of the region. It is connected also with the now used definition of architecture as accepting the interdisciplinary character of architectural design processes. Such definition of architecture includes into its scope many scientific and technical sciences, thus many methods and different formal languages of these disciplines.

At present, architecture is perceived as a dynamic art. Architectural environments, that mean whole quarters of towns and urban agglomerations, small towns, suburban and rural areas undergo and should undergo incessant transformations, for instance modernizations, restorations, repairs and renovations. As an example – the urban tissue is subject to incessant changes and transformations. The aim of such activity in the framework of sustainable development is the realization of the architectural message: artistic creation and construction of spatial order of the human being and of his/her welfare comprehended on the largest scale. At present, the Polish architecture and the process of changes of the character of Polish towns, connected with a permanent extension and modernization of their elements is driven by the rate of free-market processes.

Another classical definition states that architecture is an image of the epoch where it arises, that it is the art or science on building engineering and on things being built. At the end of the 18th century, particularly in the 19th century, with the apparition of new building materials as steel and ferroconcrete, a dynamic development of engineering constructions has taken place including then mainly bridges, as well as simultaneously a division of the profession of builder into architect and engineer.

The architect Jerzy Sołtan [32] is a Polish collaborator of Le Corbusier who was an architect, town planner, painter and sculptor – the creator who had the greatest influence on the elaboration and introduction of modern architecture. J. Sołtan mentioned that modernity passed to him from the world of feelings and intuition to the world of reasoning. He wrote also that art, thus architectural art is determined in a sufficient way if one says thereabout – art is intuition and, at the same time, art without knowledge is nothing. When carrying on considerations according to opinions of Le Corbusier about canons of beauty in architecture he stated that architecture is building engineering lifted to the level of art. He said also that architecture is building engineering that affects [32]. This statement defines the notion of architecture and indicates the significance of interdisciplinary problems in architectural design.

Creative processes that are necessary in the process of architectural design – e.g. in psychology are defined as thinking processes that result both in perceiving a new problem and

solving by a new method a problem that is already known and formulated [35, 36]. Such formulation concerns evidently also the creative design activity of the architect [37]. Art is considered for already many centuries to be one of the branches of creativity and human activity, and esthetics is considered to be one of the three branches of philosophy. In the 19th century philosophy was divided into logic and esthetics. With an analogous intention, science, morality and art were and are separated from each other.

The great Polish philosopher Władysław Tatarkiewicz wrote that differences and categories of notions which belong to the fundamental distinctions and categories in the world intellectual thought, and at least in the west intellectual thought are as follows: good, beauty, truth, theory, activity, creativity, logics, esthetics, morality, art, nature, human creatures, objective and subjective property, what is mental and what is sensual, the form and elements of form and things, signs. He does differentiate also notions of world and language, by which we are talking about the world or, otherwise speaking, they are things and symbols. This differentiation was not always on the first plan of interest of science but this type of analyses reach even as far back to times of antique Greece. The conviction, being hitherto actual among artists and architects, that beauty results from the proportion of parts to the whole, reaches also as far back to those times (Fig.1) [11, 38]. In the 20th century, searches were done for the definition and theory of beauty. The conviction concerning the subjectivity of beauty conduced to the creation of the general theory of beauty. According to this theory it is not beauty but esthetic experience is the fundamental notion of esthetics, as such experience comes into being in the contact with beauty. In such way, beauty apparently has lost in modern opinions the so long maintained position of the main, most general notion of esthetics.

The begin of the 20th century is a general and radical return from the classical idea of beauty. Symmetry, equilibrium of composition, unity in difference are replaced in contemporary esthetics by asymmetry, and equilibrium of forces and tensions becomes labile, often dynamic. Decomposition, as lack of composition, is the beginning of searches for esthetics and art of the 20th century. This process includes all species of art. At present, we talk about esthetic impression, that means about values and categories that are fully subjective. Therefore, it is certainly worth to get in the bottom of this theme for realizing the importance thereof as well as its ambiguity. The undertaken here considerations about beauty are connected with the preliminary phase of the creative process of architectural design.

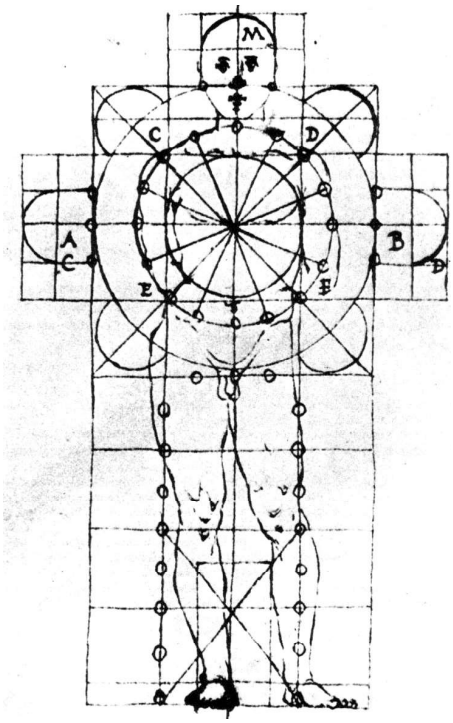


Fig. 1. Consideratons with searching for confirmation that the beauty of the human body results from the proportion of parts related to the whole.

Another phenomenon in modern esthetics and in the modern civilizational development is the integration of species and kinds of art and the broad application of technical and technological achievements, as well as the use of machines in the creative process [39, 40]. The situation existing at the turn of the 19th and 20th century made it possible to start with new thoughts and development trends which became precursors of modern architecture, and architecture became to be perceived more and more often as the synthesis of art, handicraft and technology. Modern esthetics is perceived also as a broad interest in industrial and functional form. Such artistic and avant-garde conventions as impressionism, surrealism, realism – also socialistic realism, pop art style, cubism, abstractionism, constructivism and deconstructivism, unism, environment and, finally, happening lead to the socialization of art and to new ways of their receipt, and have an influence on the appearing styles in architecture of the 20th century.

Le Corbusier, as the main but not unique creator of modern architecture was dealing with, among others, considerations on the relation of beauty and proportion of the human body. Le Corbusier occupied himself with the scale of the human being in architecture and with dimensions and proportions of the human body. Le Corbusier carried on research for the proportions of the human body [39]; the research results were finally embraced in the principle determined

as Modulor (Fig.2, 3). Le Corbusier presented this principle in his own passed doctor's dissertation. The foundation of Le Corbusier in Paris is dealing with gathering, describing, commenting and promoting his rich creative heritage.
The present time is full of disharmony but, on the other hand, it is a time of expected harmony and time of search for harmony that is found in the harmony of the surrounding world of nature. In such time, the feeling of beauty is connected, indeed, with social feeling. As an effect of these developmental changes, architectural design concerns science, art, technique, materials and the being used technologies. In the process of architectural designing, an important role is played, independently of knowledge and economic conditions, by skills and by the individual activity of the architect connected with his/her creative artistic achievement, with the applied technique, with art and its laws.

Architecture expresses itself through the form. The architect performs, in the first phase of the design process, freehand architectural sketches that become the basis of further activity and the being made design decisions. G. Nadler [24], an engineer methodologist recognized as a great authority on all technical domains being concerned with designing wrote that the design process undoubtedly influences in a deep way the results, without regard to the domain of knowledge. This principle refers in an evident way to the preliminary phase including the assumptions of that process. According to the opinions of the design engineer and methodologist Z. Wasiutyński [40, 41], the forms of the produced objects depend upon the forms of producing operations. He added also that forms are the result and effect of the realized architectural and constructional creative processes. Zygmunt Wasiutyński [41] based himself on opinions of A.A. Cournot who wrote in turn: without regard to the object of observation and examination, the form is what we distinguish (recognize) most easily. A.A. Cournot accepted that this remark has a general importance, and the notion of form refers both to things being perceivable only by reasoning and to material things, i.e. visible and touchable things. Among many considerations of Wasiutyńki [41] concerning the form one can find considerations proposing that forms of produced objects depend upon producing actions, that means e.g. upon the applied technology.

Z. Wasiutyński wrote also that the properties assigned to things are a reflection of the way of action and way of cognition. The modern science confirms this approach. As an effect, the essential role of verbal thought in science, technique and architecture should be accepted, especially the role of images and figurative ways of thinking (e.g. graphic schemes of design activity) as forms of perceivable things only by reasoning as well as material, visible and tangible things.

The being designed architecture is conditioned by a concrete phase of technical, social and civilizational development, by the environment, that means by the natural environment. Architecture is conditioned also by the broadly perceived tradition and by the search by the human being for his/her identity [42]. Ordering complicated and different architectural designing

and realizing conditions becomes useful in the architectural process in the practical and systems-based approach, analogically to the fact how logistics became useful and facilitating the realization in e.g. the organization of transport.

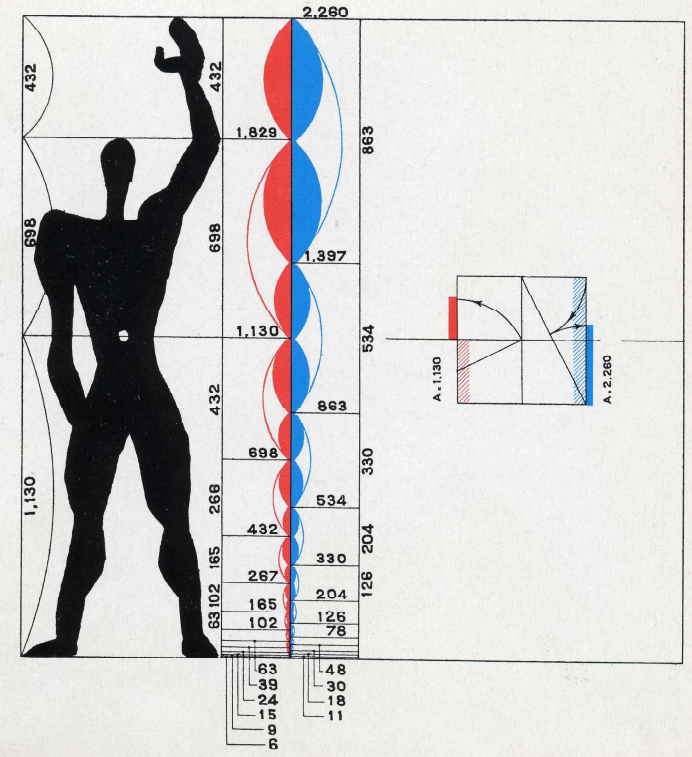


Fig. 2. Modulor of Le Corbusier is the presented beside diagram of harmonius proportions of the human body.

The designing process is a sequence of consecutive actions aiming at the elaboration of the design (project) being a conventional description of a determined designing task. In architectural design, the designer bases himself/herself on real possibilities resulting from the development of science, art and technique. The architect accepts logistic technical solutions, that means logistic constructs and simultaneously he/she overcomes these constructs in natural manner. In such way, the activity of the architect is connected with his/her artistic creation, i.e. with art and its laws. At present, this happens in situations when technologies through their reactions create an environment according to their own image, and not to the image of the human being and of his/her needs [39].

Praxeology [43] is the general theory of action, and praxeologists put, as their aim, inquiring about the broadest generalizations with technical character.

Logistics is derived from the theory of military systems. Serving the front with supplying equipment, food, medicines etc. requires logistic solutions. In course of time logistics changed into methodology of activity, and later into methodology of design.

Methodology of design deals with methods, procedures and techniques of designing creative behavior; that concerns the decision-making activity of the designer.

Methodology of architectural design is based on praxeology and concerns decision-making activity of the architect being undertaken in the process of architectural design.

Design processes, from the methodological and methodical point of view of contemporary science, being observed in many domains of knowledge, are sequences of consecutive operations. In architecture, the process of designing is a sequence of actions aiming at the elaboration of the design project constituting a conventional description of a determined design task. What concerns architectural design, J. Sołtan [Giedon S., 1965] wrote that hitherto yet unknown laws, presentiments, i.e. the so-called design intuition play an enormous role when undertaking architectural decisions. According to the contemporary knowledge, scientific design, analogically to methodology of sciences, is a systematic rational reconstruction of designing behavior. Such reconstruction requires, according to Z. Wasiutyński, a previous reflection concerning the handicraft of the design engineer and concerning consideration of ordering the designing experience supported by methodological knowledge. According to opinions of Simon H.A., 1990 and Gasparski, 1995, the complex design-creative process of the architectural form is a logical thinking sequence.

Le Corbusier, as architect and painter-purist, enhances the necessity of including art into the current of great transformations of the scientific-technical civilization where the artist has to be an equal partner of representatives of technique and science [Jenger J., 1993]. Therefore, the architect has to understand the laws that are governing them and to transfer these laws on his/her own ground {Kossakowska M., 1980, Gasparski W., 1993, Banathy B.H., 1996, Bazewicz M., 1996]. The methodological analyses of selected objects of architecture of Le Corbusier, among them the Savoye Villa, are serving such approach. These analyses prove that he used in his architectural creative activity the method of morphological analysis or elements thereof.

In the architectural design, the architect-designer bases on real possibilities resulting from the development of science, art and technique. The architect accepts the logistic technical solutions, or logistic constructs. The activity of the architect is connected with his/her artistic creation i.e. with art, technique and their laws. According to the contemporary knowledge as well as to methodology of sciences, designing is a systematic rational reconstruction of designing behavior. Such reconstruction requires a previous reflection concerning handicraft and consideration of the designer that assures ordering the designer's experience supported by interdisciplinary knowledge [48].

Fig. 3. Modern graphic approach to modulor of Le Corbusier.

In the practice of architectural design, the design project comes into being in consecutive phases of development. In the case of team-based design work, the phases of development of the architectural project can be connected with discussions, coordination agreements, verifications and modifications.

It happens also that in the preliminary phase, independently of earlier performed discussions and of coordination, the design activity is connected with the individual creation of the designer [49, 50] that arose a priori, i.e. according to assumptions, as idea and synthesis of earlier studies, analyses [51-54].

Methodical activity can be helpful in the rational co-creating of the space where we are living [55]. Knowledge about methods can facilitate analyzing the plurality of existing conditions and formulating e.g. realistic design assumptions concerning the being planned investment. In determined design situations, one realizes and applies more or less the design method [43] because the method "rises" from ways of activity; it is, as certain simplification, an "improved way" applied for a concrete aim. Generally, a method consists in selecting and arranging component actions that are unified by an objective. Methods "rise" and are developed, improved ways of activity, e.g. design activity. Repeating design actions is called iteration, and repeating actions with a significant change of the effect of such activity leading to obtain a new value is called feedback. That is a design action being observed and described in

the design methodology and used by many designers-engineers in technique and technology [36].

An a priori solution, referred to designing in architecture, can be understood as a solution accepted in advance, that means accepted according to the assumption.

Jargon: a special variant of the common national language, used by particular social professional groups, differing what concerns a specific vocabulary. It is a language that is incompatible with standards. Jargon is commonly used in architectural design [33] in the context with architectural drawings and is fully comprehensible for the communicating parties only in this context. Jargon is used to realize a fast and effective communication carried on between design engineers in the design process when the communication processing of design information takes place. For instance, in practice, jargon is used in the context of currently performed architectural sketches or drawings and of their necessary modifications taking into consideration newly introduced information. The fact of the efficient and general application of the architectural jargon by engineers-designers proves that architects use in practice values in the design process that refer not always to officially functioning notions. This language, the architectural jargon, "blows up" in a certain sense the officially functioning notions as it does not fit therein.

The human environment, being an environment of human activity constitutes a certain image [37, 38]. At the grounds of differentiation of the systems-based description of the image of the reality, in the scale from micro to macro, the being observed degree of complexity of the world is positioned [39, 40].

The architectural environment is subject to incessant transformations (extension, modernization, restoration, renovation, repairs etc.). The notion of architectural environment, created by the realized architectural objects together with the site planning, is connected in a natural way with notions of ecosystem and habitat of the human being. The being realized habitats could serve the sustainable development of architecture, also of the pro-ecological architecture and contemporary construction technologies, creating new, perfect architectural environments [41-43].

The habitat of the human being [44-46], understood in the most general sense, is a friendly fragment of the architectural environment coexisting wit the nature. The denomination habitat is derived from Latin words habitu, habito, habitatio that define: appearance, set of features, position, behavior of the human being of type: inhabitation, sojourning. Habitat is connected with temporal sojourning or inhabiting by the man in a determined space, e.g. in weekend houses or other places of temporal type (tents), or in permanent objects.

From the architectural point of view habitat is the space of house and its environment where users of that house do sojourn together with pleasure. At present as well as in this work the human habitat is understood as to be an environment that was built, that coexists with the natural environment. Habitat is defined as to be a "living system" and is a complicated system of factors and processes occurring in the environment that serve the human being and that

are accepted by the human being. The characteristics of all natural, technical and cultural factors express the complexity of the habitat. The idea of habitat indicates the possibility of using by architects the contemporary knowledge about the human being. Such knowledge can consist of: architectural, biological, psychological, systems-based, praxeological knowledge as well as knowledge on design methodology and modern technologies, among them specially pro-ecological technologies. A broad interdisciplinary knowledge becomes helpful for shaping contemporary architecture [47-49] and of a social environment as a friendly habitat of the human being in different climates, cultures and fragments of the earth globe.

The habitat is a fragment of the environment that is advantageous for assuring the human being to be in condition. The habitat is created by all factors of the surroundings, namely animate and inanimate nature that act on living organisms. At present, the problem of habitat is being undertaken by architects in conformity with the contemporary architectural knowledge and with systems theory, among them mainly with the theory of living systems e.g. in organic architecture.

The habitat of the Scientific School of Wroclaw belongs to other habitats that differ from the above-mentioned habitats. The author of the habitat of the Wroclaw Scientific University is Prof. Zbigniew Bać. This habitat is a particular form of a residential environment with pro-social and pro-ecological features. From 1985, Prof. Zbigniew Bać is the organizer of architectural conferences and workshops and of the Scientific Conference HABITAT in Poland, in Wroclaw. The aim of this conference is the integration of different approaches both technical-architectural and natural-ecological, without excluding problems of ecology of the human being, where shaping the architectural spatial environment will be the real measure of progress for the development of contemporary societies. One can present the contents as well as the importance of habitats in the following way: the habitat takes in the system of organization of human seats mostly the form of a certain unit with determined dimensions and a determined quantity of a social group. It results from socio-psychological research that the sizes of such units change from 3 families (households) until 150 families with maintaining features of home neighborhood, what is characterized among others by the fact that children know them each other, and adults (parents) call each other by their first name.

Morpheme (linguistics) – the littlest indivisible semantic part of a word (expression) or partitive form of a greater whole. F. Zwicky, astrophysicist [ ] treats morphology as the perception of such an image of the reality where should be taken into consideration in a transparent way all more important structural links between objects, phenomena, ideas and activities.

Architecture of computers is a domain of architecture and technology of information systems. According to the Landscape Convention, the landscape is the fundamental component of the European natural and cultural heritage and contributes to the welfare of people and to the consolidation of the European identity. At present, this convention exerts undoubtedly a more and more positive influence on shaping and designing the architectural environment, particularly in the preliminary phase of design. The proposed in the mentioned convention

sustainable development in architecture and building engineering concerns a friendly and harmonious shaping of beauty of natural and built landscapes, e.g. urban landscapes, creating the space of the architectural environment as built environment, co-existing with the nature.

In the Landscape Convention it has been accepted that the landscape constitutes a resource favoring the economic activity and that it is an important part of quality of life of people inhabitant everywhere: on urban areas and in the country, on degraded areas as well as on areas with high quality, accepted to be areas with extraordinary beauty, and on common areas. Such problems belong to be essential in the preliminary phase of the architectural process.

The European Landscape Convention, elaborated in Florence on 20 October 2000 (Dz. U. – (Polish Journal of Laws) of 29 January 2006) declares for a sustainable development and accepts all values that have introduced the precedent European Conventions. According to this Convention, the aim of the European Council is to achieve a higher unity of its members for the needs of protecting and realizing ideals and principles that constitute their common heritage; this aim is realized by agreements in the social-economic domain, with the concern of achieving a permanent and sustainable development. Such development should be based upon relations between social needs, economic activity and environment.

The legal framework connected with the sustainable development is presented by the following European Conventions, beside the mentioned Landscape Convention:

– Convention concerning the protection of the architectural heritage of Europe (Grenada, 3 October 1985 European Treaty Series (ETS/Série des traités européens (STE) Nr 121).p;

– European Cultural Convention (Polish Journal of Laws 1990, Nr 8, pos. 44),

– Criteria and procedures of recognizing an object as Monument of History (Document of the National Center of Research and Documentation of Monuments. Council of Protection of Monuments of the Minister of Culture, 6 October 2005)

– Principles of creating a Culture Park (Document of the National Center of Research and Documentation of Monuments. Council of Protection of Monuments of the Minister of Culture, 6 October 2005)

The mentioned conventions were elaborated among others with the concern of achieving a permanent and compensated (sustainable) development based upon sustainable (compensated) and harmonious relations between social needs, economic activity and the environment. Contemporarily, the situation is bad when the applied kinds of technology "create an environment according to their own image and not to the image of the man and of his needs" because of their action/reaction.

Problems of energy-efficient architecture and building engineering. The conditions of a healthy, friendly internal microclimate of a building, together with the conditions of a low demand of energy, are set as criteria for the modern apartment buildings and public buildings called pro-ecological energy-efficient buildings. The energy connected with thermal flow pro-

cesses in an energy-efficient building is considered as energy connected also with spatial solutions of the building, with the structure of material, with the timbering of the building and with partitions of the inside by the form of the building.

Analogically, problems of pro-ecological energy-efficient buildings are now connected with the development of ecological technologies, for instance of recuperators, solar cells and photovoltaic cells as well as with the development of contemporary scientific research concerning e.g. flow of moisture in construction materials.

The present day approach to energy efficient architecture and building engineering remains in conformity with the notion of pro-ecological architecture being saturated with modern energy-efficient technologies [5] connected for example with passive building engineering, that means building engineering drawing energy from passive resources of heat.
Decisions concerning the design and realization of energy-efficient architecture and building engineering are made in the preliminary phase of design where the designed space, the scope and the investment costs are determined to some extent.

The energy-efficient and passive building engineering applies to a more and more degree the being incessantly improved materials, techniques and technologies. Maybe the development of materials engineering will contribute to the realization of new technologies of the contemporary architecture by proposing new building materials with better and better, often surprising properties. On account of the necessity of conforming to the technical requirements of the existing and arising new ecological technologies, among them energy-efficient or passive technologies, the phase of preliminary architectural design becomes more and more decisive what concerns the effect of the undertaken activity. The contemporary technologies of energy-efficient building engineering assure, despite many yet not solved problems, a real chance of development of the idea of pro-ecological architecture as a fragment of habitat desired by the human being.

Passive building engineering (pl. wikipedia.org/wiki/Dom_pasywny) is the kind of building engineering that uses passive sources of heat. It is possible that pro-ecological architecture (which includes in its scope among others the passive building engineering) will aid, through its multi-side connections with other domains of knowledge, technique, science, art and reality to associate distant domains of science and knowledge in a whole that correspond to a higher degree to the human being and to the complex reality.

At present, the open definition of pro-ecological architecture [55], together with the interdisciplinary character of architectural processes, contains by its scope many domains of knowledge, science and technique and of methods, technologies, connected therewith as well as hermetic languages of the particular scientific disciplines and specialties.

The aim as well as feature of the pro-ecological architecture connected with the energy-efficient building engineering consists in the creation of a healthy and friendly environment that assures comfort of habitation, the possibility of economizing energy produced by the man, and the contribution to maintain the energy-dynamic equilibrium of the natural environment as well as of the planet, the unique ecosystem we dispose of.

When optimistically thinking one can consider that, so as hitherto, the energy-dynamic equilibrium of the environment of the (our) planet does respect the laws of the evolutionary coexistence and of the local and global integration of the environment as a natural system with the built environment, that means with the architectural environment. The architecture illustrates the complex needs of the human being well as the existing (in the given epoch) technical possibilities of their realization. At present, one can define architecture as the art of organizing, integrating and shaping the space of the environment of life of the human being [28-30]. It means that architecture is the science and art of creating the environment for social life. The passive house/building [57] is a building that does not consume more than 15 KWh of energy on 1 m2 of usable floor area for assuring thermal comfort of the inhabitants. The passive house is heated by applying passive heat resources and it cools down itself – in a passive way. Some technologies of passive building engineering were used already in the antiquity. An example thereof can be the ground-type heat exchanger used by the Romans that one can accept to be the first solution of the applied at present floor heating (Fig.4).

Together with the development of science and technology, more and more requirements are set to passive houses/buildings. The fundamental features of the passive house are the following: compact, not dismembered solid mass; orientation of the majority of the windows in south direction; passive solar gains cover 40% of the heat demand; mechanical ventilation with heat recovery (recuperator). For example, heat being emitted by thousands of people passing through the central station in Stockholm will serve for heating the near building – so did inform the representatives of the firm being responsible for the realization of the project. Recuperation of a part of the produced by them heat will aid in heating the buildings. Everyday about 250 thousands of people pass through the station. Each of them produces heat. Instead of opening the windows, we want to gather the heat through the ventilation system. The heat of the human body can serve to heat water with will be supplied to the building where will be situated offices, a small hotel and shops. The mentioned above building should have been finished at the beginning of 2010.

The autonomous house (building) is a development of the idea of the passive house (building). Such a building does not need external infrastructure. It does not use for instance electrical energy, water supplied from outside and does not produce wastes as well as does not use a storm water sewage system. According to the opinion of adherents to such solution, an autonomous house (building) exerts a minimal influence on the environment.

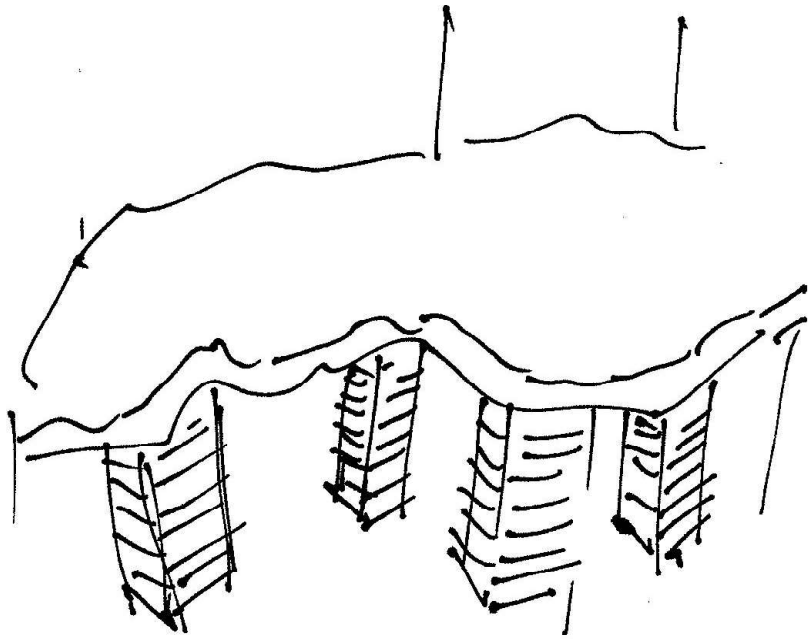


Fig. 4. Ground-coupled heat exchanger, used by the Romans. Certain technologies of passive building engineering were applied already in the antiquity. An example thereof can be the ground-coupled heat exchanger, used by the Romans in the system called hypocaustum. It came into being in the public baths of the Romans where compartments with basins and pools, together with the repose room were warmed by heat air distributed in the space under the floor.

It is possible that, when new ecological technologies develop, the pro-ecological architecture will become the architecture of the future, as it will save energy, protect the health and condition of the man, being together with its environment a well-kept fragment of the rich ecosystem of the earth.

Photovoltaic cells are a new and expensive type of ecological technology; nevertheless being slowly but more and more intensively used in many countries for the production of electric current from solar radiation.

Systems knowledge was called by the Professors: W.C. Dorosiński, W. Gasparski and arch. S. Wrona (In: Zarys metodyki projektowania – Outline of design methodology, 1981) the singularity of the science of 20th century. Systems knowledge is a discipline-based freedom of unhampered intellect.

The present-day development of systems knowledge has fully confirmed the significance and the actual character of these formulations. This knowledge creates new possibilities of many-sided verification of processes of architectural design and thereby of their improvement. The

above mentioned authors wrote that systems knowledge, in common with the progressing differentiation and integration of knowledge, do accept the lack of discipline barriers, the freedom of using knowledge and technique gathered in one of the domains to problems appearing in another domain. That is a disciplined freedom of the unhampered intellect, they added. The present development of systems knowledge and computer science and informatics confirms the significance and the actual character of these formulations despite of overcoming many notional barriers that exist and function in concrete domains of knowledge, in architecture too. The contemporary progress in technique and technology and organization of labor leads to the phenomenon of collective elaboration and development of the resulting achievement of architecture, and confirms the actual character of the mentioned formulations. This development does confirm also the possibility and the need of applying systems knowledge that creates new possibilities of development and of efficient verification.

New intellectual, technical and technological possibilities can allow designing and realizing, when using the interdisciplinary approach, ecological architecture being compatible with the natural environment, i.e. architecture serving a harmonious development and survival. Interdisciplinary problems in the design of architecture can, in the future, play a greater, because an inspiring and innovative role. Jerzy Sołtan (Sołtan J., Monograph, Museum of the Academy of Fine Arts At Warsaw, 1995), when carrying on considerations about canons of beauty in architecture states that architecture is building engineering elevated to the level of art, i.e. building engineering that affect feelings. This statement shows the meaning of interdisciplinary problems in architectural design. The contemporary development of technique, technology and organization of work leads to a collective phenomenon, thus an interdisciplinary process of generating an architectural work (architectural achievement).

The interdisciplinary process of architecture design is a process of shaping an architectural form that is conditioned in a many-sided way. This process is, in the work, presented on examples of architecture of Franc O. Gehry: Museum at Bilbao and Energetic Forum at Bad Oyenhausen as well as on the example of the Geothermal Heating Plant at Reykjavik. These solutions show the features of the pro-ecological architecture, they harmonize with the environment, they enhance its values and qualities wile maintaining the identity of place.

From the systems-based, methodical and ecological point of view, considering the process of architectural design as an interdisciplinary process leads to the reinforcement, in this process, of the creative role of "the architect who stands at the side of the human being" (Prof. Halina Skibniewska, General report. In: XIV World Congres of the International Union of Architects. Architecture-Man-Environment, Warsaw, 1981). The interdisciplinary, systems-based and methodical point of view conduces to the consideration of the being designed building as a being designed whole that is simultaneously part of a greater whole, that means of the environment. According to the knowledge concerning the theory of living systems one can consider this being designed and realized whole in interdisciplinary teams as a functioning organism, for example an urban organism.

Prof. Wojciech Gasparski, being an engineer, a methodologist, a praxeologist and an ethicist dealing with e.g. ethics in business asks the question: " Would the search in the world for a being more and more realized by us technical-social complexity really summon the Greek ideal of beauty and good for assistance (...)?

CHAPTER III

Inspiration and methodical activities of A. Gaudi and of J. Utzon

The creative personalities of Antonio Gaudi and Jorno Utzon are connected with different types of methods of search for architectural inspirations. The considerations refer mainly to preliminary design assumptions [54-58]. Our epoch is really the suitable moment to take an interest in the architecture of Antonio Gaudi (1852-1926), a Catalan architect, famed for extraordinary architectural projects [61, 62]. The architectural forms of A. Gaudi, considered one of the mostly creative architects, show evidently their relation with nature.

The nature-self became often the inspiration for the creative activity of Antonio Gaudi [55-58]. For Gaudi, also contemporary buildings that he found to be great achievements of the past and that were very interesting for him were a creative inspiration. He was a designer of sacral buildings, apartment buildings, e.g. Casa Vincens, and of smaller individual houses, e.g. Casa El Capricho (what means in literal translation humor, caprice). An intricate, often fabulous, wonderful architectural form characterizes his buildings. Gaudi designed with passion, with thought about the human being, wide park installations.

Gaudi engaged a good deal of time and attention to elaborate details, e.g. toys and ornamentation that cause great impression of the whole of the architectural assumption. For instance, the roof was for Gaudi always an essential composition element. He often hid chimneys beyond a twirled form and a rich ornament executed of colored ceramic tiles.
In the architecture of Gaudi one can find forms modeled upon forms found in the nature, what consists a permanent behavior in the activity of this creative designer. His greatest achievement, Sagrada Familia (Fig. 5), has such features, as well as the bell tower Sagrada Familia that brings to mind conches.

It is difficult to inquire what kind of forms would realize Gaudi if he would dispose of new materials, that means of reinforced concrete, known a little later, and called at the beginning ferroconcrete. As construction engineer, he built in his apartment models of his future buildings. He verified their strength by hanging and charging them from below. He created, from

materials being accessible for him, forms of buildings with intransient beauty and with resistant structures.Gaudi died suddenly in consequence of an accident and he left the church La Sagrada Familia (Fig. 5) in a not finished state.

Fig. 5. La Sagrada Familia by Antonio Gaudi, view, Barcelona. Modification of natural form. Drawing by author based on photo.

For Gaudi, an ideal house or building was as if an organic body (Fig. 6). His creative activity was specific, full of amazing forms and colors. Construction engineers often ask the question: how such building could come into being, despite Gaudi was not a theoretician of strength of materials. Often, as architect, he worked in a direct contact with the place and the arising object. In his apartment, he carried on experiments and charged elements with various forms in many ways.

Antonio Gaudi created wile thinking about the future. Just the development of the present building engineering and architecture allows us to realize the richness and greatness of his architecture and of the ideas that governed him in his fascinating creative activity. The beginning of his creative achievements was Casa Vicens (1883-1888), and Sagrada Familia (1883-1926) in Barcelona, a church in gothic spirit was the main achievement of his life (Fig. 5).

Fig. 6. Apartment house, façade. Barcelona 2010, Antonio Gaudi.

In 1881, on the periphery of Barcelona at that time, lots were purchased for building a new church with the invocation of the Holy Family: Sagrada Familia. Gaudi, as he was too young at that time, was not chosen directly as designer engineer of this building.
Gaudi had built many objects and he was not indiscriminately impressed by tried and proved patterns. Gaudi never was characterized by a determined style, and he never imitated anything exactly.

Analogically to his opinion and behavior, we also have enough of gray, rectangular façades and too expressive, tedious lines thereupon. Characteristic for Gaudi was the use of fanciful forms and a great variety of colors and materials. Gaudi initiated in Catalonia the fashion of walls with rich decoration by colored tiles according to Spanish ceramic traditions, and raw materials. Influences of the Moroccan art seem to be present in his art. After an analysis, we perceive, for instance, that the rich patterns of tiles are typically European. The architecture of Gaudi is characterized also by severity of the form and, for instance, by methodical use of straining arches as an indispensable element of Gothic architecture. One can call buildings of this period of his creative activity neo gothic buildings in the particular interpretation of Gaudi.

An example of the contemporary shaping of architecture of landscape is the Park Guell (Fig. 7), being realized during the years 1900-1922 [54, 55]. The terrain, at the North-West of

Barcelona, is at present a rest center of the town. On a great area, surrounded by a vertical forest and by palm avenues a color bench wriggles as if a serpent .That is the beginning of the assumptions of the park. Gaudi had greater intentions than the here achieved ones. He planned there also an exemplary housing estate as a housing paradise, a garden city. Today we read his architectural achievements that are differentiated by form and destination, as pro-ecological architecture, connected with architecture of landscape. Gaudi did not doubt what concerns the influence of his architecture upon its future development. The majority of his achievements are located in Barcelona.

Fig. 7. Design of a building. Antonio Gaudi, Park Guell, Barcelona (1900-1914).

The architectural inspirations of the form of the Opera House in Sydney are presented by the author him-self, i.e. Jorno Utzon [37] in his sketches as the preliminary phase of the process of architectural design of that historical object. The Opera House in Sydney is an example of a particular architectural creation (Fig. 8-11). In the building of the Opera House in Sydney of J. Utzon both the artistic and methodical creation of the contemporary architect and designer are simultaneously visible. This methodic creation of the designer is connected with the preliminary, creative architectural design through joining partial forms (morphemes) [56-58]. The architect-designer wrote that he took the idea from the parts of an orange. He stated also that, independently thereof, he searched for inspiration by regarding the sailing ships floating beside the future place of the building of the Opera House.

J. Utzon searched surely for inspiration also in the floating white clouds on the azure sky above the peninsula Bennelong Point; he registered that on here not cited freehand sketches of that period of his creative activity. The forms of the roof of the Opera House are, cut into pieces, fragments of the surface (of the bowl) of a sphere. Thus, the joined fragments have all the same spherical curvature. When regarding the juxtaposition of forms of the roof of the Opera House we see the arrangement of geometric forms.

Maybe we read (perceive) therefore in the building of the Opera House in Sydney the creative method of the designer-architect. This method, as being a set of ways and manners, can be, in architecture, connected with creatively joining architectural forms. The Opera House is situated on the peninsula Bennelong Point on a specially prepared platform; thus the form of the Opera House, as a whole, is isolated from the surroundings and splendidly exposed.
Under the roofs-shells, there are five separate rooms for symphonic concerts, opera spectacles, chamber music and scenic spectacles. There is also an exposition room and many other rooms of that institution of public service.

The construction works concerning the realization of the Opera House in Sydney began in 1959. Despite different troubles, the edifice of the Opera House has been finished by a team of Australian architects in 1973 and solemnly opened by Queen Elisabeth II.
The realization of that building was connected with numerous material-based, constructional, technological, geometric, methodical, organizational, logistic and financial problems.
The main material used for constructing the Opera House was concrete and glass. For instance, the height of the shells of the roof was 66 meters. The first proposition consisted in the execution of the roof as a vault of concrete, poured into curved wooden or steel forms.
The successive proposition of J. Utzon was the execution of the shells of prefabricated concrete ribs positioned beside each other and having the same spherical curvature. All the shells had to be executed of fragments being cut from the surface of a sphere with radius 75 meters (Fig. 6, 7). The sketches (Fig. 8-10) of Jorno Utzon represent a morphological form of vault shells of the roof of the Opera House in Sydney, this form being developed by joining partial forms.

The fact with essential significance consisted therein that the simplest possibility of assembling the vault from prefabricated elements could be assured by a regular surface of a sphere. Finally, one has decided that the shells would not be executed as single elements but that they would be joined of ribs poured in separate segments on the building site.
For constructing that object several kinds of forms were used, joined by means of glue and reinforcement bars. Prestressed concrete, applied for building the Opera House, is characterized thereby that inside it steel ropes are running that are stretched by means of hydraulic servomotors. When trying to recover their original length, the ropes assure prestressing the concrete.

The following important phase of building the Opera House was the selection and arrangement of tiles serving for lining the ferroconcrete shells. Utzon thought that the tiles had to be

resistant to temperature fluctuation and that they had an appropriate appearance i.e. they had to brighten in the sun. Finally, ceramic tiles were selected. As the shells were executed with spherical curvatures, that signified that from the geometric point of view their surface could be covered by tiles with one only dimension (12x12 cm). The support of the shells was assured by joining great shells with shells of smaller size turned contrariwise as to form, together, a spatial whole. Otherwise speaking, the whole of the architectural form was created by adding forms of smaller shells. Each shell of the roof of the Opera House is mounted upon four supports.

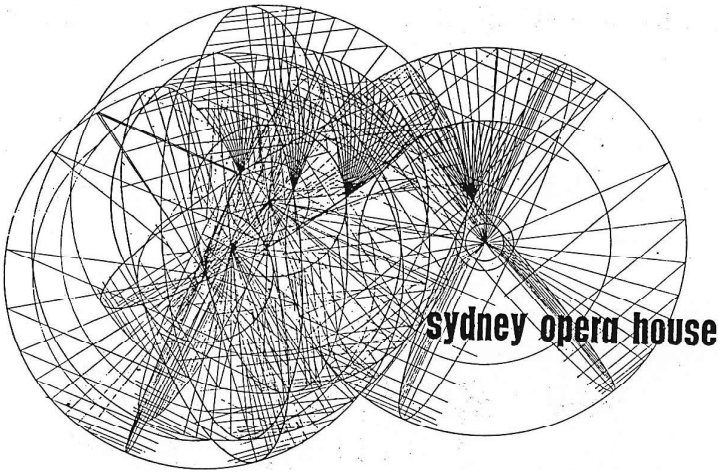
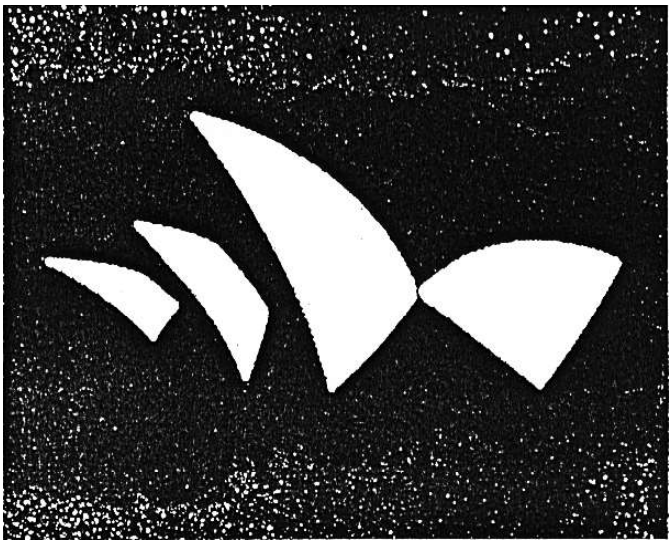


Fig. 8. Drawing by author based on sketch of Jorno Utzon presenting a morphological structure of the roof of the Opera House in Sydney in the form of vault shell, executed on the basis of a spherical cap.

The glass walls were leant (reinforced) on vertical columns. The discussed historical description of the construction (structure) of the solid mass of the object as well as the form self of the building proves that the principle of absolute repeatability of shell-type concrete segments was applied, that means elements of the form of the object.

Figure 9 presents the arrangement of partial forms (the later shell of ferroconcrete) composing the roof of the Opera House. The drawings performed by Jorno Utzon include Figures 8, 9, 11 [61]. The edifice of the Opera House in Sydney became the symbol of Australia [56, 57]. Its brilliant white roofs superpose one on another and are similar to white sails, and one sees plenty of such sails on the waters of the port of Sydney. Maybe these white sails, and the being just cut orange as well as the shapes of its shells, as said some persons, became one of the artistic inspirations of the creator of this Opera House [56-58].

Fig. 9. Forms of the roofs of the Opera House at Sydney, or, otherwise, setting-up of partial forms composing the roof of the Opera Hosue. Setting-up of forms performed by the Author of that architectural achievement, i.e. Jorno Utzon. Drawing by author based on sketch of Jorno Utzon.



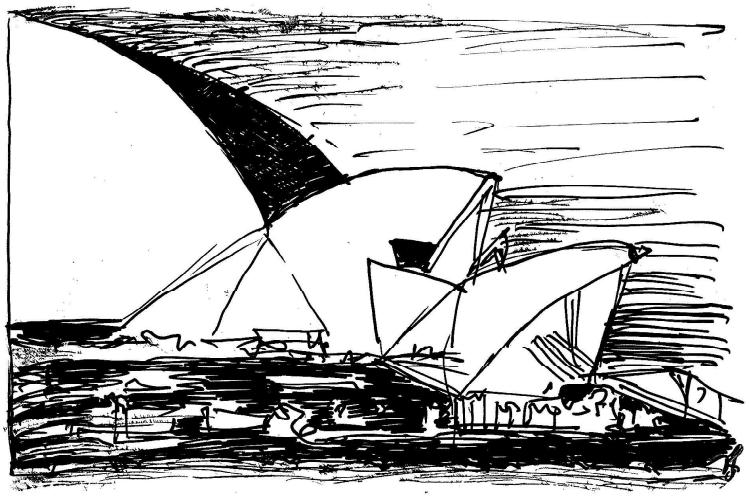


Fig. 10. Opera House in Sydney, view. Jorno Utzon, 1973.

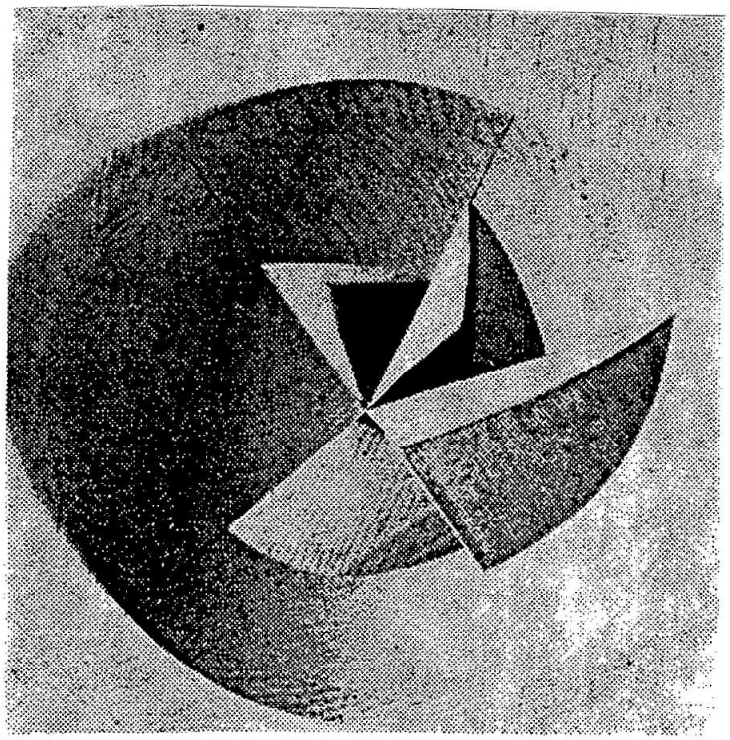


Fig.11. Drawing by author based on sketch by Utzon. Methodological interpretation of the forms composing the roofs of the Opera House on the sphere.

CHAPTER IV

Methodological analysis of architectural activities of the preliminary phase of the process of architectural design, the case of the Carpenter Center of Le Corbusier

Le Corbusier was an architect and design engineer; his architectural creative activity exerted an immense influence on the development of the contemporary architecture. One says emphatically about Le Corbusier: he is a creative artist who changed twice the direction of development of the contemporary architecture. Le Corbusier enhanced the necessity the art to include itself into the current of transformations of the scientific and technical civilization [73, 74]. He stated that the architect has to be an equal partner of people dealing with technique and technology. At present, we do observe such process explicitly in the development of the contemporary architecture.

Le Corbusier appreciated the value of preliminary (preparatory) phases of his creative design processes. He described many times and with passion the preliminary phase of his process of architectural design. While considering these problems, he drew architecture and its elements and, as an effect, he left many freehand architectural sketches that illustrated the creative preliminary processes.

The presented here, elaborated by Le Corbusier sketches of the process of designing the Carpenter Center [73, 74] are a documentation of the preliminary phase of that design project. An interpretation of the preliminary phase was methodically performed in conformity with the contemporarily existing knowledge on design methodology. That design process was realized based on drawings left by Le Corbusier from his architectural process of the building of the Carpenter Center.

Le Corbusier self wrote about his sketches that, if future generations will set much by his works as architect, a deeper significance will have to be assigned to drawings from design processes. The presented analysis assigns a methodical significance to these processes. Maybe the methodic values of achievements of the architecture of Le Corbusier allowed his imitators in

the whole world to create, in an efficient and in a comparatively rapid way, further design projects, to develop and realize modern architecture.

The presented below freehand drawings were prepared consciously by Le Corbusier as a transmission of values and of experiences for future generations of architects, for facilitating them the science of architectural designing. From the point of view of the contemporary knowledge concerning design methodology, these are methodical experiences. A modest part of his drawings was subject to analysis and methodological interpretation, namely drawings concerning just one building. The performed description and methodological analysis of a fragment of the architectural process, caught by Le Corbusier on freehand drawings, serve to improve architecture in theory and practice.

The adduced documentation-based analysis of means of creative activity of Le Corbusier, performed by Ron Kellett [74], presents a set of drawings of the creative architectural process. Maybe this description reveals the architectural actions that Le Corbusier thought to be essential, as he registered them on his freehand sketches. The analyzed elements of the preliminary phase of the architectural design process of the Carpenter Center of Le Corbusier are elements of architectural activity with methodical significance. On the drawings executed by Le Corbusier were recorded the modifications of the solid mass being designed as well as successive iterations of architectural design actions that illustrate the complexity of processes of designing architecture. An interesting fact, particularly for young adepts in architectural art, can become investigating, as an exemplary process, the methodical creative process of Le Corbusier in the preliminary phase on the selected example of the building of the Carpenter Center. This building is an architectural solution with a high degree of complexity, still being attractive from the artistic point of view. Le Corbusier designed that object as a Center of the Family Carpenter in 1960. Figures 20 and 27 present the view of that object.

Problems of creative design process in architecture were important for Le Corbusier being an outstanding personality of architecture. These problems were fixed (recorded-illustrated) on "drawings of the process" as he-self called them. Beauty, force of plastic expression as well as functionality of the language of architectural forms of Le Corbusier (thus also of the language of forms of the exemplarily discussed building of the Carpenter Center) were the cause of the fact that other builders on all the continents applied them in a considerably broader scope. These forms became "morphemes" of the contemporary architecture that means semantic particles of the language of architecture.

What concerns his own creative architectural activity, Le Corbusier wrote that it seemed to him that he got into bottom of the sense of architectural logics, that he discovered the fundamental principle: the architect creates words [10]. Words in this meaning are architectural forms. It was in this way that Le Corbusier wrote about the significance of the language of forms in architecture. This formulation has an imperishable methodical and architectural sense. The language is, indeed, the oldest system that was created and is incessantly being created by the man. An architect-designer uses in practice, in connection with the complexity

of designing, ways or manners that sometimes are transformed in design methods and strategies, even if he/she does not call them so.

According to Professor J. Sołtan, architect, collaborator of Le Corbusier during long years, in architecture the connection of art and architecture takes place or the connection of problems of designing all kinds of useful things with complex problems of life [30].

Designers-practitioners sometimes call decision-making in designing to be art of synthesis. The notion of synthesis includes and designates the creation of the design-project without respect to how this notion is understood. The complexity of designing architecture is enhanced in contemporary objectified analyses concerning the design process and the elements thereof.

J. Sołtan writes about the complexity of architectural processes that architecture is guided by somewhat other laws than visual arts, and the architect has to overcome many obstacles, has to live down many prosaic dramas before he reaches the final form of his/her achievement. He writes also that a painter or sculptor has to do with only one drama. This drama takes place between him/her and the canvas, clay, a piece of metal.

Fig. 12. The Carpenter Center of Le Corbusier, Harvard Yard, 1960. Façade and ramp to the exhibition hall. Drawing by author based on photo.

An architect, before he stands at the appropriate expression (or appropriate architectural design project), the synthesis of his/her activity, has to consider and determine a great number of more or less prosaic problems. The main problems concern the function and the way of execution of the building, the applied technology, the structure, the material.

Sometimes, the quality of design project, artistic, architectural quality, results from the ability of concentrating on a single thing, on the one expression. In practice, we call that in

everyday considerations a thought, an idea. The analyzed here drawings of Le Corbusier [10] are dedicated to this question of the first idea of the form, the idea of the solution accepted in the preliminary phase of the process of architectural design , and to further elaboration of that idea.

The architect-designer performs during the design process a detailed comparative analysis of many possible variants of technical solutions being considered from the viewpoint of fulfilling earlier determined, different needs. He/she considers the possibilities of their realization, in parallel to other conditions, e.g. spatial conditions, calling them design limitations. In such a way, the system of design criteria is examined and formulated. An ordered description of design requirements and limitations is formulated, i.e. the design conditions.

The so formulated by the designer system of criteria is simultaneously a formal description of earlier determined and identified needs that the future architectural object should fulfill. The description of needs is included in the architectural brief fordesign, which is the starting point for the realization of the architectural preliminary design. Le Corbusier and many design engineers apply permanently the strategy of improving in the preliminary phase of the architectural process. It is the search for an interesting and optimal solution. By using the strategy of improving, the designer searches for a better solution by modifying the earlier solution. In other words, the architectural solutions can be modified with using then different ways or techniques. In his architectural creative activity, Le Corbusier built, among others, paper models [10]. Such technique served, in the preliminary phase of the process of architectural design, a rapid improvement or identification of the architectural form by adapting it to current technical requirements. At present, techniques of computer assisting are applied and models of architectural design projects in virtual space are built.

Contemporaneously, when using techniques of computer assisted architectural design one has to remember that the architectural creative activity of the human being cannot be fully automated. The main design decisions of Le Corbusier were made in the preliminary phase of the architectural process. Le Corbusier illustrated that phase on his freehand drawings (Fig. 21-25). From the point of view of present methodological knowledge the following design actions in the creative activity of Le Corbusier, as actions being necessary about which he wrote many times in his works, letters and books were characteristic actions: analysis, synthesis, strategy of improving and iterations, being repetitions of design actions. Many design engineers, not only architects permanently apply iterations what results in introducing changes.

It happens that an idea of design solution suddenly appears in the imagination of the designer. This solution is called an a priori solution. It is a solution accepted in advance, or by assumption. On the freehand drawing (Fig. 13) of the design process concerning the Carpenter Center of Le Corbusier an a priori synthetic artistic vision was illustrated in the form of a circle. In other words, an a priori idea appears in the preliminary phase in the presented creative process of the Carpenter Center. That is a synthetic approach to earlier being analyzed particular problems of different type. It is a freehand sketch of the spatial solution idea (Fig. 13).

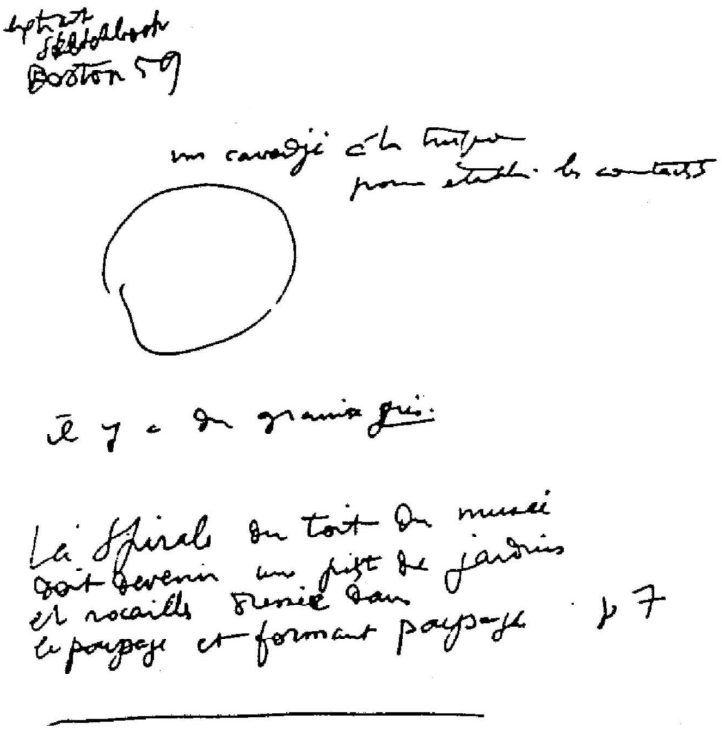


Fig. 13. Methodological interpretation of synthesis type view a priori of an architectural solution. Drawing by author based on free-hand sketch of Le Corbusier.

Le Corbusier stated that the determination of the problem is necessary in designing. He devoted lot of time to the study of conditions to which the design project is subordinated, for instance on account of its environment, its function, its structure, the mutual distances of existing and being designed objects, etc. In the case of the Carpenter, it was the phase of analysis and research of conditions of the environment, of needs – in other words requirements that the building has to fulfill as well as the real technical possibilities of their fulfillment. Ron Kellet [ ] describes, in his documentation-based analysis of means of design of Le Corbusier, that in many design projects of Le Corbusier an unusually long time passes between the acceptance of an order, of the first contact with the customer, and the appearance of any material testimony of undertaking the design process. His own words, that silence is golden, witness also the existence of a relatively long preliminary phase in the architectural design process of Le Corbusier. He stated that he knows from his own experience that the conception of a building comes then, when it is ready. According to these words, Le Corbusier studied, when realizing the design project of the Carpenter Center, many-sided design conditions thereof.

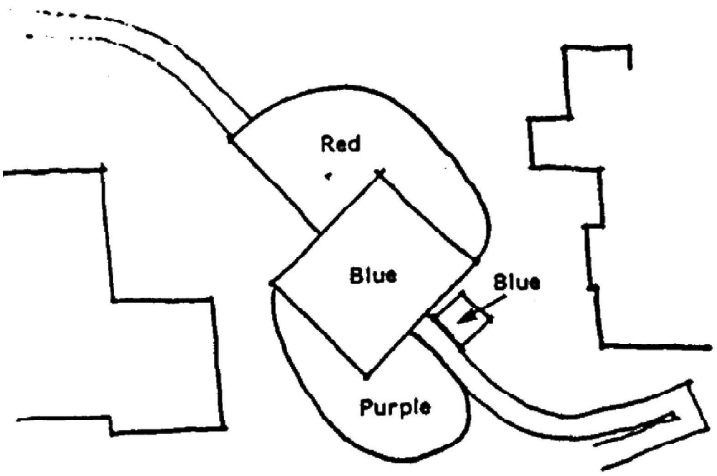


Fig.14. Methodological interpretation of free-hand sketch of Le Corbusier. Illustration of the modification of a designed architectural mass form. Drawing by author based on free-hand sketch of Le Corbusier.

In architecture, the preliminary phase is connected with the acceptance of a general spatial conception of the architectural solution. The majority of architects perform also freehand sketches for their design projects.

In the design project of the Carpenter Center the synthetic freehand sketch (Fig. 13-18), containing the whole of the design problems was the first real prove of undertaking the design process by Le Corbusier. According to opinions of many authors and according to existing documents in the form of sketches of design processes, left by Le Corbusier, he began, after the "stage of incubation" as he-self called it, designing from outlining the synthesis of the solution, or from the synthetic artistic vision.

Le Corbusier wrote that his sketches for the design projects were not inspired by his own will, but were a way to record something what was already seen. At the same time he stated that a drawing is useful only as an aid in the synthesis of ideas that are already been studied. It results from these considerations that on the notebook sketch (Fig. 13) of 1959, the form of circle is a synthetic approach of an architectural problem that was earlier analyzed on many decision levels. Le Corbusier drew in detail the so approached preliminary spatial conception, as well as improved it and adapted to more and more detailed design needs and conditions, namely functional, structure-based and material-based needs and conditions.

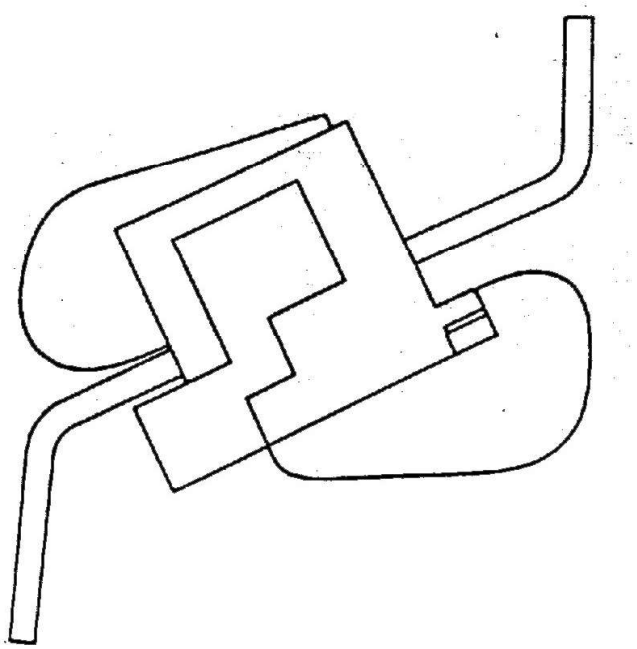


Fig. 15. Drawing by author based on free-hand sketch of Le Corbusier, successive methodological design step as modification of an architectural mass form.

This preliminary phase of the architectural design process is illustrated by figures from 21 to 26. These drawings present the use by Le Corbusier of the strategy of improving, a method applied in general by design engineers. A designer-architect is subject, during the complex design process, to many conditions and he/she simultaneously participates on many decision-making levels. His/her decisions concern: the structure, the more and more complicated and determined building construction techniques and the accepted technologies, the selection of materials, the being designed form, and technical details.

Successive modifications of the form in the preliminary phase of developing the design project of the Carpenter Center concern the horizontal projection of the being designed architectural solid mass. The originally assumed forms of this building, drawn in their horizontal projections were subject to modifications and transformations, that means they changed their parameters. That took place in conformity with the rationally assumed functions therein and the earlier analyzed spatial and material-based, structural and technical possibilities.

For the sketches of Le Corbusier the characteristic fact consisted therein that, during the design activity, he remained under the influence of the first idea i.e. of the circular form of the building, as considered in that case. Le Corbusier assigned a great importance to the preliminary phase of the architectural design process. In that phase as well as in the following design phases he undertook complex and many-sided analyses that were always adapted to a concrete stage of advancement of design works.

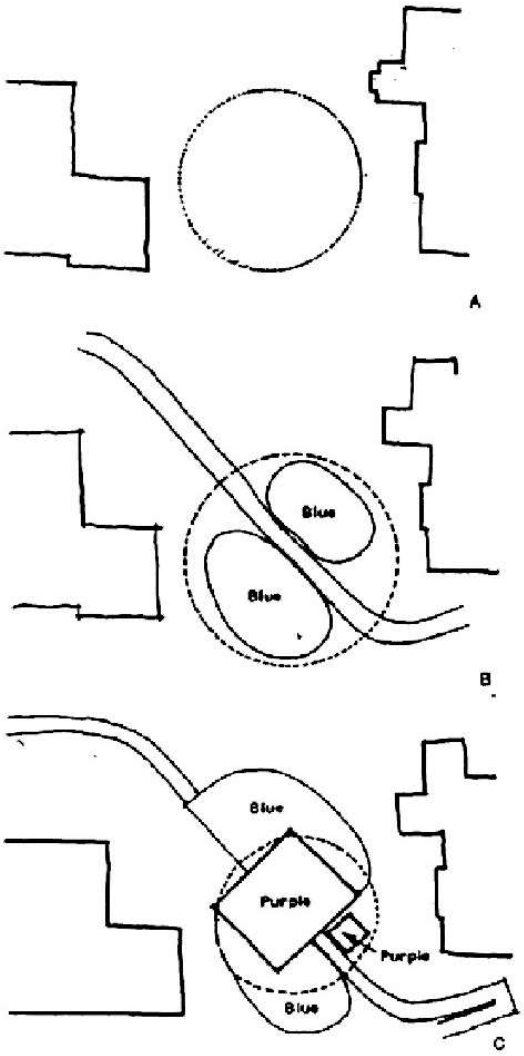


Fig. 16. Methodological interpretation of free-hand sketches, set up by Le Corbusier, illustrating the main phases of coming into being of the project of the Carpenter Center. Drawing by author based on free-hand sketch of Le Corbusier.

In the designing practice, after having finished the preliminary design (fordesign), one elaborates the architectural design, and then the architectural-building design, the building engineering design, the technical project, and the realization design. These are successive design project phases of the being designed building. When undertaking the analysis of the drawings left by le Corbusier, one finds that on each of the presented drawings (Fig. 20-27), Le Corbusier drew the communication system i.e. the path students pass between lectures and classes. Le Corbusier did not change the form of that path during the elaboration of the architectural design of the building of the Center. He only lifted it up by means of a platform onto the level of the first floor of the being designed in the building gallery of art, the bar and other functions generally accessible for students just passing along that path through the building. The presented sketches on the figures concern successive phases of the professional preliminary architectural process leading e.g. to elaborating the preliminary version of the architectural vertical section of that building.After reiterated modifications of the being designed architectural form, the circular form remains the visible feature of the form of the realized building (Fig. 27).

When summarizing theses considerations, one can state according to the opinions of Kellet that Le Corbusier who realized scores of design projects generally did not abandon the original idea but improved and defined it more precisely, used the technique of collage as well as paper models. In this way, he adapted the idea of the spatial solution to technical realia or technical parameters, to expectations or needs, and to materials and techniques accepted to be realized.

In his creative activity, Le Corbusier applied in general in his professional activity ferroconcrete structures, and these were the first applications of ferroconcrete in the world with such wide scope. For example, the Unité d'Habitation (Residential Unit) in Marseilles, 1947-1952 was the first modular prefabrication in house building engineering. The being analyzed sketches of Le Corbusier concerning the design project of the Carpenter Center, i.e. a building with ferroconcrete structure, present elements of a complex, creative process of the architect, conditioned in a many-sided way in the preliminary phase of that process.

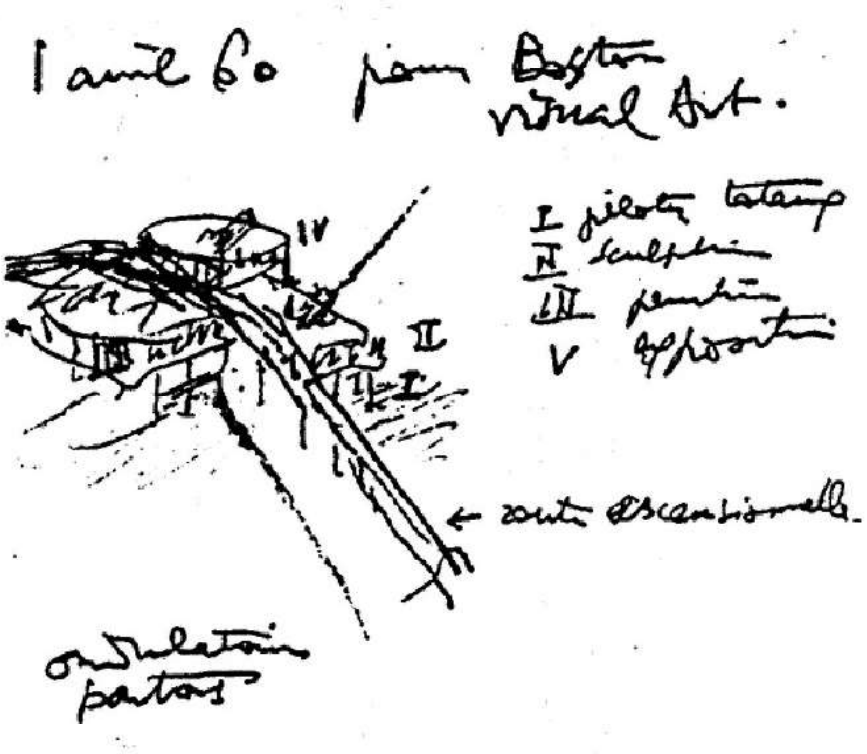
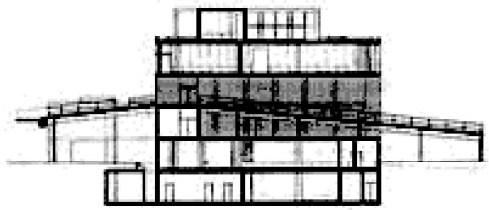


Fig. 17. Methodological interpretation of freehand sketch of Le Corbusier presenting the spatial and moving subsystem of the Carpenter Center building. Drawing by author based on free-hand sketch of Le Corbusier.

The presented freehand drawings of the object of the Carpenter Center of Le Corbusier illustrate the decision-making processes of the contemporary architect in the preliminary phase of that creative process. The development of an a priori design possesses features of a phenomenon of illumination. That is, as earlier mentioned, the acceptance by the designer of the a priori idea as being the idea of the design solution by assumption. The freehand sketches of the Carpenter Center as well as sketches of many other design processes performed by Le Corbusier arose for conserving what was not possible to be transmitted by words.

For contemporary architects-designers it can be useful to apply, in designing architecture, the a priori idea in an analogical way as done by Le Corbusier. That idea can in the preliminary phase of the architectural process, stimulate positively the natural creative possibilities of the architect-designer. The use of the a priori idea by Le Corbusier in the preliminary phase of the design process conduces to recognize that element in the design workshop of the architect to be a methodical element that assists and strengthens the creative forces of the architect-designer.



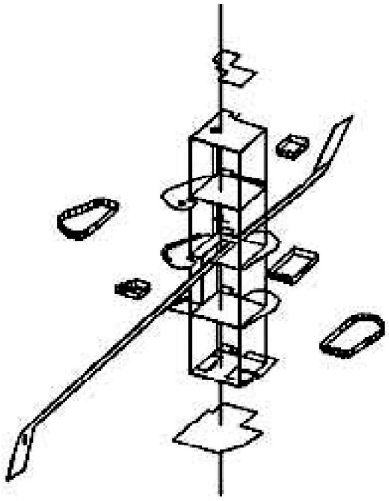


Fig. 18. Section through the exposition hall and moving subsystem of the Carpenter Center building. Drawing by author based on free-hand sketch of Le Corbusier.

Maybe the use of the a priori idea in the preliminary phase of the creative process will allow architects-designers a higher and greater creative freedom, creative imagination acting according to the assumed purpose, knowledge, skills, techniques as well as technical possibilities and limitations, to a higher degree. Numerous realizations of architectural and town development design projects of Le Corbusier fulfill, in spite of passage of time, the therein assumed and accomplished useful and esthetic presuppositions and needs, and inspire permanently positive emotions of the users of these buildings.

Fig. 19. Carpenter Center – the original form of a circle became characteristic for the being performed building. Drawing by author based on photo.

The a priori preliminary idea, accepted after a systematic and professional analysis of an architectural problem is being a characteristic element not only in the creative activity of Le Corbusier but also of architects of different schools and in different time.

The presented above methodics of shaping already historical architectural forms do illustrate and indicate new possibilities of development of architectural creative activity. Architects are more and more conscious of these new possibilities; they use them in a more efficient way, widening that application by methodical actions serving creative processes as well as serving the beautiful architectural form.

CHAPTER V

Methodical significance of freehand drawings of Le Corbusier and of Santiago Calatrava

Creating of sets of notebooks with freehand drawings performed by Le Corbusier and sets of freehand drawings performed by Santiago Calatrava is a feature being characteristic for both these creative architectural processes of these great creators in their preliminary phase [59, 60].

The role and importance of the sets of freehand drawings of the great co-creator of the modern architecture, Le Corbusier [61-65], cannot be overestimated. Le Corbusier executed many sketches already from his young age [65]. Many of his sketches are sketches of historical architecture, among them architecture of antique Greece and Rome. Le Corbusier left numerous sketches from his design processes. Irrespective of the realization of design work, i.e. individual and collective work, this architect-designer created important notebook drawings (of less than half A4 size), for instance as a kind of reminiscence of a journey. Le Corbusier, being a purist painter, generally painted before noon when the light was favorable and he designed as architect in the afternoon. Maybe this habit facilitated him transferring and modifying forms from painting onto architecture.

Forms from collections of notebook drawings and puristic painting were transferred by Le Corbusier onto architectural design, according to resulting practical need , for instance according to an order received for performing a design.

The notebooks of this designer constitute an open set of forms "kept in mind" in notebook sketches. These forms served for Le Corbusier to perform a creative search and consecutive modifications, e.g. of the solid mass just being designed. They became an inspiration in solutions of design details.

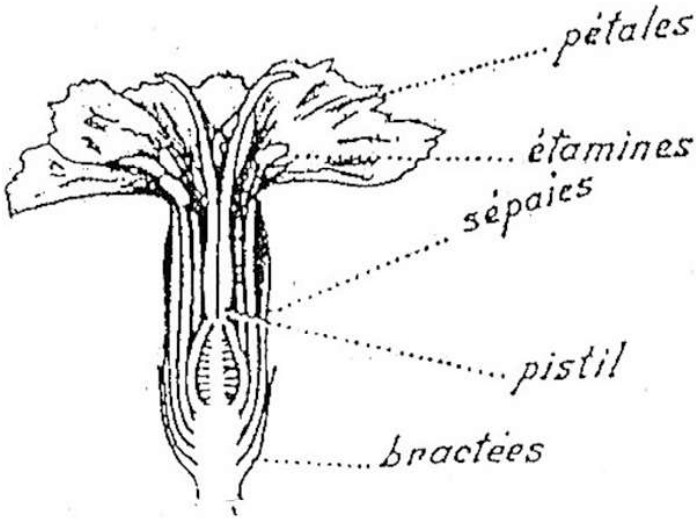
The documentation-based analysis of means of the creative activity of Le Corbusier, performed by Kellet [66, 67], is among others an analysis of mentioned here assembly drawings, the so-called notebooks documenting the arrangement (juxtaposition) of forms "kept in mind" in currently executed notebook sketches. Le Corbusier joined fragments of these freehand

drawings with each other, often after many years, and used them in a methodical way. Such methodical activity created a specific kind of library of forms contributing to methodological analyses. These reference collections of forms, which were recognized by the designer to be interesting, were then used in his preliminary architectural design processes.

Many historians of architecture enhanced and do enhance, together with the Foundation of Le Corbusier (having its seat in Paris), the problem of sketches of Le Corbusier [65, 67]. At present, these works and other works of Le Corbusier are often exhibited on periodically organized exhibitions as well as in magazines, for instance in the Journal of the Foundation of Le Corbusier. Jencks, a contemporary critic being passionately fond of the creative activity of Le Corbusier, wrote that Le Corbusier joined technical determinism to a certain extent with a broad interest in the form (Fig. 12), the shaping whereof he elaborated in the first phase of the architectural process with having recourse to his old sketchbooks [66, 67].
Such differentiated approach to design problems allowed him to create a whole repertory of new forms – architectural signs and, maybe, to create a new language of modern architecture. For architects-designers and users of his architecture the important fact consists therein that the forms of Le Corbusier are various and semantically rich. Jencks [48] stated that in those sketchbooks Le Corbusier collected so many original signs-forms that it could make possible to solve even very complicated functional problems. In a sense, one can, as stated Jencks [ ], design an entire town by using only the graphic words-signs that he had created or, at least, improved or modified. That is a not terminating museum, as comments R. Kellet these architectural sketches [66, 67] as explorer examining his creative activity.

The plans of development of a town are plenty of graphical signs or forms taken directly from his puristic painting. An example thereof is the plan of the town of Algiers [A. Prokopska hab.]. In like manner, numerous created spontaneously collections of drawings of the contemporary Spanish architect and construction engineer Santiago Calatrava, with world-wide reputation, exert a creative influence on the preliminary phases of the architectural processes of this author. Many freehand sketches of Santiago Calatrava [68, 69] constitute an inspiration for his organic architecture. The organic architecture of Calatrava starts with a specific creative process, particularly in the preliminary phase. This artist takes his inspiration from forms of natural things. He begins his creative process from sketches of things existing in the nature.

This architect-designer, analogically as did Le Corbusier, does not begin his design from projections/views and sections. Calatrava begins his design so as contemporarily do many architects from freehand sketches [68, 69]. Calatrava draws birds, human shapes, animals, also naturally curving sheets of an open book. In the works of Calatrava as architect and designer-constructor of many bridges, one can read his fascination by forms of the nature [70-72]. For example, Calatrava draws the silhouette of a horse (Fig. 13).



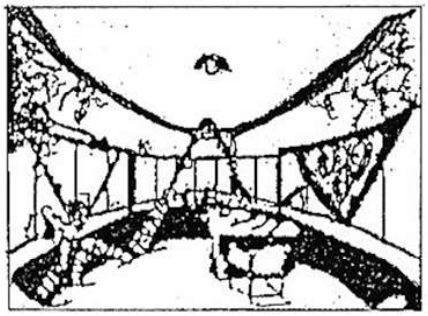


Fig. 20. Methodological interpretation of study of a flower form. Drawing by author based on free-hand sketch of Le Corbusier.

The sketches of the silhouette of a horse became the archetype for the bridge in Valencia designed by Santiago Calatrava. Based on sketches being modeled upon the nature, and strictly speaking based on perceived therein fragments of forms, accepted by him as to be inspiring, Santiago Calatrava creates the model of a bridge (Fig. 13). Then, as design engineer, he makes this model more realistic by using classical engineering, constructing and architectural knowledge.

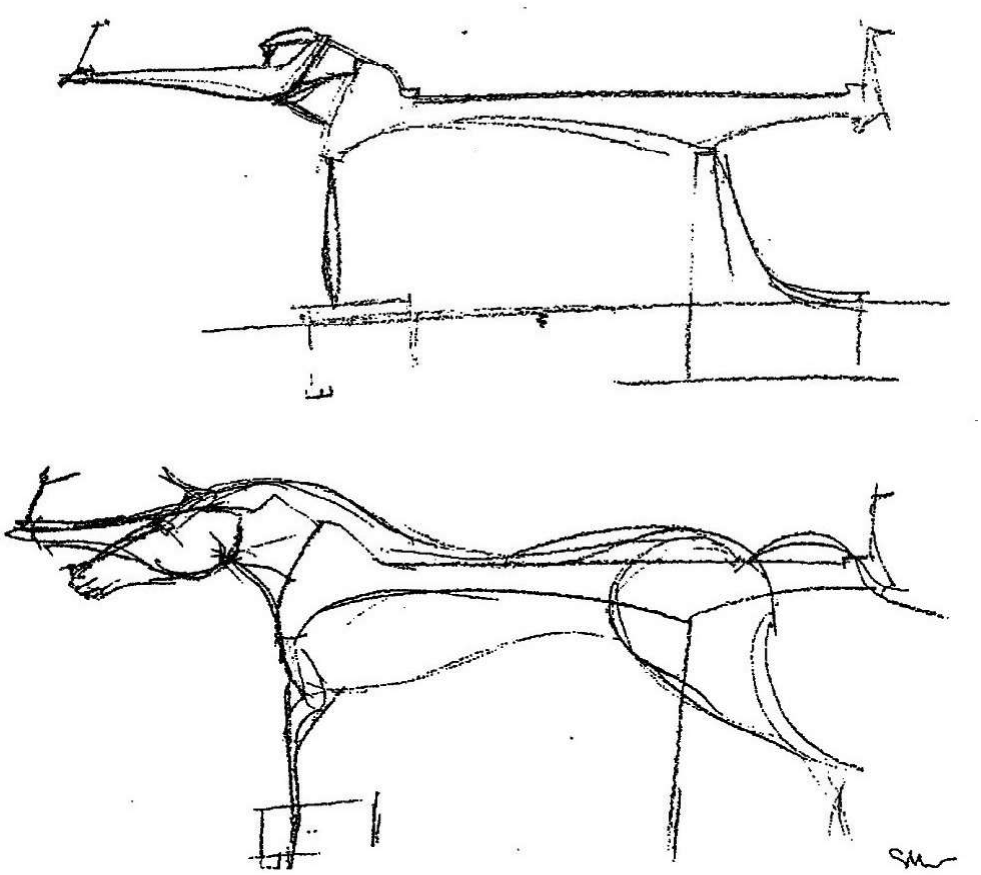


Fig. 21. Methodological free-hand sketch of a horse of Santiago Calatrava. This sketch was the archetype of the bridge 9 d'Octubre in Valencia. Drawing by author based on free-hand sketch of Calatrava.

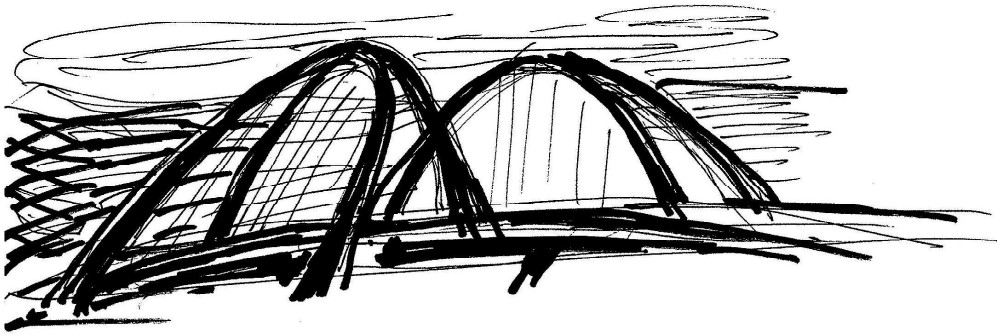


Fig. 22. Bridge in Barcelona, of Santiago Calatrava, a bridge of the beginning of the nineties; modern example of an organic form in architecture. A ferroconcrete bridge.

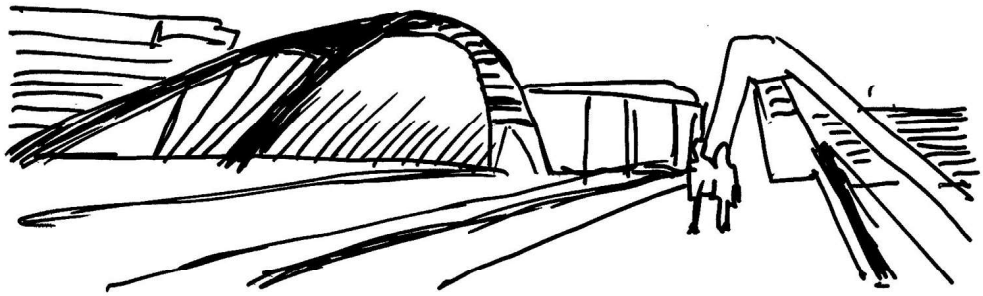


Fig. 23. Santiago Calatrava. Bridge in Barcelona. View.

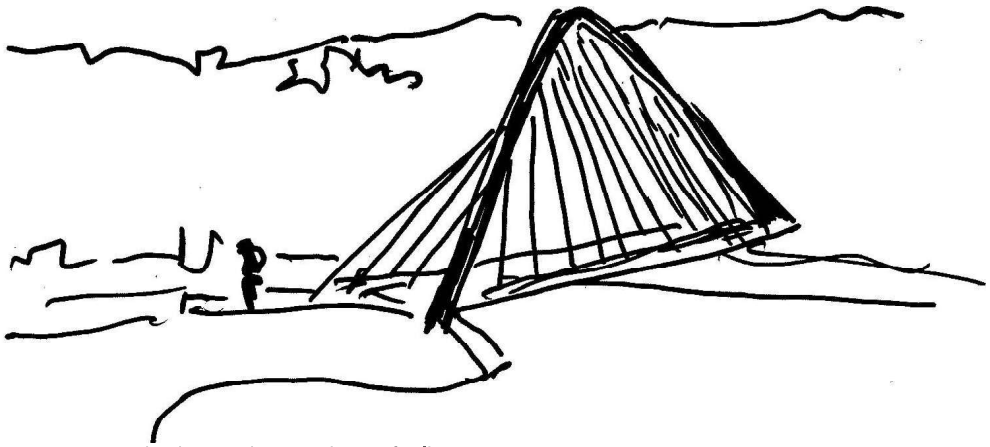


Fig. 24. Footbridge on the periphery of Bilbao.

In this way, his numerous bridges and other buildings came into being. Before the buildings of Calatrava became professional design projects and engineering realizations, they were drawn ideas of unity of construction and form, e.g.: shape of a flying swan (bridge Pont d'Austerlitz in Paris), head of a bull (structure of the bridge Puente sobre el Guadiana in Merida, and also bridge in Seville Parnas San Lazaro), silhouette of a horse (bridge 9 d'Octubre in Valencia), boughs of trees – it was an inspiration of BCE Place Gallery in Toronto and of other galleries in other cities of the world.

Santiago Calatrava, a Spaniard, belongs to the few creative architects who were successful in connecting the contemporary achievements of engineering with organic forms. The personality of Calatrava is extraordinary, analogically to the personality of Le Corbusier. Santiago Calatrava joins three professions: of sculptor, architect and design engineer. Undoubtedly, his architectural and design engineering-based education (defense of doctoral thesis in the domain of building engineering) contributed to his professional activity.

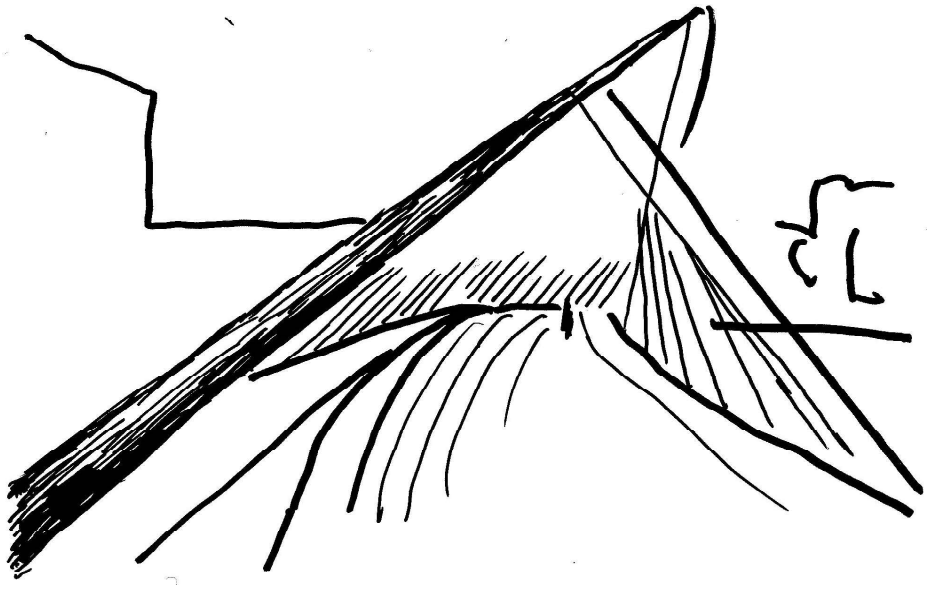


Fig. 25. The presented foodbridge of Santiago Calatrava, Campo Volamin in Bilbao, is realized as ferroconcrete construction. Steel suspension members are used.

Santiago Calatrava takes into consideration the conditions discussed above and so he obtains in his architectural solutions of different buildings, of bridges, the unity of form and structure (Fig. 15-18). In the preliminary phase of the creative process, he searches in the nature for such unity. Thanks to "organically" shaped forms, the architecture of Calatrava seems to be, already in the preliminary phase, particularly close to the man. One can meet in Calatrava's works slender elements that are thickly spaced as ferroconcrete or steel ribs. The esthetics of the architecture of buildings, among them of bridge structures of Santiago Calatrava (Fig. 14-18) is connected with the obtained in these solutions unity of architectural form and structure, being observed in organisms. This integrating, whole-based aspect is the feature of each natural system, also of the designed by him architectural solid mass. The whole controls the components, and subordinates the components. In other words, from the architectural point of view the proportions of parts to the whole are here essential. In architecture, as result of these specific relations between parts and the whole we have, generally, no doubt that a given part belongs to that and no to another whole [15].

The designing process is a mental sequence, taking place in the first phase of the process of architectural design, partially in the subconsciousness of the designer. For designers having a design experience, a synthetic approach is possible, e.g. of the form of a bridge adapted to many various architectural, structural and topological requirements (Fig. 18). The creative way of behavior of the architect can make possible, in consecutive designing steps, to select the final, rational conception of the solution. A further efficient elaboration of the technical design project of a bridge or/and a building is carried on according to rational principles of the construction process and with other requirements.

In the creative process of Calatrava the finally accepted in consecutive phases of the design process and then elaborated form and structure of a bridge or of another building is a working/functioning whole, in which parts are not mutually contradictory but, on the contrary, are mutually complementary.

The effect of such design process consists in the fact that, for instance, the bridge does not lose the esthetic values being assigned earlier. This approach being used by architects and design engineers in a more or less consequent way and, largely intuitively, can be observed in the design achievements of Calatrava. It is visible in the presented examples of designs of buildings.

The architectural task should fulfill the following conditions: esthetic, static, material-based, functional, psychological conditions as well as other conditions, e.g. resulting from the context of environment where the being designed object will appear, for instance the space of a street. Let us compare the freehand drawing of S. Calatrava, Fig. 14a, and the realization thereof: the view of the object on Fig. 14b.

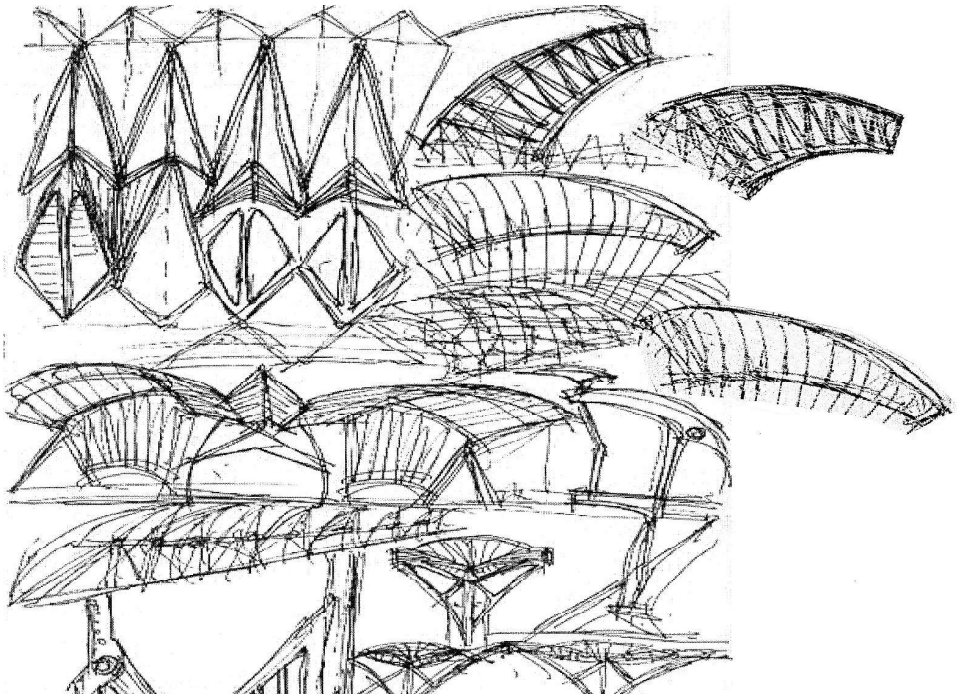


Fig. 26. The free-hand sketch of Calatrava, so as many other sketches of this Author, possible to be found In books and articles related to his architectural creative activity, and also in the Internet. Forms indicated on the drawing as a and b are exemplary forms that many times were methodically used by Calatrava after necessary modifications in his designs of buildings, e.g. of bridge buildings. Drawing by author based on free-hand sketch of Calatrava.

The use, in the realized objects, of forms possible to be found on earlier freehand drawings proves the application of a design way that, maybe, is transformed in course of time in a methodical approach of many different creative actions of this famous architect.

In the presented on Fig. 14a,b freehand sketches and in the formally connected with these sketches architectural realizations, oriented independently of the above onto construction (structure), one can remark a methodical approach of Santiago Calatrava to design processes. The freehand drawing of Calatrava on Fig. 14a has been completed by a fragment of a photograph (Fig. 14b). That also is a fragment of creative considerations concerning the preliminary phase of the architectural process.

Many similar examples of formal dependence (Fig. 14a,b), concerning forms of sketches and being often later realized forms of architectural objects can be found in the creative activity of this artist-architect.

The complex design-creative process of Calatrava assures shaping the architectural form as well as the construction (structure) adapted to spatial features of the place of realization; an example thereof is the solid mass of the Airport, inspired by the wing of a bird (Fig. 19).

In conformity with the contemporary architectural knowledge, the complex design-creative process that fashions the architectural form and the construction is a logic mental sequence where the preliminary phase plays a significant role.

This approach seems to refer fully to the creative activity of many architects, not only for instance to Le Corbusier and Calatrava, what appears to fill with optimism. Such optimism is connected with the faith in the realization of the needs of the human being, independently from his/her domicile in the world. That concerns also the growing new possibilities of development of the contemporary architectural art and technique. These architects take into consideration the general and particular tasks that the given, being elaborated architectural solution and realized object has to fulfill.

Fig. 27. BCE Place Galery, Toronto, Santiago Calatrava.

From the architectural point of view, the preliminary phase in the creative processes of Le Corbusier and Santiago Calatrava includes, among others, freehand sketches of forms found in the nature and processed (transformed) in the creative architectural process, into design projects of buildings. The presented discussions concerning different buildings of both these Creators are the proof of a methodical use of freehand sketches in their architectural processes.

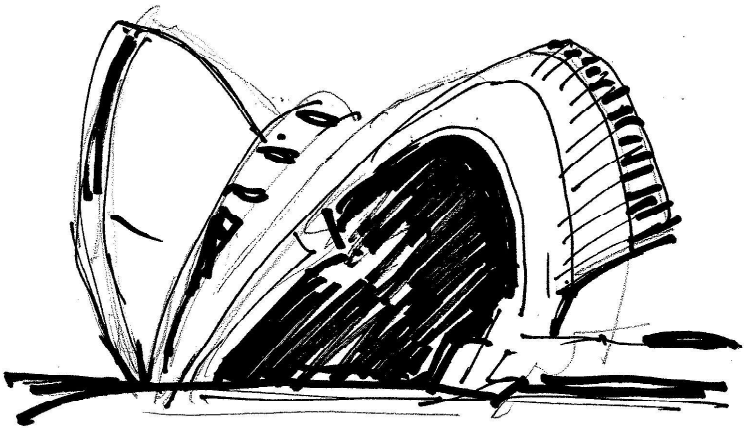


Fig. 28. Air terminal Satolas in France, 25 km from the center of Lyon. That object was realized during 1989-1994.

CHAPTER VI

Ecological habitats and forms of pro-ecological architecture

Processes of architectural design, connected with designing habitats and pro-ecological architecture, require an interdisciplinary and methodical approach to problems of design because of differentiated technical, technological and ecological conditions, to which the processes are subject and which they take into consideration.

Forms of architecture, also forms of pro-ecological architecture are shaped to a high degree in the preliminary, interdisciplinary creative process where architectural assumptions and conditions as well as the use of, for instance, selected new technologies have an influence on the architectural form of buildings.

The presented examples prove that it is possible to realize modern architecture according to knowledge and science, technique, requirements of pro-ecological architecture as well as the independent and timeless need of the human being, i.e. the need for living beauty.

In the discussed examples, the specific technical functions and the applied there technical systems have not influenced in a negative way the structure/construction or the esthetics of the architectural solid mass.

When searching for methods of improving the quality of the environment, architects return to the idea of habitat [75, 76, 77, 78, 90]. The notion of ecosystem, thus also of habitat, is connected with survival of the human being on the earth and with conservation of the terrestrial nature. The considered examples present an ecological architecture that fulfills the various and multi-aspect needs of the man. In these examples, the pro-environmental way of carrying on the process of designing is realized that, beside ecologically positive solutions, concerns also and mainly the reduction of financial outlays destined for executing the building

Such examples are discussed from the point of view of significance of the creative preliminary design phase in the mentioned interdisciplinary architectural processes; they indicate the high degree of complexity of the architectural ecological creative processes. With that kind of problems, the necessity of undertaking an analysis of design questions according to praxe-

ological, methodological and systems-based knowledge is associated. The contemporary possibilities of creating habitats and forms of pro-ecological architecture constitute a problem that arose in the technically conditioned pro-ecological architecture. That is a great challenge, with which the architecture of the future is faced. The progress in the future will depend upon a successive and more and more common solution of that problem. Maybe habitats will assure greater and greater managed spaces or architectural environments where the man will live readily and with pleasure.

The process of shaping the space of the more and more expanding architectural environment as a being built environment is associated with an absolute kind of entering into the natural environment, the space of which, so as the space of the (our) planet, remains finite. The ecological and systems-based point of view in architecture conduces to considering the being designed building as a functioning whole that becomes a part of a greater whole, or ecosystem.

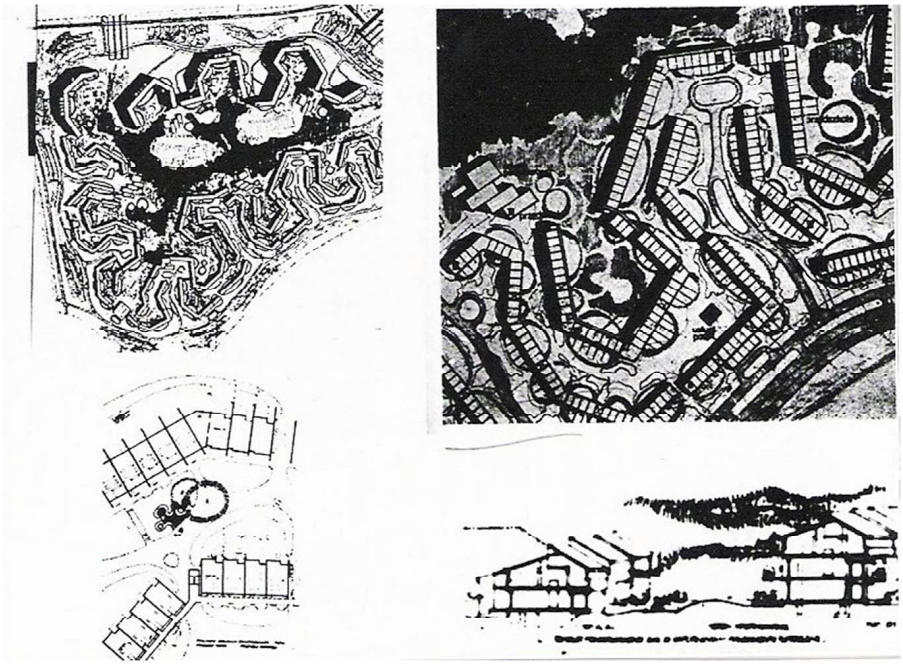


Fig. 29. Examples of habitats - spaces of defined dimensions associated with a certain social group size.

The European Landscape Convention declares for a legal recognition of landscapes as an essential component of the surroundings of the man. In that convention, "landscape" means an area perceived by people. The character of that area is a result of action and reaction of natural and /or human factors. In the light of the above-mentioned formulations, the habitat and the sustainable development are connected with a friendly and harmonious shaping of the architectural environment coexisting with the nature.

The habitat, as existing and desirable place, is being contemporarily perceived and considered by biologists, ecologists and architects in different climates, cultures and fragments of the terrestrial globe. The habitat-self is a fragment of the natural environment favoring the health and condition of the human being, where the man willingly and healthily resides. The space of the natural environment, determined as habitat, is historically associated in different types of place of residence, with temporal sojourning by the man in temporary houses (for instance in tents) or permanent houses. A habitat can be composed of a selected fragment of the natural and of an architectural environment, e.g. an apartment house or housing estate and of the surroundings. A habitat being referred not only to problems of the architectural environment is defined as a „living system" or an organism. A habitat is a composite spatial system of elements of buildings with different degree of technical complexity, and of actions and processes occurring in the so determined built-type environment and natural environment. The characteristics of all natural, cultural and technical factors illustrate the complexity of the habitat that can be found in different climates, cultures and fragments of the terrestrial globe. Independently of the existing habitats, one can create new ones. A habitat can also be connected with pro-ecological technologies, saving the environment, e.g. urban, rural environment, through improving its biological, architectural, technical quality and improving the comfort of residing. For example, scientific conferences serve the promotion of such activity as discussion forums in an interdisciplinary approach [7, 44, 45, 78, 80] on the possibility of searching for an improvement of the life, e.g. in house complexes.

According to the architectural art, the habitat can result from coupling the internal space of a house, e.g. an energy-efficient house, with the external space of a fragment of the natural environment into a functional system. These spaces, when joining, interpenetrate in a physical sense as well as in psychological and plastic sense.

One of the most famous houses is the weekend house "Falling Water". Wright began the realization of that design-project in 1936, and finished it in 1937. He designed this house for the owner of a warehouse in Pittsburg, E. J. Kaufmann at Bear Run, Pennsylvania. For the construction of vertical elements, stone was used, of the horizontal elements – concrete (ferro-concrete). The cost of the house was 155000 $, the salary of the architect was 80000 $.

A historical example of a habitat near the building of the Savoye Villa of Le Corbusier is a weekend building, the famous house at the waterfall, of L. Wright, sunk into the landscape. A part of the water of the fall flows slowly through the terrace of that building, heating in sunny days and giving joy for the inhabitants and the visitors. An inalienable feature of the pro-ecological architecture is the creation of a friendly and healthy environment assuring a comfort of residing as well as possibilities of energy saving; as an effect, such advantages contribute to maintaining an energy-dynamical equilibrium of the natural environment and of the planet.

It is impossible to design pro-ecological buildings without having previously analyzed, at the phase of the fordesign (preliminary design), the architectural and technical design assumptions concerning the planned pro-ecological values. Therefore, the preliminary phase of the design process is the decisive phase in such an architectural and building-engineering enterprise. The contemporary progress in technique, technology and organization of work conduces to the phenomenon of collective development of an architectural achievement. From the ecological point of view, the consideration of the process of architectural design as an interdisciplinary process leads to reinforcing, in that process, the creative role of the architect standing at the side of the human being. The interdisciplinary process of architectural designing is a process of shaping an architectural form that is conditioned in a multi-sided way.

Contemporary forms of pro-ecological architecture are, for instance: the architecture of the Geothermal Heating Plant in Reykjavik (Fig. 28-30), the ecological house Heliotrop (Fig. 31, 32), the building of Franc O. Gehry – Energy Forum in Bad Oyenhausen (Fig. 33-37) [81, 82, 83]. The mentioned solutions show features of pro-ecological architecture, they harmonize with the environment, they enhance the qualities of the environment and they preserve the identity of the place. From the systems-based and ecological point of view, the consideration of the process of architectural design as an interdisciplinary process conduces to reinforcing, in that process, the creative role of the „ architect who stands at the side of the human being". Such viewpoint leads to considering the being designed building as a designed whole that is, at the same time, a part of a greater existing and functioning whole, i.e. of the environment. According to the knowledge concerning living systems, one can consider the being designed and realized whole in interdisciplinary teams as a functioning organism to some extent.

The contemporary development of technique, construction engineering technologies and organization of work leads to the development of the phenomenon of collective arising of the architecture achievement.

Examples of interdisciplinary designing illustrate the possibilities of creating pro-ecological architecture and present new technical, technological and material-based possibilities of creating the architecture, i.e. the space of human environment. In objects of pro-ecological architecture, modern pro-ecological technologies are used as solutions of the contemporary science and technique, among others of engineering art, material engineering, computer science, physics of buildings. Taking into consideration the specific characteristics of technologies applied in buildings, the forms of these buildings often are subject to specific technological requirements already in the preliminary design process. As a result, these buildings have an architectural solid mass connected with the application of innovative technologies that protect, in various ways, both the environment and the human being.

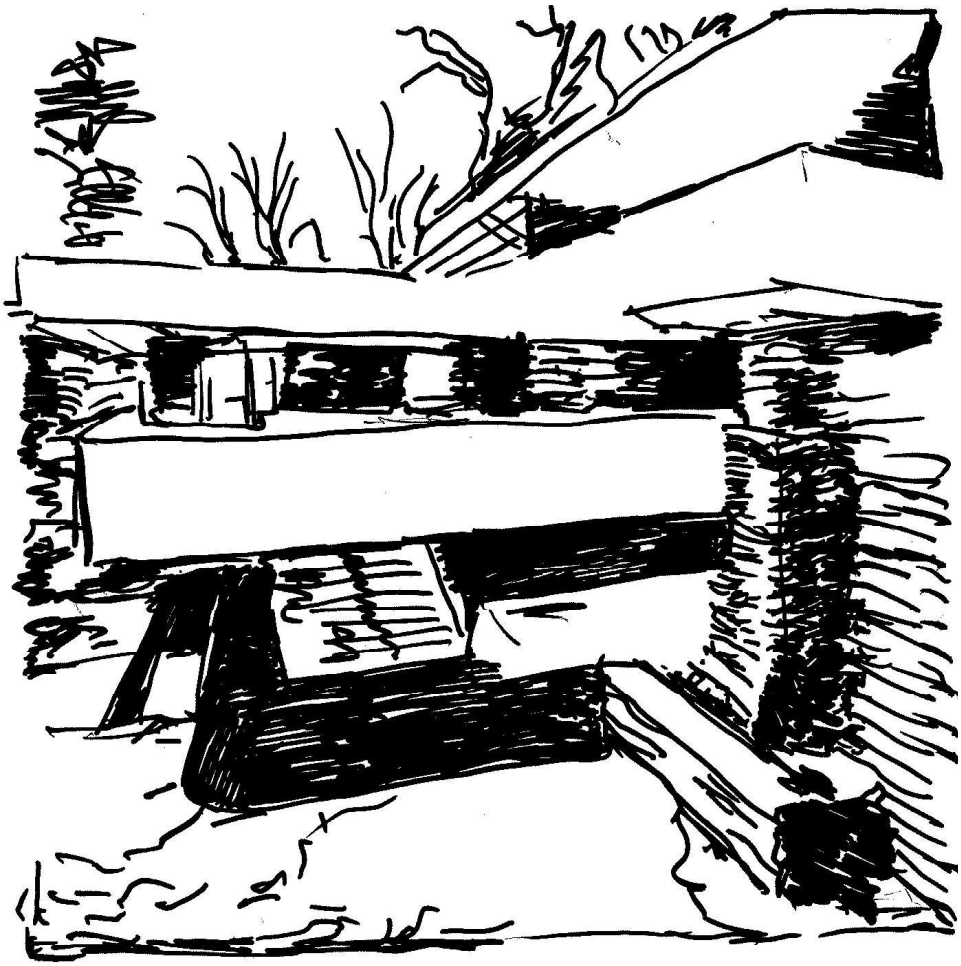


Fig. 30. A historical architectural object, being a pro-environmental solution.

The presented example (Fig.) concerns Reykjavik, the capital of Iceland, where hot water sources are directly used for heating houses/apartments. In Reykjavik, the heat of thermal waters assures heating more than 80% of residence resources.). It is a well-liked place as well as a place of great resort, a popular and now restored object of that town.

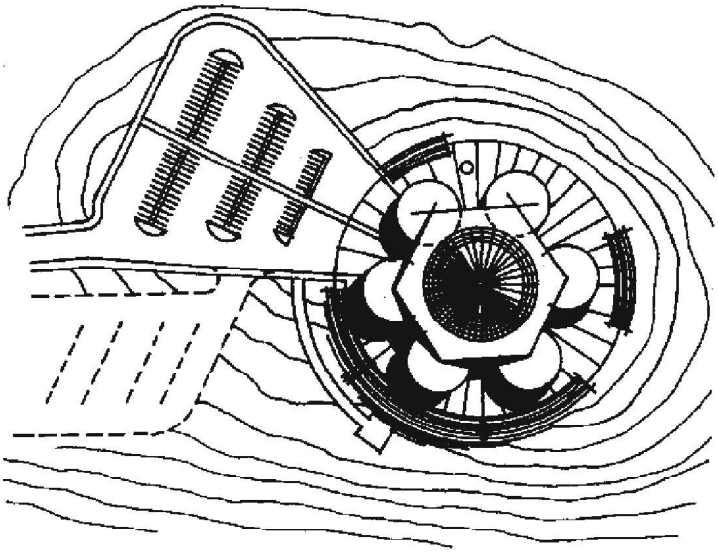


Fig. 31. Reykjavik, Iceland. Geothermal heating plant. Drawing by author based on original drawing.

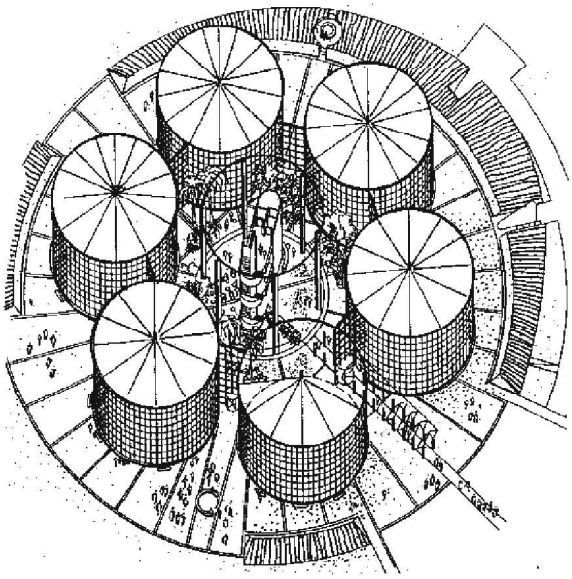


Fig. 32. Reykjavik, Iceland. Geothermal heating plant. Axonometry. Drawing by author based on original drawing.

Six cylindrical tanks of hot water are located one to another as flower petals (Fig. 28-30). The internal space between the tanks (that could, according to the first assumption, accommodate 600 persons), is covered by a glazed dome executed of reflexive glass (and full of various green plants, among that of tropical green plants). The glass dome is located above the tanks of thermal water, executed of concrete. This building heats the housing estate in the neighborhood. The fundamental functions of the object include a greenhouse and a palmhouse as a rest place being popular with the inhabitants, a restaurant, a nursery, a hotel, conference halls, movie rooms and others. The form of the solid mass of that building results directly from the technical requirements of the building structure of the geothermal heating plant. The applied industrial technology did not constrain the creative vision or the architectural creation, and became an architectural creative inspiration. Because of specific requirements of the applied geothermal technology, i.e. because of the necessity of construction of ferroconcrete tanks for thermal water, the architect made the fundamental decisions in the preliminary creative design phase.

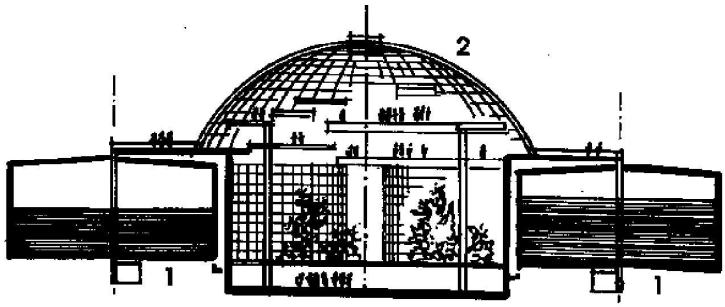


Fig. 33. Reykjavik, Iceland. Geothermal heating plant. Drawing by author based on original drawing.

Also interesting and original from the point of view of the undertaken theme „habitat" as an ecosystem and form of pro-ecological architecture, is the already historical example, namely the executed in Germany ecological house – Heliotrop (Fig. 31) [84,85].The name is derived from the Greek language Helios – sun and tropos – turn, rotation. On Fig. 34, that house is visible on the background of an urban building development.

This house is an object that was designed and financed by the German architect Polf Disch and was put up for continuous sale on the German market in the nineties of the 20th century. The object possesses many technical solutions being friendly for the environment; thus, one can call it an ecological house [86-89]. Source of heat are solar collectors. In that house, one has foreseen sewage treating, composting organic wastes and utilizing rainwater. The low storey is destined to assure the functions of garage and other auxiliary rooms. Heliotrop is a cylinder rotating on a centrally located shaft with wooden structure (diameter 2,6m, glued wood)

being reinforced by steel shackles. In that shaft, the staircase is located. The usable floor area is 200 m2. The glazing is executed with triple glazed windows filled with krypton; this solution assures obtaining an overall heat-transfer coefficient K= 0,5 W (m2k). This coefficient for the floor, the external wall and the flat roof is about 0,1.

A computer program watches over the regularity of the rotations and over other functions in that object, e.g. functions connected with the optimal use of the solar panels being mounted on the roof. According to the assumptions, all kinds of materials applied for the construction of the building can be used for the second time. The function of living/residing (Fig. 32) has been completed by office functions and technical functions. Another variant of functional solution is the hotel and restaurant. The architecture of that type, connected with the application of solar technologies, assures a limitation of energy consumption and contributes to a reduction of the greenhouse effect as well as to the protection of the ecosystem of the Planet.

Fig. 34. Ecological House – Heliotrope.

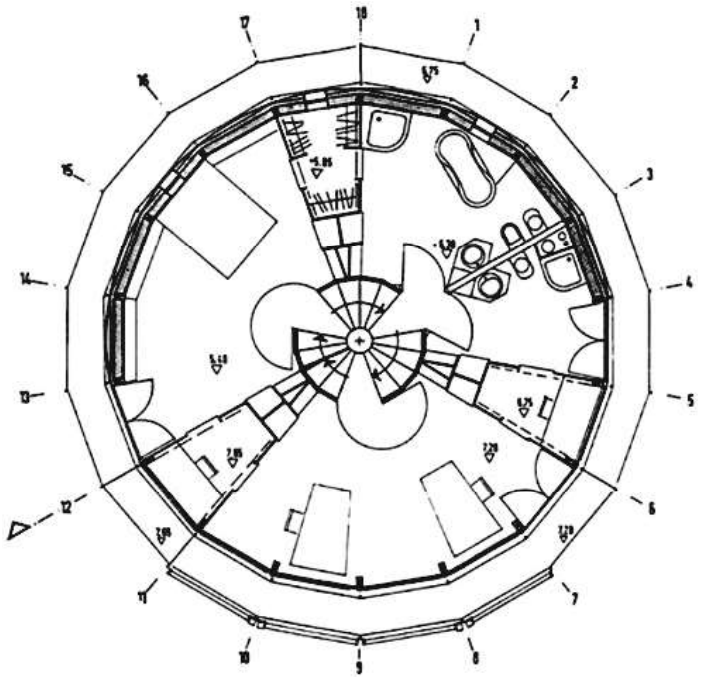


Fig. 35. Floorplan of the ecological house heliotrope. Projects of such type are still being realized.

It is an attractive, rotating building, the shape of which is determined as a result of the assumed main function and of the applied technology allowing rotating after the sun. For the sake of specific characteristics of that rotating building as well as the used there pro-ecological and structure-based technologies, the decisions concerning the organization of its space or architectural decisions were made in the preliminary creative design phase. The design process of the being analyzed building is a process that is connected with an interdisciplinary collaboration of several teams of specialists, among them of architects, designers-engineers, computer scientists, artists and visual (plastic) artists [87, 88].

Another historical example that is interesting from the point of view of the architectural preliminary creative process and of the architectural form, as well as of the applied there various pro-ecological technologies is the Energy Forum (a service center of energy network). (Fig. 33-37) in Bad Oyenhausen. The author of that building is the architect Frank O. Gehry, who worked together with an interdisciplinary team. Maybe, the architectural form of the Energy Forum in Bad Oyenhausen (Fig. 33, 34, 35, 36, 37) is an example of a future architectural and technological solution. Maybe also, the general interest in and the architectural attractiveness of that object, what is associated with a friendly shaping of the environments as well as with the quality and the technologies of that Forum [87-90], became one of many reasons of a further dynamic development of pro-ecological technologies in Germany and in entire Europe. In that object with ferroconcrete structure, analogically as in the case of the earlier

mentioned object, the most modern in that time solutions of contemporary science and technique have been applied: namely of engineering art, material-based engineering, computer science, building physics [91, 92]. That object is, analogically as the earlier discussed Heliotrop house, a result of an interdisciplinary collaboration of teams of specialists of many knowledge disciplines [93]. Because of its functions and the applied there pro-ecological technologies, that building became an inspiration for many imitators. Such architectural solution saves and gains energy in a not conventional way. The building is characterized by the use of informatic technologies of the 20th and 21st century as well as by interdisciplinary design.

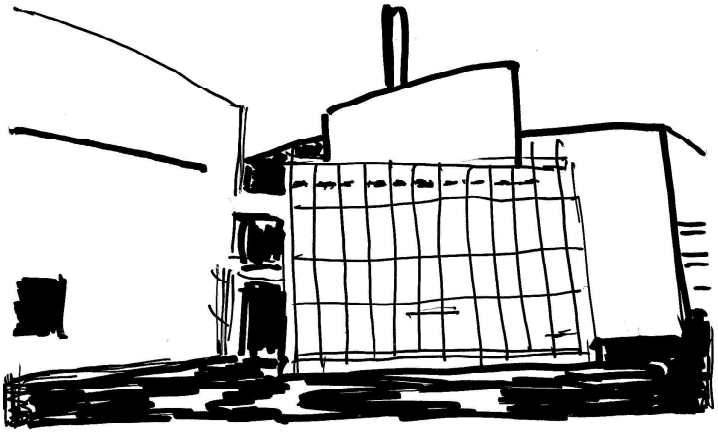


Fig. 36. Energy Forum. Frank O. Gehry, 1996.

Subtle, extended architectural forms are partially built into the traditional environment of this little European town. For people visiting the city of Bad Oyengausen, this building brings to mind a spaceship of a new generation that stopped here for a moment. However, others say that there is a lack of context of place. Maybe, the first cited here association is more attractive for tourists who, in numbers, visit that already historical place when taking into consideration the present development of pro-ecological technologies. The extended architectural forms in Bad Oyenhausen possess their own language of architecture that express the intentions, purposes, feelings, presentiments of the architect-creator and of the designing team. At the same time, the forms applied in that ferroconcrete building enabled for their easier and more conscious adaptation to specific needs what concerns the used there modern technologies.

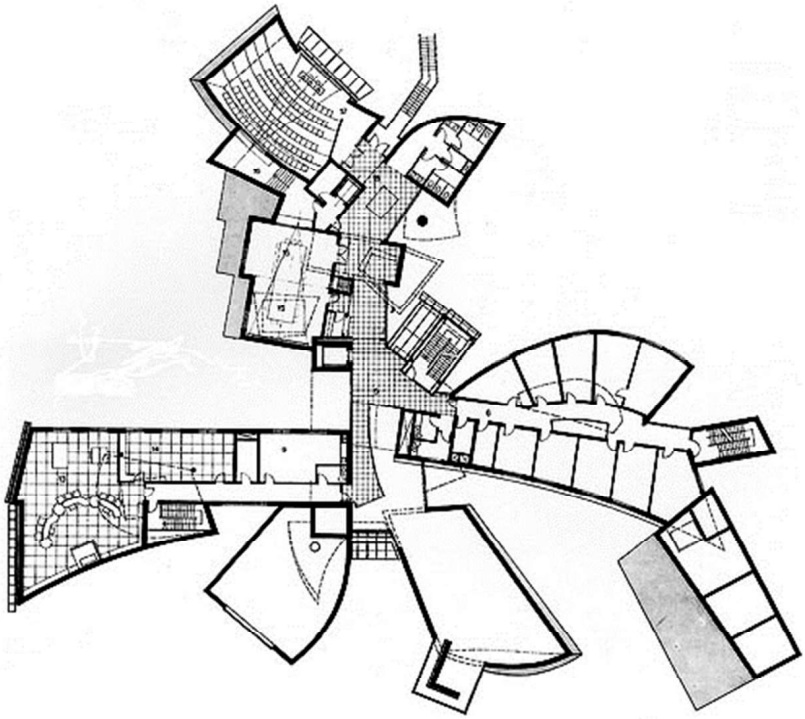


Fig. 37. Bad Oyenhausen, central service of power network. Floorplan of the project of Energy Forum.

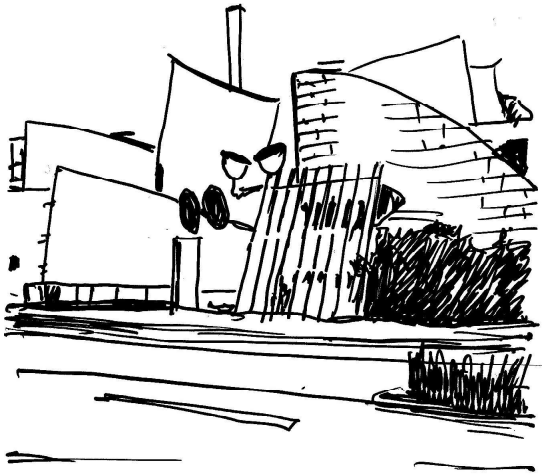
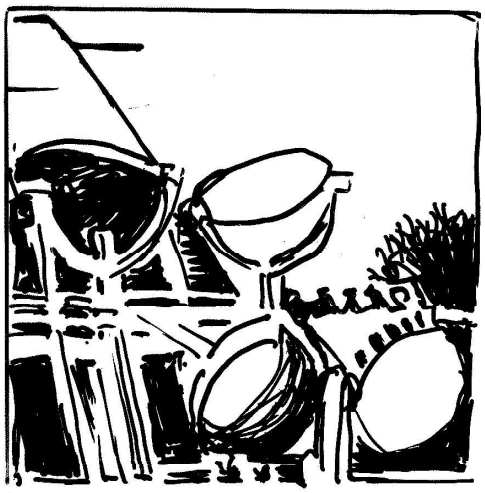


Fig. 38. Energy Forum, view.

Rys. 39. Bad Oyenhausen, Centrala obsługi sieci energetycznej. Elewacja kotłowni.
Fig. 39. Bad Oyenhausen, central service of power network. Facade of the boiler house.

Beside the necessary technical rooms, different functions have been realized in that building, among others conference rooms, exposition rooms and movie rooms, as well as a nursery. Maybe, the main intention and inspiration of that building was to propagate the numerous pro-ecological technologies that have been applied there.



Rys. 40. Oyenhausen, Centrala obsługi sieci energetycznej. System luster prezentujących techniczną możliwość doświetlania światłem dziennym wnętrza budynku.
Fig. 40. Oyenhausen, central service of power network. System of mirrors presenting the technical possibility of additionally lightening the inside of the building with daylight.

Two pairs of circular mirrors as „heliostat" (Fig. 37), located at the main entrance of the building constitute a sculpture accent and an element of the architectural form of the building. These mirrors confirm the possibility of additionally lighting of hardly accessible places in the building. The mirrors, with a diameter of 1,6 m, each with a weight of 600 kg, with electronic control, guide the solar light into the exposition rooms of the building. Generally, the used there systems control and optimize with high precision and in an individual way the production and distribution of energy in the building, thus contributing to saving energy and improving the comfort of utulizing the rooms. On the south wall (of the center of network service) a transparent thermal insulation is executed. The glazed roof of the auditorium was executed as an „energy system" including several different functions: producing electric energy in photovoltaic cells, uniform additional lighting of the interior by stray light and protecting against over-heating. The building has adapted its dismembered form to the main fulfilled task, namely the promotion of contemporary pro-ecological technologies [89] and it has capitally discharged of this task.The building is systematically visited not only by tourists but also by students of the near faculties of architecture and building engineering.

CHAPTER VII

Methodological premises of improving the architectural processes in their preliminary phase

Notwithstanding the differentiation of culture and the existence of distinct social instruments, practices and skills, we are searching at present for confirming our particular human community, as well as the resulting thereof responsibility of architects in the contemporary civilization. From the point of view of the architect, one of the barometers of that responsibility is the separation and the shape of the existing and the being designed space wrote Prof. H. Skibniewska [ ].

The present development of systems-based knowledge and design methodology allows for methodical investigations and analyses of the process of architectural design [prok, nadler, altszuler]. The existing knowledge concerning design methodology permits to describe, in an objectified way, elements of the architectural design. On the basis of the already existing architectural knowledge, design methodology, contemporary knowledge concerning systems theory and praxeology, it is possible to perform a more and more objectified research on creative design processes in architecture.

Methodical premises of improving design processes in architecture, in the preliminary phase of these processes, were determined to be possible on the basis of earlier carried on scientific investigations and methodical analyses concerning exemplary architectural preliminary processes. Famous achievements of contemporary architecture of outstanding creators: Le Corbusier [94], L. Wright [18] and S. Calatrava [95] were selected for methodical analyses. The presented analyses can constitute a contribution to further methodical research having in view and serving the improvement of design processes in architecture and town planning.
The observed methodical and innovative approach in creative processes is a partially intuitive application of elements of methods or/and methodical approach in designing architectural forms, for instance by Le Corbusier, L. Wright and S. Calatrava. The artistic creation of the presented achievements concerns mainly the preliminary phase of the architectural process.

The power of artistic creation of the achievements of these architecture creators [92, 93] determines the force, rationality and efficacy of the intuitive use of elements of methods as well as of the methodical approach to design. The present development of the civilization is associated with acquiring the new, still and again amazing systems-based knowledge, also computer science (informatics) and design methodology. That knowledge is an effect of tendency to make the acquaintance of the reality, tendency about which A. Einstein wrote that it was for him one of the independent aims, without which the conscious acceptance of existence seems to be impossible for a thinking man.

One has to reckon, to these problems, also considerations concerning the architectural form, also methodical, methodological and systems-based considerations. An effect of such considerations is the conclusion that the design method is an intellectual tool that is possible to be more generally used in architectural design and teaching. The form is an inalienable feature of the nature, and shaping the architectural form is an inalienable feature of the conditioned in a many-sided way process of architectural design. Antoine-Augustin Cournot [10], (1801-1877 – L'ordre et la forme) noticed that „without respect to the object concerned by our observations and our research, the form is what we most easily recognize". He admitted that „this remark is of a general importance" and that, only therefore „the notion of form should be written in the headings of all lists of categories and sets ordering fundamental notions and construction-oriented notions of cognition".

Among numerous considerations of Prof. Wasiutyński, methodologist and construction-engineer of bridges [94] about the form, one can found opinions, where he states that the notion of form refers both to objects that are perceivable only through reasoning and to material, visible and tangible objects, and that the forms of produced objects are dependent on the forms of producing actions. Z. Wasiutyński stated in his scientific works that properties assigned to produced objects are reflections of the way of action, thus also way of cognizing. He convinces us also that these properties can come into being as a result of action (activity) and can be adapted altogether or partially to the intended useful aim, or can not serve that aim.
The thought that the sense of architecture exceeds far its physical properties arose frequently and persistently in the history of culture. According to this idea, architecture accepts logistic technical solutions and, simultaneously, overcomes them in a natural way and the actions of the architect are associated with his/her creative artistic creation, i.e. with art, its laws and technique.

Methodical analyses of the language of forms of Le Corbusier, on the example of the solid mass of the Villa Savoye, belong to the undertaken methodological analyses. Methodological analyses concerning the language of forms of the architecture of Le Corbusier possess a permanent sense because the language is the oldest system that the human being has created. The beauty, the power of plastic expression and the functionality of the language of architectural forms of Le Corbusier, of his numerous and beautiful forms of buildings, were the reason that other architecture builders used them in a considerably broader scope. The presented methodological analysis of the architectural process of the Villa Savoye of Le Corbusier [10, 95] (Fig. 44) reveals new methodological design possibilities for the contemporary architect. These possibilities do concern shaping the architectural form. In the being analyzed already famous achievement of architecture, in the form of Villa Savoye (Fig. 42), it is difficult, indeed, to discover any chaos. This architectural work is a finished whole. Thus, one can accept that Le Corbusier has made, in the preliminary phase of the creative architectural process, a creative selection when joining elementary partial forms, the so-called morphemes that are visible on Figure 45 and, as proves the image, that are transferred, bluntly copied from his own puristic painting „ Great Still Life with a pile of plates" (Fig. 44). In some sense, we can say that he transferred selected forms from this puristic painting into the third dimension, which means into architecture. The example of dynamics of the creative design actions of Le Corbusier [93] assures that his method was an instrument he used as artist and architect.

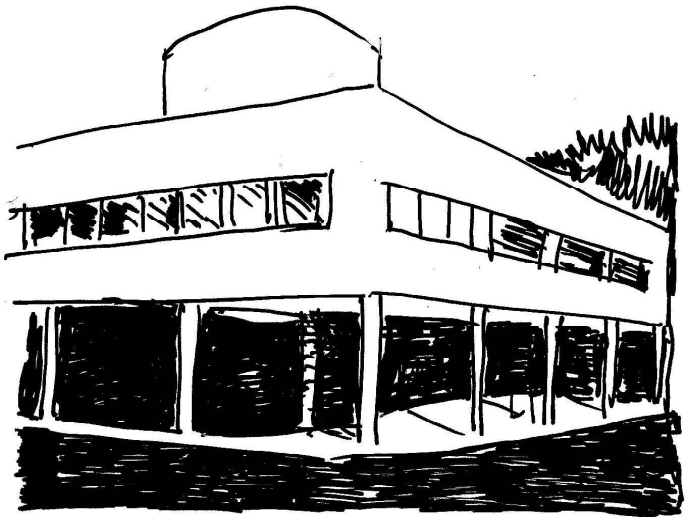


Fig. 41. View of the building of the Savoye Villa, realized near Paris. At present, the seat of the Foundation of Le Corbusier.

Analogically to the so being proved methodical actions of Le Corbusier, each architect can contemporaneously use them in a creative and efficient way in his/her design practice. Selections made mainly in the first phase of the creative process can concern the choice of different forms or creative inspirations. The performed methodological analyses, presented on the figure (Fig. 44), made it possible to separate (isolate), with a geometrical precision, concrete types of partial forms, the so-called morphemes that were used in the project design of that villa. These partial forms can be found in his painting of still life (Fig.).

It results from the mentioned analyses that the preliminary creative process of design of the architectural form of the Villa Savoye is a creative process characterized by methodical actions. The performed methodological analysis of the forms of Villa Savoye proves that Le Corbusier drew the partial architectural forms as morphemes from his puristic painting. In an analogical way, Le Corbusier behaved when designing the town of Algiers in Algeria i.e. when making a town planning design.

Fig. 42. View of the inside of Villa Savoye. It is the first so-called Great Window, being now generally used in architecture.

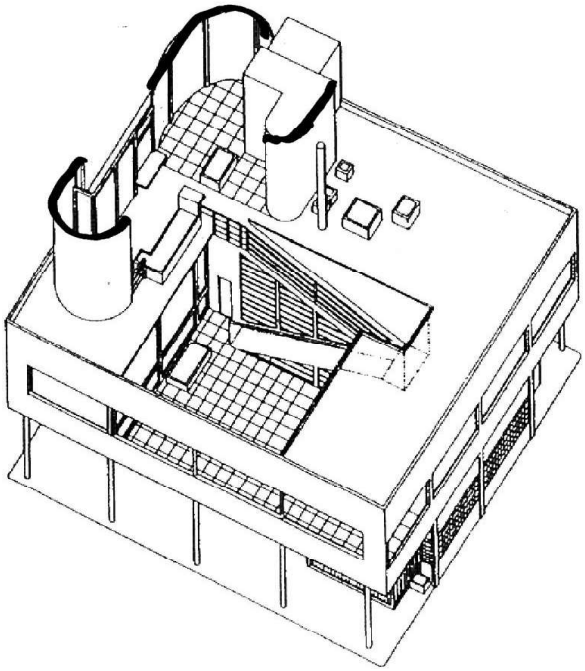


Fig. 43. Spatial model of Willa Savoye of Le Corbusier with a view to the solarium and inside of the building, with, surely, the first ramp for disabled persons. Drawing by author based on original drawing by Le Corbusier.

The methodological analysis of the creative process of Le Corbusier, when taking the example of the Villa Savoye, is a trial of an objectified description of the process of design, also of architectural design according to considerations discovered in the works of Niezabitowski A., 1980, Gasparski W.W [1993] Arne Collen [ ]. The being undertaken methodological analysis is a proof of answering the question: is it possible to describe the process of architectural creation arising in the imagination in a more objectified way than it is the case hitherto?

The presented methodological analyses conduce to a reconstruction of the actions (activity) in the preliminary phase of that complex creative process of designing the architectural work. The undertaken analyses lead also to determining the architectural inspiration of the already historical, famous building of Le Corbusier, namely the Villa Savoye. It is a villa called by architects also „box on pillarets", and strictly speaking, it is a weekend house with a drive, garage and a room on the ground floor and with rooms, the kitchen and the bathroom upstairs.

In order to reveal the hitherto not yet described in a objectified way elements of artistic and technical actions as methodical intellectual actions of the architect, the existing knowledge and the objectified language of notions of praxeology, design methodology and systems theory were used. One has described methods or their elements being applied by ar-

chitects in practical design and recognized their objectified description in design methodology. One has also declared them to be instruments of the cotemporary architectural science and design methodology (Fig. 1 a,b,c,d ,,Villa Savoye view, projections, inside, stairs). One has accepted that the contemporary development of science and knowledge i.e. architectural science and knowledge, praxeology, design methodology, cybernetics with informatics, systems theory, assure new research possibilities of the process of architectural design.

J. Sołtan [Giedion S., 1965) wrote that when making architectural decisions, an immense role is played , strictly speaking, by yet unknown laws, being foreseen and being called design intuition. The modern knowledge creates possibilities of undertaking trials of their describing by an objectified language, e.g. by the language of design methodology.

According to the contemporary knowledge, scientific designing, analogically to methodology of sciences, is a systematic, rational reconstruction of behavior of the designer. In the opinion of Z Wasiutyński [ ], such reconstruction requires a previous reflection of the designer, this reflection concerning his/her craft and consideration that assures ordering the designer's experience supported by methodological knowledge.

The being analyzed in this work opinions continue the problems scope of the phenomenon of human design, considered, among others, in works of the following intellectuals: Gasparski W., 1993, Wrona S., Gregory S.A., 1981, 1985, Nagy E. 1980, Niezabitowski A., 1987, Skibniewska H., 1981, Szparkowski Z., 1993, Kucz-Kuczyński K. 2000, Pawłowski A., 2000, Zalewski, and many others.

According to the opinions of such intellectuals as Einstein A., (1035), Wasiutyński Z., (1981), White M., (1993), Wise J.A. (1989), our way of thinking, where imagination is necessary, proceeds without the necessity of using words and, moreover, has an unconscious character to a great extent. These opinions can be referred directly to the highly complicated and conditioned in a many-sided way process of architectural design.

The first research [ ] concerning creative architectural processes was undertaken under the influence of opinions of many architects as well as the opinion of Prof. W. Gasparski, who wrote that, when searching for generalization, one ignores the individual (...). A technocrat, a bureaucrat, an organizer, all of them endeavor to not have to do with the individual, unless embraced into categories of types, mean collective quantities [Gasparski W. 1978].

It has been accepted that, maybe, the confirmation of immense creative possibilities that are assured by the use of methods, for instance in the being examined creative activity of Le Corbusier, can be found also in the creative activity of other architects. That is often manifested in the „morphology" of architectural forms of designed spatial structures. An essential practical premise was the fact that the creative activity of Le Corbusier has been documented by him-self and examined many times by architects and historians of art and architecture of the whole world.

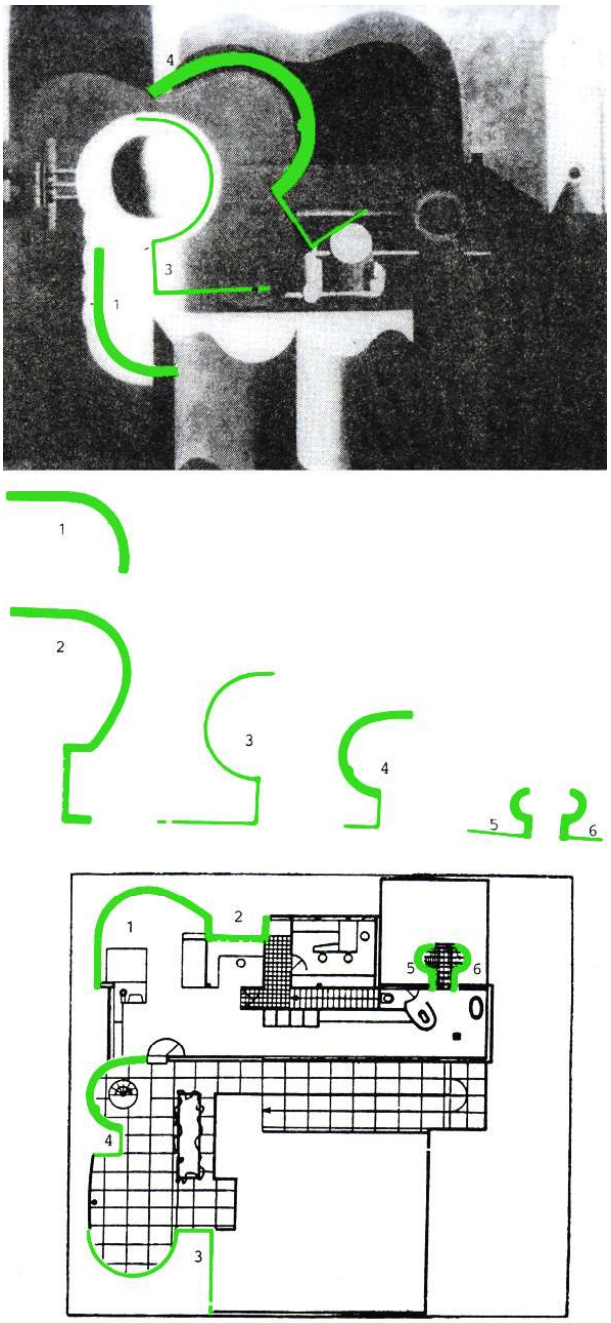


Fig. 44. An inspiration for Le Corbusier when he designed the horizontal projection of Villa Savoye was his own purist picture: "A great still life with a pile of plates". Le Corbusier, as being a painter and an architect, did set up, on that horizontal projection of Villa Savoye, partial forms (morfems) possible to be found on that purist picture. This is the main thesis of the habilitation dissertation of the author. Drawing by author based on original drawing by Le Corbusier.

According to the views of Simon H.A. [1990], Gasparski W. [1995], and [Prokopska], the complex process of creative designing of the architectural form is a logical mental sequence. Le Corbusier, as architect and puristic painter, emphasizes the necessity of introducing art into the current of the great transformation of the scientific and technical civilization where the artist has to be a parallel partner of people of technique and science [Jenger J., 1993]. Therefore he/she has to understand the laws managing them, and to transfer them onto his/her own ground [Kossakowska M., 1980, Gasparski W., 1993, Banathy B.H., 1996, Bazewicz M., 1996]. The previously performed methodological analyses of selected objects of architecture of Le Corbusier, among them of the presented villa Savoye served, indeed, just that purpose.

As a result of analyses and examinations, i.e. systems-based, methodological and architectural analyses and research, among others of the design of the villa Savoye [Prokopska] the thesis was advanced that Le Corbusier applied in his creative activity a method that in the contemporary interpretation is compatible with what is called the method of morphological analysis2. The undertaken research experiment consisting in the methodological analysis and the decomposition of the selected architectural form and puristic painting is a proof of that thesis. The methodological analysis of the villa Savoye has been performed by the method of decomposition. The method of decomposition has been acknowledged and accepted as to be a research tool that makes possible the identification of the creative design method of Le Corbusier. The force of expression and the functional quality of the language of forms of Le Corbusier were the cause of the fact that other builders applied them to a considerably broader extent. They became „morphemes" of the contemporary architecture – semantic parts or particles of the language of architecture. With treating words in descriptions concerning the creative process of Le Corbusier in a literal way, i.e. with treating his expression „principle" as a method of working, the search was undertaken for a creative method in his creative activity. During about twenty years of his architectural activity, the painting of Le Corbusier lived the use of architectural and town-planning elements. E. Nagy, when analyzing the creative activity of Le Corbusier, stated: „ Thus, we have here to do with a „morphological system"[4].

The puristic painting, entitled „ Still Life with a Pile of Plates („Nature morte à la pille d'assiettes, 1920") [Kossakowska M., 1980, Nagy E., 1977] (Fig. 3) and the architectural drawing of the horizontal projection of the roof terrace of the villa Savoye in Poissy, realized during 1929-31 (Fig. 4), were subject to decomposition, with searching for morphological component

[4] Morphology is the science ob forms/shapes and of the external and internal construction/structure of plants and animals. Well-known examples of morphology are the morphological system of blood, morphology of languages, expressions and of their forms. Morphological systems appear in the nature, analogically as the system, in many shapes. The being analyzed morphology of methods of creation in architecture, on the example of the creative activity of Le Corbusier, manifests itself through the spatial form, i.e. the form that can be divided into morphemes, or such fragments without which the being analyzed architectural form does not appeal as a whole. Morphemes as components of the architectural form in the architectural creative activity of Le Corbusier can be often recovered in his painting.

forms. In the creative activity of Le Corbusier, the combinatorial arrangements of forms in design processes played an essential role. The first combinatorial arrangement of forms takes place in painting. On his puristic paintings, guitars and bottles „do arrange themselves by settling into a whole as obedient things" [Nagy, Jencks]. The puristic painting (Fig.) of Le Corbusier is a formal whole being presented so as on architectural drawings. Then, the arrangements of forms verified in such a way in painting (having, namely, the force of artistic plastic expression) are transferred by Le Corbusier into the space. Ch. Jencks [Jencks Ch.. 1982] stated that one has not performed a systematical classification of works and achievements of Le Corbusier, but that it is certainly possible thanks to the consequent, logical application of forms in his creative activity. When talking about the architectural vocabulary of Le Corbusier, Jencks stated also that Words are Forms in that vocabulary. Le Corbusier creates complex architectural forms from single words (i.e. forms). That comparison has logical and methodological sense, as language is the oldest system created by the human being.

When comparing the painting "Still live with a pile of plates" with the selected architectural horizontal projection of the roof terrace of the villa Savoye, one sees explicitly the repeatability of characteristic forms on the architectural projection, in their different modifications. The analysis and description, performed by the method of decomposition into partial simple forms appeared to be surprisingly precise and geometrically exact, clear and verifiable. In the being described experiment, one can reassemble the forms obtained after decomposition of the architectural design project into the being analyzed original form. That fact was confirmed in an independent way by a computer-based analysis [Prokopska A., 1992, 1997]. The detailed purpose of the analysis and decomposition of the selected horizontal projection consisted in the isolation and determination of the basic partial forms composing the being analyzed architectural form.

The first type of partial form – simple form, is a rounded line that was determined in the analysis as type x (Fig. 5). Its successive modifications appear on the being analyzed horizontal projection of the terrace (Fig. 4).

The second type of partial form – simple form was determined as type y (Fig. 6). Successive modifications of that form appear on the being analyzed horizontal projection of the terrace and are designated in this monograph as forms: y1, y2, y3, y4. These are fragments with different length of circles with different radii. That type of form has two mutually independent parameters accepting different values: the length of a fragment of a circle and the radius of the circle.

The third group of forms appearing in the being analyzed projection is composed of forms of type z. This type of form is the form of letter L, two straight lines with different length making a right angle. The figure 7 presents the being analyzed horizontal projection of the terrace devoid of forms of x and y type. It is easy to observe that, as a result of such action, on that figure (Fig. 7) only straight lines remained, creating rectangles with similar proportions and straight lines creating inclined planes on the projection of the building.

The reduction of forms performed by Le Corbusier, a puristic painter, of the analyzed architectural solution and the forms recovered in the puristic painting composition, composed of simple forms (so determined by the author of this work), is limited to the three types of simple forms as basic forms: oval (rounded forms of type x), circle (forms of type y) and right angle (forms of type z). As an effect of the analysis through decomposition, the complex form was found as the dominating form, being at the center of the analyzed puristic painting (Fig. 8) [ ]. That form is composed of earlier partial forms that were determined as to be basic forms, bluntly with a geometrical accuracy in several modifications and different configurations. In other words, it results from the performed investigations by the decomposition method that, in the being analyzed painting composition, the form of a circle or of its fragments, oval-type lines (rounded lines), parallel lines and lines with an intersection at a right angle are dominating. In this contribution, the methodological reconstruction has been undertaken of the process of approaching and reaching the achievement of architecture (work of architecture). The description has been presented of the form of the horizontal projection of the roof terrace of the villa Savoye with a skeleton-type reinforced concrete structure. The form of that object is arisen as a result of a creatively joining forms elaborated earlier in painting art. The distinguished partial parts can be found on the architectural projections of that villa. The chosen painting composition was for Le Corbusier as an experimental laboratory making possible to obtain sets of variants of partial forms that proved true from the artistic point of view, having the force of artistic plastic influence.

In the presented analysis of the achievement of Le Corbusier, the contemporary knowledge concerning architecture, praxeology, design methodology, systems theory and cybernetics were put to a good use. The discussed analysis was carried on with the aim of revealing facts resulting from the architect's designing practice, these facts being hitherto not yet described as consistent what concerns a methodical approach, with taking the example of the creative activity of Le Corbusier. The undertaken research does confirm the use of the method of morphological analysis in the process of architectural design by Le Corbusier.

The performed decomposition is the proof thereof that the being analyzed process of designing the villa Savoye derives its origin from puristic painting. As a result of the undertaken investigations, the morphological structure of the architectural form of the villa Savoye has been revealed. When accepting the fact that, in the being analyzed work of Le Corbusier as an exemplary work, it is difficult to find marks of chaos, one should admit that Le Corbusier made a creative choice among the possible further arrangements and formal modifications of the being designed architectural solution; and that is, indeed, the fundamental attribute of the morphological analysis.

However, at present it would be important for architects-designers that, when using the method of morphological analysis, one can join in a combinatorial way many elements of forms of the being designed objects and create (or generate) variant-based solutions, also not

conventional solutions and among them the desired solutions, which can be selected as valuable and creative, or can be rejected according to the knowledge and individuality of the designer. That method as a tool, as a whole or elements of the method being applied in an intuitive way in the practice of architectural design, supports and intensifies the creative forces of the architect-designer and allows him/her to design in a more efficient way and to maintain his/her creative individuality as well as the individualized architectural form, with applying evidently the technical achievements of the (our) epoch.

That method was used by Le Corbusier and maybe by S. Calatrava in their architectural creative activity, because that method is something more than e.g. a simple combinatorial approach applied to forms, being read out not only by architects. The method used by Le Corbusier, or the method of morphological analysis, although it is not a ready prescription, favors creative activity and unconventional creative solutions. The method „liberates" the natural creative qualities of the architect-designer, particularly in the preliminary phase of the architectural process. The being performed decompositions of the selected architectural achievement, i.e. the villa Savoye of Le Corbusier, made it possible to notice and to make sure that elements of the used methods are natural for many complicated creative design processes in architecture if they are considered from the point of view of knowledge of design methodology.

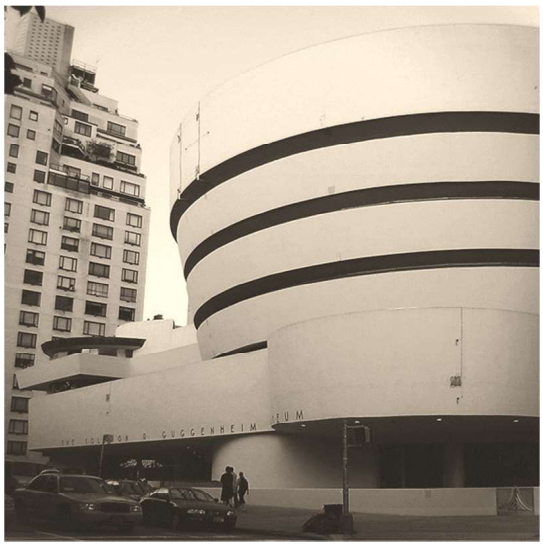


Fig. 45. Guggenheim Museum, F. L. Wright, New York. Drawing by author based on photo.

A methodical premise of improving the process of architectural design and of the effect of that process, i.e. of the architecture, can be also found in the language of the architectural solid mass of the Guggenheim Museum in New York, of the author L.Wright [18, 95] (Fig. 48, 49). It is an interesting example showing the importance of the preliminary creative design process and of the form of the architectural solid mass. The language of forms of that architectural solid mass of the Guggenheim Museum indicates a realization of an a priori assumption (see the definition on page) in the preliminary phase of the architectural design process. The language of forms of the architectural solid mass of the Guggenheim Museum in New York [94, 95, 96] results from the acceptation of the form of the building as a spiral and from the connected therewith method of architectural actions in the preliminary phase of the design conception.

Frank L. Wright accepted an a priori conception, i.e. a conception according to the assumption of the architectural form in the preliminary creative phase and he did realize that conception; he designed the building with a spiral form. L. Wright created the spirally shaped solid mass of the museum in a methodical way from partial forms being fragments of a circle. The spiral arrangement of the solid mass, accepted by the designer as spatial assumption (fordesign), as well as the language of forms has been realized in a consistent way. Starting from his early design project of a prairie house and ending with the building of the Guggenheim Museum [18] in New York, Wright placed, indeed, in a consistent way the human being as a central point of his professional interest.

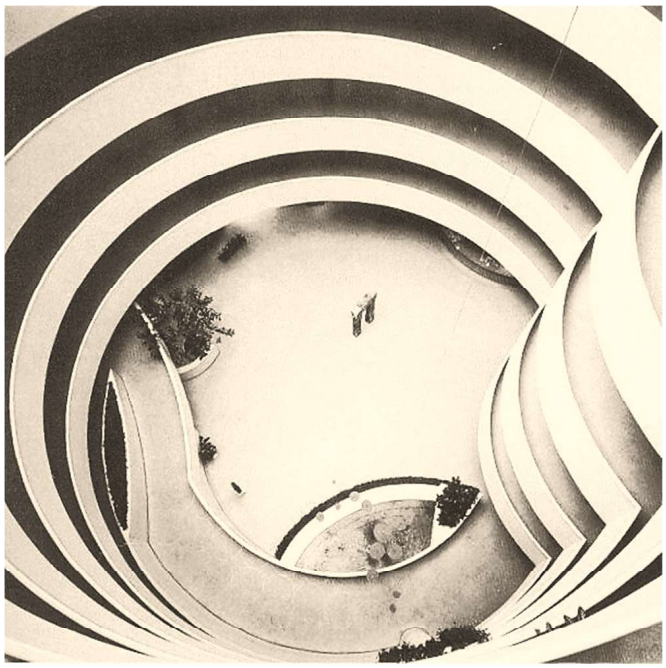


Fig. 46. View of the inside and "horizontal projection" of Guggenheim Museum, F. L. Wright, New York. Drawing by author based on photo.

Methodical premises are particularly visible in the creative preliminary phase of the architectural design process of Santiago Calatrava what concerns organic architecture. His organic architecture derives from a specific creative process and, more exactly, from its preliminary phase. In the preliminary phase of the architectural process as a phase of searching for creative inspirations, Santiago Calatrava, a Spanish architect and design engineer arranges forms taken from the nature and then he modifies them in a creative way, through adapting them to real functional and technical requirements [37]; he does visualize that on his freehand drawings. Calatrava, being an excellent draftsman, begins in the first phase of the design process the creative process so as are doing many architects (e.g., Utzon, Le Corbusier, Gehry) with freehand sketches. This artist takes his inspiration from forms of natural things. In the works and achievements of Santiago Calatrava one can read out his fascination by forms of the nature.

Fig. 47. Oriente Railway Stadion: Train Stadion. Santiago Calatrava 1993-98. Aesthetic forms.

For instance, architectural forms that one can see e.g. in the solid mass of the train station (Fig. 50) and that bring ribs to mind seem to be particularly close to users of his architecture. Calatrava draws also the silhouette of a horse (Fig. 13), he creates his architecture on the basis of sketches imitating the nature, and strictly speaking, on the basis of perceived there fragments of forms, acknowledged by him as to be inspiring forms or consistent forms, he creates a model, e.g. the model of a bridge. Then, he gives reality to that model by using classical

engineering, construction and architectural knowledge. In that way many bridges of Santiago Calatrava arose, for example the bridge in Barcelona on the basis of the ovoid silhouette of a fish (Fig. 15) and numerous other buildings. The method consisting in imitating forms of the nature can be acknowledged to be an intellectual tool that is possible to be more generally applied in architectural design. Santiago Calatrava, analogically to Le Corbusier, performs many free-hand sketches (Fig. 14a and 14b); these sketches become sometimes an inspiration, an idea of an architectural form or of its fragment (Fig. 14b), i.e. a morpheme. S. Calatrava arranges forms taken from the nature and then he modifies them in a creative way by adapting them to real architectural and constructional requirements.

The organic architectural forms of the creative activity of Calatrava present achievements of the contemporary art, construction and, at the same time, technology and material-based engineering. What concerns Calatrava, his creative process that shapes the architectural form, for instance the structure of a bridge is a logic mental sequence taking place during the first phase of the design process, maybe partially in the designer's subconsciousness. The creative process of Calatrava is a process of shaping the architectural form as well as of the structure of the building that is adapted also to the spatial features of the place and the context of development of the building.

CHAPTER VIII

House-machine destined to live, as the idea of Le Corbusier. Energy-saving architecture and building engineering, passive houses, intelligent houses

The consciousness of the fact that the human being self is an element of the nature is more and more frequently the pra-cause of undertaking rational actions directed onto the environment of the life of the man, thus also onto the architectural environment and building engineering environment. Ecological, energy-efficient technical and technological solutions become more and more essential from many points of view, what is connected among others with new materials and renewable energy sources.

New environmental purposes that one can observe in world tendencies of design as well as the development of not only building engineering ecological technologies lean towards a reflection concerning the workshop and process of design of the architect. That most probably is signifying a change and, at least a reorientation in the decision making scheme of architectural designing. The watchword 'House – machine for habitation' is maybe the idea of the house of the future; belonging to the authorship of Le Corbusier. Le Corbusier, as architect-designer and great co-creator of the contemporary architecture, as well as man of the renaissance, had many interests, because he was interested in architecture, town planning, prefabrication in building engineering and architecture, technique, mathematics, sculpture, painting – particularly puristic painting as he was its co-creator. Le Corbusier assumed that the house of the future will be conditioned strongly and in a many-sided way by the development of technique, art (also architectural art), construction, materials and he realized the relations and the ecological interdependence of the being designed homes, also designed by him-self. In some sense, he dealt maybe with and considered problems of yet not existing fully pro-ecological technologies, e.g. he considered the appropriate insolation of the rooms of a building or of the building as a whole.

According to the opinions of Le Corbusier and with the present development of science, technique, technology not only concerning building engineering but also art, also architectural art, the house as machine for habitation is maybe a house that already is conditioned and will be conditioned by the development of technologies, also ecological technologies, and of the fast progressing systems-based knowledge, informatics, architectural and building engineering knowledge, design methodology. Maybe, the house for habitation is the idea that we determine today and do realize as 'intelligent house' and 'passive house'. On account of the immense present rate of progress of knowledge, thereby of design conditions in architecture and building engineering, the idea of the house for habitation as a machine for habitation can be in the future an essential problem. Because of the rapid and efficient development of materials-based sciences and systems-based sciences, also of design methodology and informatics, it can happen in the future to a greater and greater extent that it will be possible to create in a methodically way energy-efficient architecture and building engineering. Maybe, in designing that type of buildings, the architectural creation will be conditioned more and more technically also in the preliminary phase of the architectural process, what will not cancel its creative character.

At present, it becomes necessary and practically indispensable to create and execute energy-efficient architecture and building-engineering. The progress concerning building technologies results in the development of other domains of functioning of the human being.
The future architecture of the house: machines for habitation as the effect of development of building ecological technologies and of computer assisting of design today and in the future. The present-day various techniques and technologies are connected among others with passive building engineering, energy-efficient building engineering, winter gardens, intelligent houses and with the use of renewable sources of energy, e.g. energy of the sun as well as with other ways of economizing energy. These pro-ecological tendencies are the cause of the fact that the development draws to shape an architectural, energy-efficient object as a house „machine for habitation", through improving the comfort of inhabitation.

The task of the contemporary architecture and of the architecture realized in the future is maybe a creative and innovative search for new esthetic architectural solutions that are technically and technologically conditioned and where the man would live healthily and would feel good and safe in that architecture. The ecological and systems-based point of view in the contemporary architecture conduces to consider the being designed building as a functioning whole, which becomes a part of a greater whole or ecosystem. The present ecological technologies of energy-efficient building engineering, among them passive building engineering with e.g. technologies of intelligent houses, assure the chance of realizing the contemporary architecture as a machine for habitation and, at the same time, as a fragment of the ecosystem.
Nowadays, the existing various techniques and technologies used in energy-efficient and passive architecture and building engineering often are connected both with economizing energy

and with the use of its renewable sources, e.g. energy of the sun [2, 3]. The contemporary technologies of solar cells and photovoltaic cells, recuperators, appearing for instance in the architecture realized by F. Gehry [4], present pro-ecological tendencies in architecture and building engineering and are the cause of the fact that the development of the contemporary architecture is tending, to a more and more extent, towards shaping the house as a „machine for habitation". That opinion is compatible with the conception being stated by Le Corbusier [5, 6, 7] who is declared to be, indeed, the creator of modern architecture. In such an approach, architecture as an image of the epoch, in which it comes into being, is the contemporary architecture that is conditioned in a technical way, where technique is subordinated to the needs of the human being and to his/her environment. Architecture as the effect of development of technology in the past and at present.

The development of technology results in the progress concerning all domains of functioning of the human being. When considering the technology of acquiring energy from solar energy through e.g. the used at present photovoltaic cells on the roof of a building, the question arises whether that action consists yet in adding, „sticking" a modern device that is self strange to the architectural form of the building, or constitutes an integral whole of the contemporary architecture form? And so, by returning TO the past, a chimney made of bricks being built in a house, required wisdom and knowledge, as well as a great discovery at these times, namely concerning the fact that bricks set in a proper way can assure creating a chimney as a hitherto irreplaceable technological „device". Thus, such an idea allows the brick to play not only its constructional function, but also the technological function. On the other hand, when taking care of the esthetic side in past epochs, this element also received its architectural detail by creating a specific „crown" of the whole object. If one device or another (e.g. the being discussed chimney) is combined (integrated) with the whole of the building or if it is bluntly an architectural and building engineering element in such a strict way, it does perturb neither its form nor its function, but it creates really the composition and the beauty of the building. In such a way building elements, necessary to compose the whole of the object, cease being an „unwanted" additive, and have received their place in the whole of the architectural and building engineering composition [kret, prok]. Analogically, it can happen when applying other new, various ecological technologies in architectural and building engineering design. At present, such an element is e.g. the photovoltaic roofing-tile (Fig. 1) that does not perturb the hitherto way of building if we want so, as architects, or does not perturb, among others, the traditional composition of the solid mass of the building of an apartment house.

Thus, from the architectural point of view, when using new technologies, the essential difference consists in the fact in what way a modern device is integrated with the architectural form. That is visible on the photograph (Fig. 1) where the applied often at present solar panels can be simultaneously „sticked" to the traditional form of the roof or be completely integrated with that element by constituting a full external layer of the roof bulkhead.

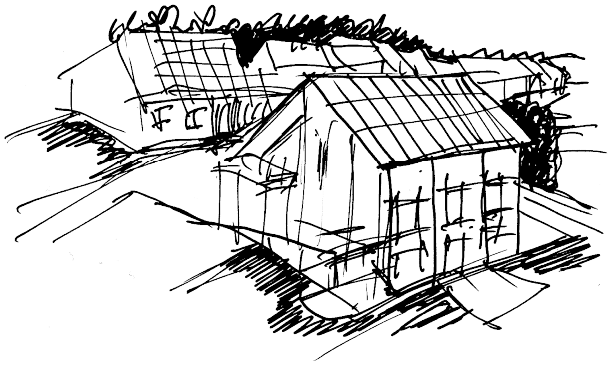


Fig. 48. On the roof of the building, solar panels form the plane of the roof.

Similar considerations can be carried on about other building elements that are modernized thanks to the achievement of contemporary technique and technology. For instance, the mentioned photovoltaic roofing-tiles (Fig. 2) or solar panels, presented on Fig.1, are contemporary elements having a technological function and a construction-based function (Fig. 1) that does not perturb the hitherto used way of building if we want so, or we do expect e.g. a traditional composition of the solid mass of an apartment house.

The passive house (Fig. 48) [3, 8, 9, 19] as an example of using contemporary ecological technologies in building engineering.

When undertaking a trial of presenting the definition of a passive house, we can generally state that such a house does not need autonomous, active heating system because the passive house heats and cools itself by itself. – i.e. in a passive way (page).

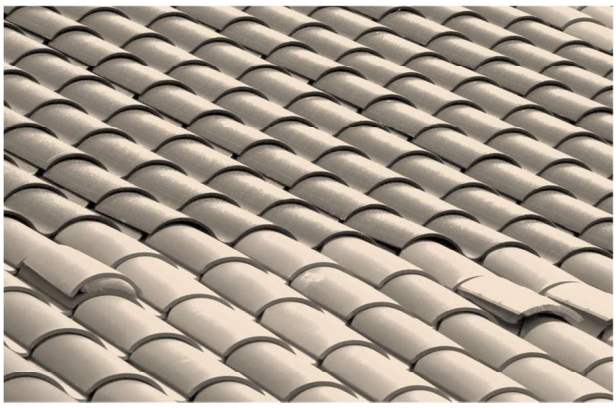


Fig. 49. Roof built of photovoltaic roofing-tiles.

A passive house is a building that, for assuring heating comfort of the inhabitants, does not consumes more than 15 kWh energy/1 m2 usable floor area. That signifies in practice that, during the whole heating season, for heating one square meter of the apartment one needs 15 kWh, what corresponds to burning 1,5 l fuel oil, or 1,7 m3 gas, or 2,3 kg coal. When comparing with other conditions, the heat demand for conventional houses being built at present amounts to about 120 kWh/m2 per year. In passive houses, the total final demand of energy is 4 times lower than in the nowadays being realized energy-efficient buildings, and even 8-10 times lower than in traditional houses but built according to valid standards. In a passive house the thermal comfort is assured by passive sources of heat that earlier were not duly appreciated. These can be the inhabitants, the electrical equipment, the solar heat and the heat recovered from ventilation i.e. by recuperation. In a passive house, the total, joint energy demand for heating rooms, preparing warm water and functioning of domestic equipment cannot exceed 120 kWh/(m2/year).

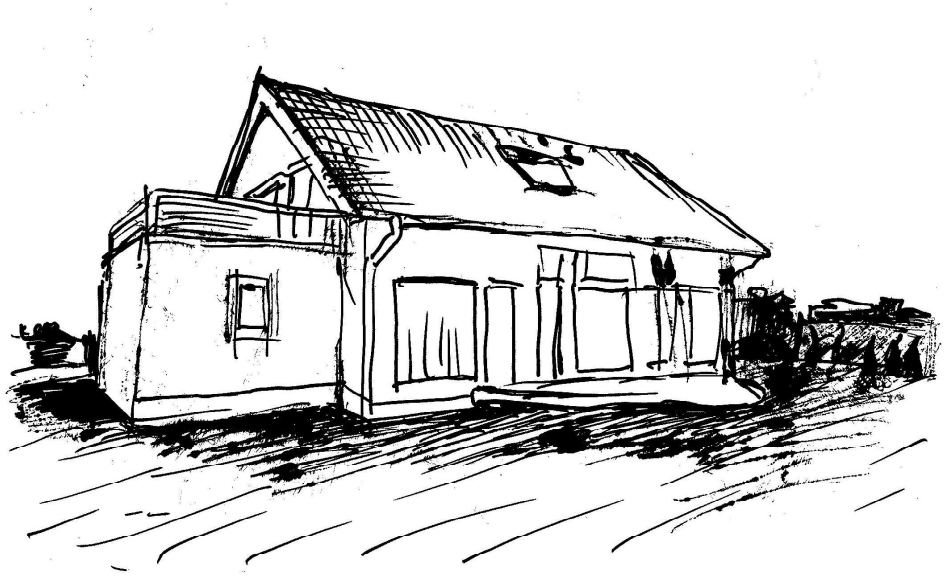


Fig. 50. The first certificated, passive show-house, possible to be applied in a similar climate, thus not only In Poland, was realized in Smolec near Wroclaw according to an author's design in the design office of Lipinscy. That passive house was elaborated in cooperation with specialists of the Institute of Passive Houses with the National Agency of Energy Saving. The realization of the innovative design project "Lipińscy Passive House 1" is really an extraordinary investment.

Intelligent control systems operate many functions of such intelligent buildings. 'Intelligent houses' are a comfortable architecture that fulfills all standard and not standard functional and applicational requirements. Here energy economizing is essential, connected with the use of many various ecological technologies, for instance the use of heat pumps, photovoltaic cells, solar collectors. Standards of intelligent houses assure the comfort habitation through the fulfillment of the different needs of the user [8, 9, 10].

Maybe that idea is an architectural utopia that rationally and harmoniously conduces to the sustainable development of the architectural environment. The idea of the 'machine for habitation' leads to a harmonious coexistence of each man with the nature, by integrating the natural and the artificial environment, also the architectural environment being built on the level of micro- and macrostructures of these environments [1, 2].

At present, many scientific teams are dealing with elaborating technologies improving the capacity of the existing solutions of gaining energy from renewable sources. An example thereof can be the American invention of the firma v3Solar (Fig. 1). This society has elaborated photovoltaic cells that generate 5 times more energy than traditional panels. That became possible through the use of the form of cone and the use of advanced electronic systems.

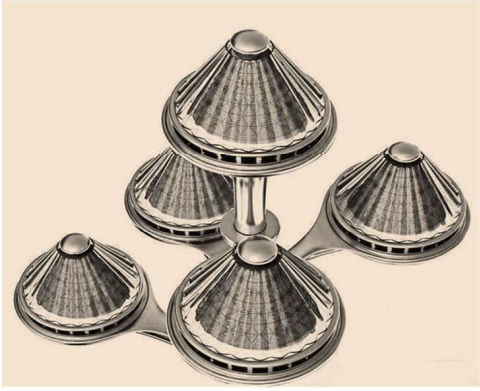


Fig. 51 The v3Solar company has developed photovoltaic cells that generate 5 times more energy than conventional panels. This was made possible by the use of forms of cone and advanced electronics.

One should reckon, among new energy-efficient usable technologies, the new and newer technologies of thermal insulating and additional thermal insulating [5, 6], appearing on the Polish and European markets. An interesting Polish example of a new ecological technology of the future, possible to be used also in the existing housing tissue is IZOPET-R (Fig. 2).This material is characterized by a high compressive strength, a low coefficient of thermal conductivity and high parameters of water flow. The material appears (Fig.) in the form of plates of pressed and bound flakes of cut bottles made of polyterephthalate ethylene, what means of popular plastic packages (containers).

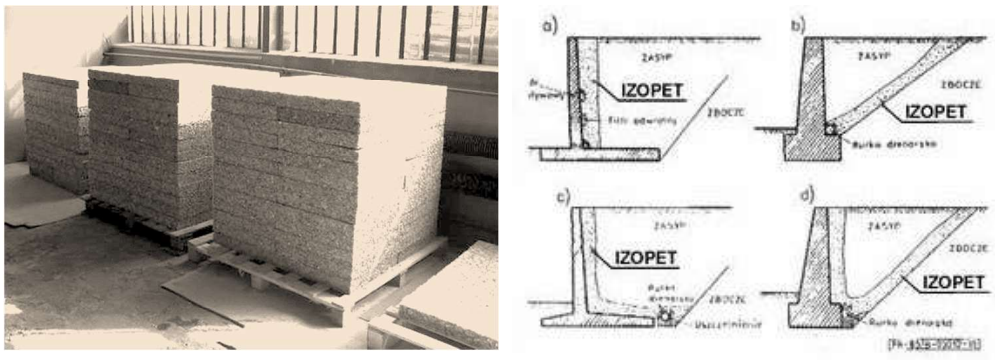


Fig. 52. Example applications of the new technology of IZOPET-R, as a drainage and protective layer. Storage of IZOPET-R.

The building in Ulm as an example of creating architecture of intelligent houses and architecture of the future. In architectural and building engineering objects, e.g. in passive and intelligent houses with different structures and made of different materials, new energy-efficient techniques and technologies are applied [4, 5]. At present, building engineering low-energy consuming, technical systems-based solutions are possible to be used within a different scope. In these interdisciplinary architectural processes, the creative preliminary phase is indispensable. The interdisciplinary character of the architectural conditions and, as an effect, of the solutions proposed by such objects, induces to the consideration of the process of designing that object as an interdisciplinary process of shaping the architectural form. On account of the economic study, these houses, having features of passive houses, will be maybe in the future a richer and richer, technical compilation of different technologies and new materials. At present, we are witnesses of a rapidly progressing degradation of the environment. The phenomena of environment degradation became for the representatives of the European Union a stimulus for implementing new energy-efficient technologies and standards for the realization of pro-ecological technical and building engineering purposes.In that activity, a pro-environmental way is visible of leading the design process as well as the use of ecologically positive technical and technological solutions concerning the reduction of financial outlays necessary for executing e.g. energetically efficient buildings.

The above mentioned approach influenced the forms of the designed architectural solid masses, particularly in the preliminary design phase where technological conditions were taken into consideration among other conditions being characteristic for architectural design processes. As a result of such approach, the presented buildings are connected with innovative ideas and technologies that protect in various ways both the environment and the human being. Particularly interesting are, on that account, energy-efficient architectural solutions, which were executed during the last years.

A passive and intelligent building that can be a model and become an inspiration for the application of modern technical solutions has been built in the year 2002 in Ulm, Germany (Fig.). The office building „Energon" was at that time the greatest passive and intelligent building in the world. It is an office object with a surface of 7000 m2 [ ]. Notwithstanding the passing of time, that building designates new standards and constitutes an excellent example of pro-ecological building engineering. Energon (Fig. 39, 41) was built on a great building lot. It is placed inside a landscape park, surrounded by water reservoirs – ponds gathering rainwater, as well by terraces, little bridges, slopes. That creates an appropriate, unique atmosphere. The building has a surface of seven thousands square meters and five storeys. It is the place of work of 420 persons. Thanks to the used there technologies, the building consumes only 25 percents of energy necessary in a conventional building for heating, air conditioning etc. The excess of the being gathered electric energy by the building is transferred to the network. The idea of passive houses is developing and more and more often such houses are built, and investors are disposed to contribute even a higher sum in order to have to pay less in the future for bills concerning energy consumption for heating or cooling such building. The less is the energy consumption the less the pollution, emitted to the atmosphere.

According to the presented above building plant, as a model in the preliminary architecture process of an energy-efficient or passive building, it becomes necessary to analyze and take into consideration new concrete environmental and technical conditions. The main architectural conditions, taken into account in that building are: material-based conditions concerning knowledge about the materials, of which the building was executed, spatial conditions, functional conditions and structure-based conditions, as well as technical conditions resulting from the applied building engineering and energy-efficient technologies [88].

Energon – was in 2002 the greatest passive house in the world. One can see here the freehand sketch of the horizontal projection of the building as its graphic sign, and a fragment of the façade of the realized building.

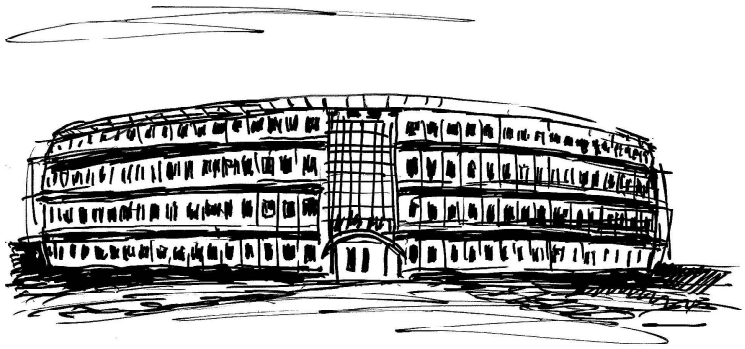


Fig. 53. Energon: passive office building in Ulm, surface 7000 m², Germany. Front facade.

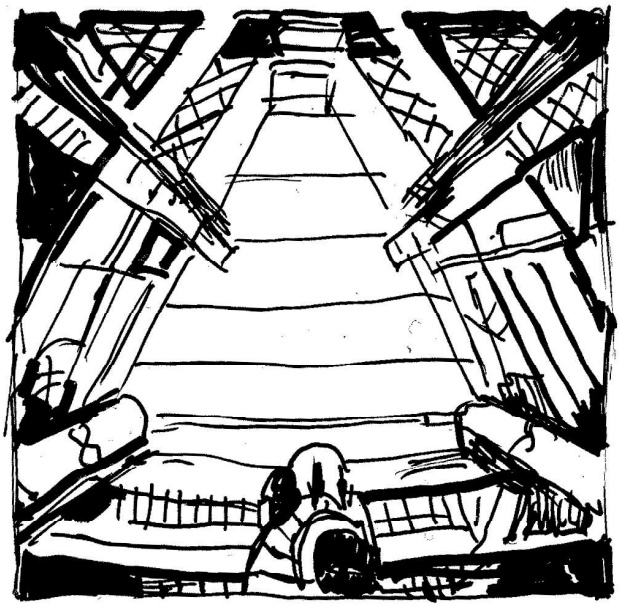


Fig. 54. Atrium of the passive office building in Ulm.

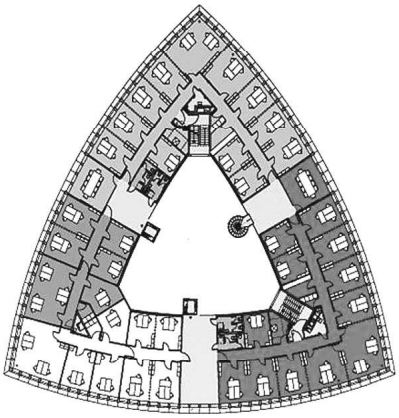


Fig. 55. Passive office building, executed in 2002 in Ulm as the greatest passive building in the world. Drawing by author based on original drawing.

During the design of architectural passive houses, one should follow the principle of both appropriately designing the space for the future inhabitants and saving energy that one can obtain, among others (so as in the discussed case), through an appropriate shape of the future building. The choice of the shape of the being designed building is made mainly in the preliminary phase of the architectural process.

From the point of view of shaping the architecture of energy-efficient buildings, an object with compact and simple form is recommended, similar to the building being presented on the figures from 38 to 41 [5, 6, 7]. It is the greatest passive office building with horizontal projection in the form of a rounded triangle. In the functional systems of passive and intelligent buildings open interiors are preferred, facilitating ventilation. Particular requirements are set to passive buildings, for instance: design projects of passive houses should always be characterized by climatic comfort; these buildings should also fulfill the contemporary psycho-sociological needs of the users. In the passive building in Ulm, an intelligent air conditioning has been applied that allows for maintaining a stable, comfortable temperature. In the floors, about 350m of pipes of plastics have been mounted. They are destined to assure the flow of heat and cold water that is heating or cooling the rooms depending upon the needs. Besides, around the building 40 gauges have been placed that reach the depth of 100 meters under the ground. The ground stores heat; it is possible to collect that heat in order to assure preheating the cold air falling there in other times of the year. Changes of temperature and insolation cause cooling of heating of the building. A conventional counteraction would require high outlays for heating or air conditioning.

In order to minimize the air conditioning outlays, the façade of the building in Ulm is composed in 44 percents of glass surfaces. That proportion assures simultaneously a good visibility. Mechanically controlled shutters protect against an excess of insolation. The façade of the building almost does not conduct heat at all. In the façade of the building, an isolating layer with 35-centimeter thickness has been placed, and under the foundation plate, an isolation with 20 centimeter thickness has been placed. On the roof, the isolation thickness amounts to 50 centimeters. For assuring a high level of isolation, three-pane windows have been built-in.

A great, glazed roof of the atrium (Fig. 40) assures sufficient quantity of light in the rooms inside the building, thanks to what the use of artificial lighting has been minimized. When the use of electrical lamps becomes necessary, in the office rooms electronically dimmed and brightened lamps are switched on that are controlled on the basis of measurements of the intensity of the daylight reaching the rooms. Motion sensors are also helpful, which switch off the lighting in the room, where nobody is staying. Besides, the roof of Energon, except the part that covers the atrium, is covered by photovoltaic cells with a surface of 328 m2, which gain 12000 kWh a year. Besides, on the roof of the multi-story garage near the building another photovoltaic installation has been mounted, which gains 125000 kWh per year. Totally, the gained electrical energy exceeds the demand of Energon; the excess is sold as ecological current.Fully automated systems are responsible for the surveillance and regulation of the equipment controlling the building.

The presented office building Energon in Ulm (Fig. 39-41), as intelligent building, constitutes the proof that an esthetic energy-efficient architecture realization is possible, creating a friendly climate inside the building and offering landscapes being friendly to human beings. In other words, from the economic and technical point of view, it is possible to improve the

quality of the architectural environment through building energy-efficient intelligent and passive houses. The presented example of the intelligent, passive building in Ulm shows the achievement of ecological architecture that fulfills various and multi-aspect needs of the human being and the environment. The specific, particular technical functions as well as the used there technical systems influenced not negatively the structure nor the esthetics of the architectural solid mass – also the specific solid mass in that case but, bluntly and on the contrary, made the esthetic aspect more attractive.

In the presented example of architectural and building engineering realization, we observe a pro-environmental way of developing the design process that starts with the preliminary phase. That being observed pro-environmental way of developing the design process concerns, besides obtaining ecologically positive solutions, also reducing the financial outlays destined for the exploitation of the building. This building is energy-efficient during its exploitation, in assumptions concerning its design as well as its usefulness. The environment of that building serves maintaining harmony between the designed and the natural environment. The being executed, in the last years, examples of pro-ecological architecture allow for the hope that the future ecological architecture of the 21st century (and particularly the architecture of buildings producing electric energy) can be designed as a beautiful and comfortable architecture being realized in accordance with the natural environment and the nature of the human being and that the future energy-efficient buildings will serve maintaining the harmony of the designed and the natural environment,The pro-environmental way of developing the design process, e.g. consisting in economizing energy and thus limiting the emission of greenhouse gases, leads both to ecologically positive solutions, and to the reduction of financial outlays necessary for realizing energy-efficient buildings.

Maybe features of the architecture of the house of the future as intelligent house and as house–machine for habitation can be really determined by technical attributes of such building, among others by:

– resistant installation solutions with high thermal values and acoustic values and with high capacity of accumulating solar radiation, as well as ecologically friendly products serving modernizing or erecting external walls,

– thermal insulation materials with low capacity of heat conduction and relatively high degree of sound insulation, non flammable,

– thermally tight, appropriate low-energetic windows,

– helioactive, efficient solar collectors or their modern interchangeable equivalents,

– efficiently functioning systems of room aeration, with particularly taking into consideration the installations of heat recuperation from the outlet air,

– equipment producing energy from renewable sources. The installation of photovoltaic cells is more rapid and simple comparing with the installation of solar collectors. That is specially important in the case of mounting them on existing buildings,

– technical solutions using heat energy from the surroundings, possible to be applied within a limited scope on account of technical and economic grounds,
– technical solutions called heat pumps using geothermal energy,
– other technical solutions, integrated into technical systems, among them systems based upon renewable energy.

The most general purpose of the present and future interdisciplinary design and realization activity concerning intelligent, passive houses or houses of the type machine for habitation should become the improvement of comfort, also of safety of functioning and residing. The possible energy efficiency obtained thanks to the use of new ecological materials, techniques and technologies contributes to reaching that aim, because such activity in macro scale serves limiting the emission of carbon dioxide to the atmosphere, as well serves assuring the protection of the climate.

CHAPTER IX

Methodological analysis of architectural activities in the designing process

For many decades, solving the task of generalizing design-based decision actions and operations made by designers-architects and by design teams seemed to be difficult and almost impossible. The contemporaneous development of methodology knowledge, particularly of design methodology and systems knowledge is now assuring such a chance. Designers-architects use, in the undertaken design actions and operations various kinds of knowledge, among them also know-how and know-that. The language of design methodology and systems knowledge creates new conditions of investigation and description of real design activity of the architect by means of objectified notions belonging to know-that knowledge. The methodologist, Wojciech Gasparski, wrote: "When searching for generalization one neglect the unit or individual (...). The scholar, technocrat, bureaucrat, organizer – they all aim at having not to do with the individual, unless an individual enclosed in categories of types, mean collective quantities [1].

In earlier contributions of the Author of the present work [2], an analysis of the architectural practice has been presented. The architectural process is an intellectual process concerning art and many domains of science, technique and technology. Realization-oriented processes in architecture and building engineering are preceded by complex creative design processes of concrete designers or architectural design teams. The development of scientific knowledge can be reduced to the investigation of artificial languages and logical calculi. Such an artificial language from the point of view of the architect-practitioner is the language of notions of praxeology , design methodology and systems theory, as metalanguage of designing. Systems knowledge, knowledge concerning methodology and praxeology is now developing at the rate of progress in information theory and modern psychology [3-6]. Fleck [7], basing upon the theory of Kuhn [8], denotes the conditions of genesis and development of the scientific fact. He treats the cognitive act as a result of historical development of thought. The theory of Fleck [7], dedicated among others to problems of knowledge methodology and sociology,

enhances the impossibility of marking the boundaries between scientific cognition and the sphere of emotion and values. In this contribution, considerations and praxeological and methodological analyses are undertaken concerning the creative design atelier and approach of the architect.

According to the methodologist and bridge design engineer Z. Wasiutyński [9], the essential role of the not verbal thought in technique and architecture has been acknowledged, particularly the role of images, imaginations and figurative ways of thinking, as forms of objects that are perceivable only through reasoning, as well as of these being "material, visible and tangible". This statement concerns directly the process of architectural design that is connected, indeed, with problems of technique, technology and art [10,11]. The existing wide knowledge on architectural design, praxeology, ecology, systems theory and methodology permits to better describe, understand and improve real processes of architectural design as design-creative processes . The performed in this article methodical analysis of designing, with taking into consideration computer science application, and with multidisciplinary approach [12-22] – can serve the methodological consideration of some elements of architectural processes basing upon creative design actions and operations of Le Corbusier [23].

The present development of technique and technology as well as of organization of labor confirms the possibility and need of knowledge of design methodology. According to the opinion of Z. Wasiutyński [9], we are not able to embrace by our minds in one moment a too great quantity of design solutions; that, as a matter of course, makes the design process, thus the design process in architecture more difficult. Le Corbusier, the great creator of modern architecture, who changed twice the direction of development of world architecture, succeeded in organizing his proper design atelier and approach that was richer than all the other being created by contemporaneous architects. He enclosed therein such a multitude of significances that they can embrace and illustrate the complexity of the contemporaneous life. In the case of Le Corbusier, this multitude of values – "embarras des richesses" – arose from the creative force that seems so far to be almost superhuman and to be rather the act of the nature than of a human being. That superhuman creative force arises, perhaps, in many architectural ateliers and approaches, similarly as in the case of Le Corbusier, from applying creative design methods and strategies or their elements in an intuitive, that means – in a more or less consequent way [23-26]. Hitherto, a systematic classification of achievements of Le Corbusier has not been elaborated, but it is certainly possible thanks to a consequent, logic use of forms by this creative author. When utilizing contemporaneous design knowledge it is possible to perform an analysis of fundamental semantic units and also a more precise analysis of values hiding in the architectural creative activity of e.g. Le Corbusier. Architectural values in the creative activity of Le Corbusier are connected with a methodical shaping of the form. The architectural creative activity of Le Corbusier is characterized by creative changeableness. He had a rare ability of continuing creative ideas. That elasticity of Le Corbusier is the reason of the fact that criticism of his works takes vengeance on the critic self, as warns Jencks [23]. In the creative

works of Le Corbusier successive, detailed methodical decision-making operations of the architect-designer are distinctly evident. That is visible in his architectural design processes, among them of the Carpenter Center, the Savoye villa, the Ronchamp Chapel [19,20,22,24,26]. Le Corbusier distinguishes himself among other architects by his capability of synthesizing and mutually conciliating in his architectural works formal and conceptual contradictions. That results, perhaps, partially from decision-making actions in his design-creative processes that frequently are characterized by methodical features. The above statements can concern, to a higher or lower degree, many other creative architectural ateliers and approaches, as well as creative architects.

Elements of the architectural process from the point of view of design methodology. In methodology of development of knowledge the latter is generally systematized in two categories: knowledge directly on something (knowing-that) and knowledge on the way of proceeding (knowing-how) [28]. This remark concerns perfectly architectural designing. For performing methodological analysis were selected, as exemplary, certain elements of design actions (operations) of the creative architectural process of Le Corbusier. The creative activity of Le Corbusier is particularly good described in reference literature, also by the author and creator self, in the form of books and freehand drawings from architectural processes, executed in a special and careful way. What concerns Le Corbusier, many months passed between the acceptation of an order and the first real evidence of undertaking the design process. Le Corbusier dedicated that time to investigate the environment [14,22] where the project should be realized as well as the needs the project should meet. He used to say hat the conception would come itself when ready. In the initial phase, he studied and analyzed the undertaken order and he laid drawing aside because of detailed investigating design requirements and conditions. In architectural designing it is not possible to renounce an objectified description of needs, for example in favor of an only intuitive description [29].

System of criteria. In design methodology, the system of criteria is a formal description of the need(s). For this reason, the system of criteria, every time determined by the designer-architect, as ordered presentation of requirements and restraints, is a formal description of needs, with regard to the possibility and necessity of meeting earlier defined and identified needs. In architectural design the objectified determination of needs is an essential element. The designer participates during the designing process at the same time on many decision-making levels [20,29,30] concerning, for example, a technical detail, and takes into account simultaneously many other, various needs and conditions of that process. In design practice, the designer-architect performs, during successive phases of the design process, a detailed comparative analysis of many possible variants of spatial and technical solutions. These solutions are subject to consideration from the point of view of fulfillment of earlier defined needs of different kind and – on the other hand – considered by the designer from the point of view of their realization possibilities as well as other design constraints.

The idea of the spatial solution. The idea of the spatial solution, accepted by assumption in the first phase of the architectural process, appears on the basis of earlier analyzed needs and conditions of different kinds (among them: spatial, technical, ecological, economical, organizational, culture-oriented, psychological and other conditions) that constitute general and detailed design assumptions. For example, in the architectural process of the outstanding creative architect, Le Corbusier, the main idea of the a priori spatial solution appeared in the initial phases of the design process [19-23]. Many contemporaneous architects-practitioners acknowledge developing the idea of spatial solution in their creative processes. That idea is really an element of the creative process that stimulates in a positive way the imagination of creative designers.

Modification of the architectural form: varianting. In the creative process, modifications of the architectural form generally result in creating many variants of the solution. In the phase of creating solution variants, e.g. by successive modifications, successive collecting, selecting as well as processing of information being useful in the design process takes place. In the design practice of the architect (as in the case of Le Corbusier) this information is recorded in the form of freehand drawings, e.g. as successive variants of partial solutions or design phases. In such way fragments of variants of solutions could be found on different drawings from the creative activity of Le Corbusier, for example of the first phases of design. These fragments, after their selective ordering (juxtaposition) and adapting to the finally accepted solution, or modification, were enclosed in the integral solution.

The above described design operations are connected with the original multiplication of spatial solutions or of their fragments, and next, with their reduction. Such approach is characterized by features of methodical actions.

Correcting (improving) strategy. Independently of the above-mentioned design operations, Le Corbusier used so as every architect is doing, the generally well-known strategy of correction (improving) that is a strategy of searching for appropriate or more and more appropriate solutions. For example, the use of paper collage served Le Corbusier to work on details, adapt fragments of forms (or modify them) to real architectural conditions, as well as to verify their artistic value (through creative improving). During the whole design process of Le Corbusier conscious improving, in a moderately free and easy way, according to earlier analyzed spatial, technical and functional conditions is performed in an iterative process.

Feedback and iterations. Feedback and iterations [16] are used by the architect as the need arises in each stage of the architectural process. For example, among a set of variant-based design solutions one can search for an interesting solution that is, however, not very satisfying e.g. from the economic or esthetic point of view. Such way of thinking tends to a return (or iteration) to earlier phases of that design process. Obtaining through modification in this cycle a satisfying solution signifies a design operation called feedback. In design practice, according to the need of the designer-architect, methodic operations, namely feedback and iterations are applied. Many architects, similarly as Le Corbusier [24], do not abandon the initial idea

until the end of the design process but improve it and develop in a more precise way, i.e. modify the form, searching through iterations in successive detailed feedback operations for better solutions that create the intended artistic, functional and technical whole.

Phase of reducing variants of solutions and the final choice. In the architectural process, the selected variants of solutions are evaluated e.g. from the esthetic, ecological, functional [14,22] and technical point of view, and then the set of real solutions is limited to solutions that assure a comfort of utilization and, at the same time, are possible to be technically realized. In the case Le Corbusier, the selection of a concrete solution is preceded by verifying, for instance, the perspective of the form of the line of a designed ramp on a paper model. That methodical selection phase is submitted to iterative operations [19-25].

The final choice in the architectural process is performed through successive reductions of the set of possible solutions, by using realization-oriented criteria. These criteria assure a successive selection of earlier multiplied solutions and lead to the final choice of a real architectural solution.

Conclusions. The traditional understanding of the knowledge on designing and on designing modern architecture doest not fully correspond to the increasing complexity of the being designed objects. Therefore, it becomes necessary to search for new ways facilitating the design and enlarging its creative and technical possibilities [26]. One of these ways consists in applying elements of the existing knowledge of design methodology and systems knowledge.

The aim of this contribution was to indicate practical possibilities and qualities of methodical improvement of the architectural process and methodical assistance of actions (operations) of the architect in his/her individualized creative process. Elements of the architectural process, described by the language of design methodology and systems theory, reveal an image of the potential creative capacities of the architect. That is a real task because the architect in this process intuitively and not entirely consequently uses elements of methodical operations.

Some of the methodical design operations, applied by architects-designers, e.g. by Le Corbusier in an intuitive way, assure a potential opportunity to a more conscious, efficient and creative design. That is possible thanks to methodically assisting the creative invention of the designer; such assisting, however, does not replace that invention. The existing wide knowledge concerning architectural design, praxeology, ecology, systems theory, design methodology, computer science and informatics is characterized by intellectual potential indicating new possibilities of development of the architectural atelier and approach and of knowledge on real creative architectural activity. The knowledge of the contemporaneous design methodology can serve the improvement of architectural design and of its effects, namely of spatial architectural solutions [2,4,7,13,14,16]. Perhaps, there is a possibility to reach that improvement basing, to a higher degree, on e.g. the analysis of efficient and effective architectural design processes of concrete creative architects.

Generalizing the knowledge of design methodology among architects can have a positive influence in the domain of improving processes of architectural design and of the architecture

self. Maybe this knowledge will permit to design architecture in the future in a more efficient way with taking into consideration, in a well-balanced manner, the numerous kinds of its conditions, an architecture that enters in the aerodynamical equilibrium of the planet, serving the survival of the human being and the planet. At present, the important thing is the design atelier and approach as well as the intuition and inventiveness of the architect to be assisted in a methodical, methodological and systems-based way.

CHAPTER X

The architectural designing process described by the graph of decision-making operations

The creative design process as a source of artistic successes of the architect. According to the opinion of G. Nadler, design engineer and methodologist [24], the process being used in design acts profoundly upon the results, and engineers as well as professional designers should abandon traditional schemes and start applying the multiplicity of approaches, what is required when designing in the reality [96-98]. The mentioned above design engineer, G. Nadler, also stated that the continuation of research concerning design processes will assure obtaining better methods than the ones disposed of at present. Taking into consideration the opinions above, the present contribution discusses the possibility of multiple approaches to architectural design on concrete examples of remarkable architects [89, 99-102].

Scientific works about design processes, carried on in many domains of knowledge and technique concern actions, procedures and design methods. These works indicate the possibility of analyzing the architectural process from the point of view of contemporary architectural, methodological, systems-based and praxeological knowledge [103]. The specification of the architectural design process being described by a graph of decision making actions is compatible with the existing architectural knowledge and design methodology. The realization of the particular phases of the investment process as well as the management of the objective or, in other words, the management of the whole architectural-building enterprise lies not in the hands of only one of the participants of that process. Design and investment processes are carried out by design and realization teams. Depending upon the case whether it is the conception phase, the phase of technical design-project or, finally, the phase of realization, the following participants are saddled with responsibility: the architects, building engineers, sanitary engineers (and others according to current need), contractors of building works, investors and coordinators of the investment process (it happens that sometimes architects are coordinators of that process).

The constant task and aim of the architect-designer consists in maintaining a due respect for the existing spatial architectural, culture-oriented context as well as for the spatial organization of the site, the functionality of the existing system/arrangement, and the assurance of the appropriate quality of building materials and of useful standards. In practice, the scope and extent of taking into consideration the design assumptions in the design process depends upon the preliminary architectural design-project and upon many detailed information elements as well as requirements that are taken into account as a result of a dialogue between the investor and the designers' team. It is not easy to do agree, in practice, contradictory aims resulting from financial, program-based, localization-oriented assumptions as well as from the planned time-base parameters. New environmental purposes that one can observe recently in the world tendencies of architecture design induce the architect to have a certain reflection concerning the workshop and the theory of architecture designing. Is the practical introduction of environmental aims into the scope of the existing design procedures, methods and strategies included in the hitherto "traditional" conception of architecture? Most probably that signifies a change and, at least, a reorientation in the decision making scheme of the architect's workshop.

The proposed decision graph is a scheme of decision making actions of the architect. It is a reconstruction of the real process of architectural design. A graph is the description of the structure of the multi-variant process of architectural designing. The presented decision graph of actions in the architectural design is a description of creative actions of the architect undertaken in a complex process (Fig. 53). The discussed decision making graph of the architectural process is a synthetic approach of many partial architectural decisions. This scheme is compatible with the contemporary knowledge concerning designing.

Nowadays, a new notional situation is observed in science and technique. We are collectively searching not only for new procedures but also for new purposes as well as for a new level of achievements. The being discussed decision making graph of the architect serves, indeed, these general purposes. In order to describe, in an objectified way, elements of creatively design-based artistic and technical actions (as being intellectual actions of the architect), the existing architectural knowledge has been used, as well as knowledge concerning design methodology. In the presented decision making graph, the design process has been defined through successive, following each other, actions according to the marked direction of the arrows and through iterations. In that decision graph, one of the designing decisions has been determined by one action and illustrated through a transition from one graphical point to another. In the process of architectural design in successive designing steps (determining the decision process), the architectural object is designed and shaped according to the creative artistic vision, to the environmental conditions and the technical possibilities, as well to the knowledge and the skills of the architect-designer.

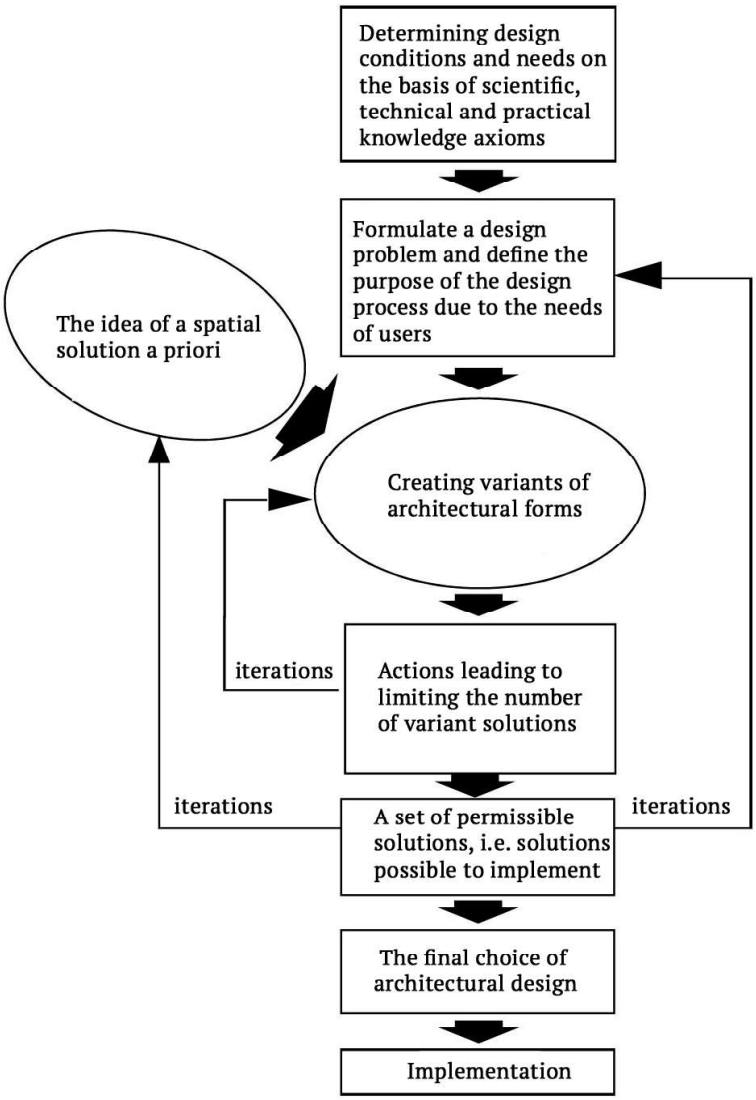


Fig. 56. Decision making graph of an architectural design process.

The first phase of the architectural process connected with decision making activity of the architect consists in determining the design assumptions (brief fordesign) resulting from the various conditions of the design problem. In the process of architectural designing, the determination of the conditions and needs [103, 104] takes place on the basis of scientific, technical and environmental axioms as well as on the basis of practical knowledge; the determination of the conditions and needs influences the formulation of the design problem. The architect-designer or the designing team simultaneously takes into consideration many conditions concerning the architectural problem. The determination of the architectural brief fordesign results from the destination of the being designed object. Such determination of the brief fordesign is related to the function of that object and its environment, as well as to many other conditions. The definition of various conditions and needs, e.g. economic, social and technical conditions and needs, makes possible the formulation of the architectural design problem. The formulation of the architectural design problem determines, indeed, the design aim.

The architectural design aim, being formulated in a general way, is expressed more precisely in the successive design phases. Particularly, the design aim is expressed more precisely on account of the fulfillment of the needs that are specified more or less precisely determined as well as on account of the design constraints. In the architectural design process being conditioned in a many-sided way, the appropriate determination of the needs in the preliminary phase of the creative process influences the active behavior of the designer as regards the new problem situation. That action is decisive to a great extent what concerns the degree of accuracy of further spatial solutions [103-107]. In architectural design it is not possible to resign from the objectified description of the needs in favor of, for example, an intuitive description. The graph, as model of the architectural process, proves that the designer, during the design process, participates simultaneously on many decision making levels concerning the being elaborated whole solution as well as a concrete technical detail "included" in the general form and function of the being designed object.

As societies are developing, the achievement of the state of fulfillment of the needs of social groups and of particular individuals becomes more and more difficult, and adequate actions tending to fulfilling new needs become more and more complicated [105]. The system of the accepted design criteria is an ordered approach to needs and constraints thus is a formal description of the needs. The question arises how to realize the development and the needs of the human being in a well-balanced way? In architecture, determining and investigating the needs is a complex operation, variable in time; therefore, problems concerning needs include elements of forecasting and are connected with theory and practice of investment planning. An objectified determination of the needs in architectural design is, indeed, an indispensable element. It happens that the main idea of the spatial solution as an a priori idea of that architectural solution, or an idea resulting from assumptions, appears sometimes suddenly in the consciousness of the architect. It happens that this idea, appearing suddenly but after many

performed analyses, is a synthetic approach to previously studied, fundamental design problems, also problems connected with the needs and the investment aims of the enterprise. Creating the idea of the spatial solution, connected with the design of functional systems and with the formulation of the design problem, has been associated on the drawing with iterations. Iterations and feedbacks, being characteristic elements of human actions and human behavior in many domains, also in architecture, assure the possibility of bettering the solution through multiple verification and return to successive design phases according to the current necessity and the process of improving the design project.

An architectural design is a function with the relation "creator-need". The need is experienced by the individual as a state of frustration because of the lack of some good of material or spiritual character. When having recourse to the bases of motives of actions of the human being or of the community, one can accept that the existing state of disturbed balance or tension of an individual or of a community causes a determined behavior called activity. That is the process of conscious change of the state considered to be undesirable because of the lack of fulfillment of a concrete need into the state where that need is fulfilled. That is particularly manifested what concerns fundamental needs, as e.g. the need of inhabitation connected with the feeling of security, that means in building engineering and architecture. The proposed process, conceived in the decision making graph, assumes the possibility of creating many variants of the architectural spatial solution. In general, the number of solutions obtained by the architect-designer in the creative process is excessive; not all these solutions fulfill the expectations i.e. the aims and needs. A permanent operation of the architect-designer consists in the creation of variants of the architectural solution and then in the elimination and the modification of a part of these solutions, according to the truth that it is not possible to improve things that do not exist. The process of successive elimination conduces to obtaining a set of spatial solutions as being a limited set of admissible variants. In the multi-variant process of architectural design, the iterations and connected therewith feedbacks result in a change through a modification of detailed and general solutions of the project. In the architectural practice, the elimination of variants is performed through searching for more and more rational, detailed solutions, e.g. technical, esthetic solutions. A number of architects, e.g. Le Corbusier and Calatrava, do not abandon, until the end of their design process, the original idea (a priori idea), and do improve it, define it more precisely and modify the being designed architectural form, searching for detailed, better solutions.

The final creative selection of the design solution in the proposed design process is not possible if one accepts there is no solution that is possible to be chosen and to be realized. In such case, one has to start the design from an arbitrary, selected action being proposed on the graph of the design process. The system/arrangement of design actions of the architect, being proposed in the graph, can be completed with other design actions, more or less detailed. The decision making process, described by the graph, can be carried on according to the will of the architect in different way.

The described decision making process is not characterized by features of a technical, technological process because it is a creative process. In the practice of architectural design, the architectural object is shaped in successive design steps composing the decision making process. The architectural design process of the architect, described by the decision making graph, is a trial of interpretation and methodological, systems-based and praxeological reconstruction of the process of architectural designing. The decision activity, being described in the graph, includes decisions made according to the vision, the technical possibilities, the knowledge and the skills of the architect-designer or/and the interdisciplinary design team. Elements of creative design actions are conceived into a scheme of a multi-variant, creative architectural process being defined as the decision graph of the process of architectural design. The proposed, in the graph, determination of the set of needs and, as an effect, their prioritizing comprehended as their complex analysis, can protect against errors during designing. The idea of the design solution is the idea of spatial architectural solution that inspires and assists the further design process. This idea, as an a priori idea, can appear sometimes in the mind of the designer for instance after he/she has considered, in a detailed way, many e.g. functional arrangements and systems or/and design constraints resulting from and connected with the properties of materials and with the selected and accepted technology of execution of the object, as well as measures taken under the influence of artistic emotions. During designing, being understood as a complicated intellectual process, the architect considers many times the possible variants of solutions according to his/her creative vision, will and capacities/skills. In such a way he/she constructs an individual decision making structure of the design process. In that sense, the graph rises from the practice of architectural designing. The decision making graph indicates real possibilities of selecting design ways and paths. These ways and paths are marked by arrows on the graph. According to the development of the contemporary science, it is the method, the methodological and systems-based knowledge that is a bridge between theory and practice of designing, also architectural designing.

The description of the architectural design can support the creative activity of the architect, but does not replace his/her knowledge or talent. The proposed objectified, methodological description of that activity serves improving the architectural design processes and thus, improving the effects of architectural designing; that means the improvement of the architecture of the being realized buildings and the architectural environment.

A result of the architectural design process, together with its preliminary phase and the further phases, is the architectural design project, then the architectural-building project, the building project and the realization project that determines the functions, the form and the structure of the building object. At present, such a project determines also the energy-based and the ecological characteristics of the being designed building, as well as the accepted technical

and material-based solutions, as well as takes into consideration and refers to the environment and the fundamental requirements that are set to objects being built, for instance what concerns the degree of access for handicapped persons. The successively expanding, so-called built environment that arises as a result of the increasing design and realization activity of the human being is decisive what concerns the present and thus, what concerns the possibilities of development and survival in the future.

CHAPTER XI

A prototypical program of computer-assisted preliminary phase of the architectural process

In this work, methodical analyses of architectural forms as well as of architectural design processes were presented, among others on examples of buildings of the following architects: Gaudi, Wright, Utzon, Le Corbusier, Gehry, Calatrava. The discussed, analyzed and acknowledged as partially methodical processes of architectural design of these famous architects in the world constitute a proof of the existence of potential possibilities of computer assisting concerning creative processes of architectural design. Theses analyses became the basis of further analyses of computer aided creative processes of architectural design.

An effect of development of contemporary, ecological technologies in building engineering and in architecture, as well as of computer aided architectural designing is the architecture of Frank Gehry [1, 4], attractive from the artistic plastic point of view and advanced from the technological point of view. Technologists of Frank O. Gehry [4,10] cooperated with Dassault for adapting the powerful and progressive CAD software Catia for the creative architectural form, in the newly named Digital Project. The Gehry's Guggenheim Museum in Bilbao owes much of its realization to the extraordinary progress, which now is reaching, besides engineers, also designers and architects and influences all the society. The creative architecture of Gehry is, indeed, the practical way to realize the architect's vision of contemporary architecture as a result of ecological building technology with the application of computer aided design. Maybe it is possible, among others on the basis of systems knowledge and design methodology, to introduce computer based assistance of the creative activity of the architect, concerning preliminary design phases. As a result of undertaking that type of consideration, the presented beneath prototype program (software) of computer aiding of the preliminary phase of the architectural process is presented. That software is come into being with a close collaboration of the architect –the author of this contribution with a computer science specialist.

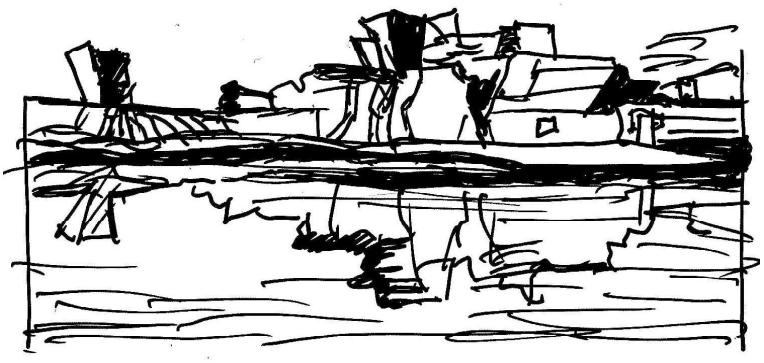


Fig. 57. Facades of titanium sheets in the Guggenheim Museum, Bilbao, Spain, architekt: F.O. Gehry.

The traditional approach to the knowledge concerning design and concerning design of contemporary architecture does not fully correspond to the increasing complexity of the being designed objects. In this connection, it becomes necessary to search for new ways of facilitating design and improving its creative and technical qualities [26]. One of these ways is the use of elements of the existing knowledge concerning the methodology of design and of systems-based knowledge. The objective of this scientific work consisted in showing the practical possibilities of methodically improving the architectural process as well as methodically supporting the activity of the architect in his/her individualized creative process. The elements of the architectural process, described by the language of design methodology and systems theory, reveal the image of potential creative possibilities of the architect. That is, indeed, a real task because it happens that the architect applies in the architectural process partially intuitively and in a not fully consistent way elements of methodical actions. Some methodical design actions, used by architects-design engineers, e.g. by Le Corbusier in an intuitive way, create a potential possibility for a conscious, more efficient, creative design. That is possible by methodical supporting the creative invention of the design engineer, as presented on selected examples. The existing wide knowledge concerning architectural design, praxeology, ecology, systems theory, design methodology, computer science (informatics), has intellectual potential indicating new possibilities of development of the architectural workshop and of knowledge about real creative architectural activity. The knowledge concerning the contemporary design methodology can serve to render architectural design more efficient and to improve its effects, namely the spatial architectural solutions [2, 4, 7, 13, 14, 16]. Maybe one can attain that when basing, to a greater extent, upon, for instance, the analysis of efficient and effective architectural design processes by concrete architecture creators. The propagation of the knowledge of design methodology among architects can have a practical influence upon improving and rendering more efficient the processes of architectural design and the architecture. Maybe that knowledge will permit in the future to design in a more efficient way a

comfortable architecture that takes into consideration in a well-balanced way the plurality of its conditions, an architecture serving the aerodynamic equilibrium of the (our) planet and the survival of the human being. At present it is important, indeed, that the design workshop as well as the intuition and the ingenuity of the architect can be supported in a methodical, methodological and systems-based way.

This presenting program Computer-based Assisting the Preliminary (Preparatory) Phase of the Architectural Process is effect works this autors Gregory B. Prokopski[5] and Aleksandra Prokopska. The aim of the presented program for computer-based assisting the preliminary (preparatory) phase of the architectural process is to intensify and facilitate architectural design activity. This program is a specialized tool, which – in the preliminary phase of the architectural process – facilitates methodically creating variants of forms of the architectural project. It is the first computer-based assisting program which intervenes in the creative preliminary (preparatory) phase of architectural design. As main information carrier in the program the definition of "Bézier" curves has been applied. In the program, a change of definition of shapes takes place into their mathematical description by Bézier curves [1,2]. In the described program the combinatorial method is used, facilitating the creation of forms of the architectural project. This is a well-known and generally applied method in technique, called method of morphological analysis [3-5]. This creative method was utilized, in an intuitive way, by Le Corbusier, architect. The presented program came into being, indeed, through imitating what was doing and achieving Le Corbusier. In the program the possibility is provided of a creative utilization of existing plastic artistic compositions preferred by the designer-architect. Design decisions in this program are made by the architect. The designer draws on the display monitor, for example, horizontal projections of architectural forms of the being designed object, forming in this way new arrangements and modifications of forms that were earlier selected and recorded in the library of forms.

The proposed program is a specialized intellectual tool the architects-designers can use in their practice of professional activity during the preliminary (preparatory) phase of the design process. The main purpose of the being presented program of computer-based assisting the architectural process, created according to exemplary activities of Le Corbusier, is to intensify the potential possibilities and the creative activity of the architect, in the process of searching for a satisfying spatial solution, namely the architectural form. In design practice, the preliminary phase concerns, among others, executing sketches of the architectural solid (cubic) form of the project that meets earlier determined needs, assumptions and corresponds to sets of conditions in the domain of architecture, construction etc. On the basis of these sketches of the architectural spatial form the architect often draws horizontal projections, sections and façades of the architectural object.

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The program renders more efficient the creative activity of the architect and proposes him/her to create, in a methodical combinatorial way, variants of the project and, next, to perform their successive selection leading to the choice of the best, satisfying solution. The program doest not exclude, but contrariwise assumes the use by the designer-architect of computer-based assisting programs in the next, successive design phases.

Project-oriented properties of the program. The program is partially automated [1,2], being inspired by methodical elements of Le Corbusier's creative activity as pattern. The starting point for elaborating the program was the set of conclusions from the earlier performed methodical investigations and analyses of the creative activity of Le Corbusier.

The design-oriented qualities of the program concern the architectural and methodological aspect. These qualities were obtained in the program through connecting elements of the method applied in technique, called morphological analysis and Bézier's curves [1,2]. The program intensifies, in a methodical and methodological way, the creative capabilities of the designing architect in the preliminary phase of the design process. In the creative design processes of Le Corbusier design operations can be discovered that are characterized by methodical features [4]. Such features are assigned, for example, to his methodically gathered, numerous freehand notebook drawings (they were utilized sometimes after many years) [3,5] and his drawings concerning concrete architectural processes (e.g. freehand drawings from the architectural process concerning the Carpenter Center) [3,5,6]. Le Corbusier laid great stress upon his drawings from design processes and stated that they would perhaps become useful for future generations of architects [3-5].

The presented program proposes to the designer-architect a partially automated combinatorial approach to forms. Elements of that method are applied by each designer-architect in an intuitive way in his/her professional practice. When building the program the combinatorial approach to forms was used as one of many possible kinds of the creative morphological analysis, according to the contemporaneous knowledge on design methodology [8-11]. The application of Bézier's curves [1,2] permits to adapt, for example, the being designed architectural form to the user function it has to fulfill. In the discussed program shaping the architectural form in three geometrical projections is assured. It goes on analogically in a traditional design atelier of an architect.

The program assures the possibility of creating a set of forms inspiring the designer, or, in other words, a dictionary of forms. The creative design activity of Le Corbusier and the application by this architect of an open "set of forms" in designing and creating modern architecture became the pattern for such type of actions (operations).

According to the possibilities assured by the presented program based upon the dictionary of forms – forms being selected from among the ones the designer prefers – the designer further selects forms considered to be particularly inspiring in the accepted concrete design task. The designer-architect performs a regrouping of these forms as well their juxtaposition and

arrangement; he/she modifies them so as to obtain a new proposition of the form of the spatial solid, with drawing horizontal, vertical projections and façades of the being designed object.

The program is characterized by technical possibilities of multiplication, combination and modification of determined sets of forms. These forms were previously recognized by the designer to be suitable and were collected in the dictionary of forms. Such forms, stored in this dictionary, are utilized through their creative arrangement and successive modifications in order to create variants of the architectural form, among them the searched for, final variant. Le Corbusier proceeded in an analogical way in his architectural design practice, in this case basing upon forms of his puristic painting [3-5].

The program assigns to combinatorial design operations their technical sense but does not replace the designer in his/her creative activity and design decision based upon his/her professional architectural knowledge. Forms foreseen for creating the library of forms can appear as forms in freehand drawings and can be transferred into the vocabulary (set, library) of forms. In the program two phases of design operations can be distinguished, determining possibilities of creatively shaping the architectural form. For example, according to the proposed program and the creative imagination of the designer forms that fulfill different architectural requirements can be efficiently obtained in the first phase of architectural designing.

The program, as intellectual tool of the architect, does not limit the possibilities of creative artistic expression of the architectural achievement. Contrariwise, this tool renders more efficient and intensifies the creative and technical creation of variants of architectural solutions. The final selection of the architectural form during the design process is made the designer-architect in the program.

Architectural sketches of projections of the spatial solid (cubic) form, designed in the preliminary phase according to the possibilities of that program show, in an illustrated way, the creative consequences of the just thought by the architect associations of forms being placed in space [13]. The dictionary of forms can serve the architect-designer for creating new attractive architectural objects through new arrangements e.g. of new forms and through their modification in the architectural creative process [12,13]. The presented program permits an efficient transformation of creative visions of the designer into projects being in conformity with modern architectural knowledge and with concrete architectural conditions, among them with concrete technical and environmental possibilities.

Technical description of the program. The employed combinatorial method facilitates the creation of architectural forms. The aim of the presented program is to support the early creative phases of an architectural process. Its use involves two phases. In the first phase model existing architectural forms are modeled to create a library or a dictionary of forms. In the second phase this library is used to create drafts of new architectural designs. The architectural forms in both: a project and in a dictionary are, from the low-level point of view, composed of curves (N.B. a line is a special case of a curve). The main operation that the program needs to perform internally is to create, store and manipulate descriptions of curves. To that

it was decided to use the definitions of Bézier curves [1,2], as they provide the needed ease of use, flexibility of manipulation, and are suited to model a wide spectrum of shapes.

The first phase concerns gathering of selected shapes to be put in a dictionary. This program can load any kind of graphics in a bitmap format: a sketch, a painting, a landscape. This graphics is treated as a kind of background. The designer then models the forms visible in the background into Bézier curves and adds the ones he finds interesting to the dictionary of forms. This way a dictionary can be created, changed or extended. Dictionaries can later be used and extended for multiple projects. The use of a library of forms allows for a closer imitation of the early phases of real-world architectural creation process. The library constitutes a record of this part of designer's inspiration that is related to the creative choice of forms considered as having potential for their use in a newly created architectural composition.

The second phase is the actual design phase. The background graphics is turned off and the designer is given an empty plane and a selected database of forms is loaded. Inspired by the work previously used to harvest the forms or just by the forms alone he creates in his mind and on the computer screen a new vision of a solution for the architectural problem he undertook. The spatial vision of a new architectural form is created by putting together selected forms from the dictionary of forms.

The forms are copied onto the plane, rotated, scaled, stretched and freely modified to create the draft of a new architectural project in accordance with the needs, assumptions and other earlier established guidelines. If so desired, new forms can be at any time added to the currently used dictionary of forms. The program allows for segregation of forms into virtual layers of the design project, similarly to layers of transparent sheets put together. A form placed on a plane is initially associated with the layer selected as “current”. Visibility of in each layer can be turned on or off, has an assigned color and line thickness. All these mechanisms are included to facilitate designer's tasks of selection and manipulation of architectural forms.

As mentioned earlier to describe forms in our program we use Bézier curves because they provide the needed ease of use, flexibility of manipulation, and are suited to model a wide spectrum of shapes, see Figure 1 a,b. Mathematically speaking they are called Cubic Bézier curves. According to [1]: “Four points P_0, P_1, P_2 and P_3 in the plane or in three-dimensional space define a cubic Bézier curve. The curve starts at P_0 going toward P_1 and arrives at P_3 coming from the direction of P_2. Usually, it will not pass through P_1 or P_2; these points are only there to provide directional information. The distance between P_0 and P_1 determines "how long" the curve moves into direction P_2 before turning towards P_3.

The parametric form of the curve is:

$$\mathbf{B}(t) = (1-t)^3\mathbf{P}_0 + 3t(1-t)^2\mathbf{P}_1 + 3t^2(1-t)\mathbf{P}_2 + t^3\mathbf{P}_3 \ , \ t \in [0,1].$$

Modern imaging systems like PostScript, Asymptote and Metafont use Bézier splines composed of cubic Bézier curves for drawing curved shapes. In the presented program each form is composed of one, two or more connected Bézier curves. Every such connection between two Bézier curves can be done in one of three ways (see Figure 2). To allow a wide range of connection shapes we enforce different sets of requirements on the control points (e.g. points P1 and P2 in Figure 1) adjacent to a connection point. In the first, default case, the points are moved symmetrically around the connection point of the two curves. If one of the control points is moved, the control point of the other curve is moved to keep the symmetry, as shown in Figure 3. In the second case it is only required that both control points and the connection point are kept in one line, as shown in Figure 4. The third setting allows the control points to be placed freely and independently, which allows for creation of rectangular forms, as can be seen in Figure 5 a,b. As is shown in Figure 5c, we ensured that during curve modifications the designer is given all information about the future shape of the curve, before the decision to change a shape is made.

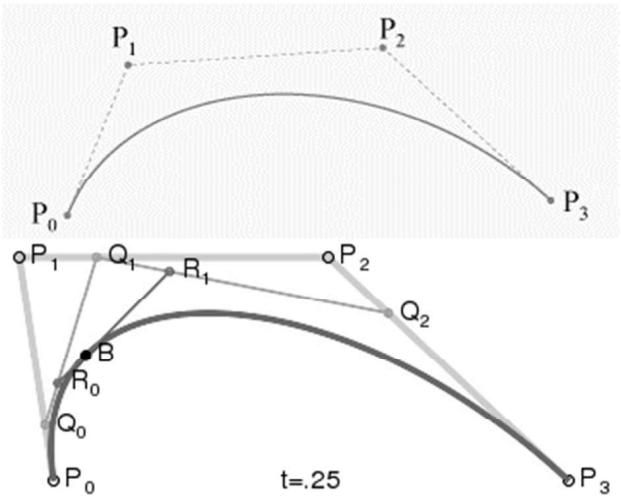

Fig. 58, 59. Bezier curves.

In the second case it is only required that both control points and the connection point are kept in one line, as shown in Figure 4. The third setting allows the control points to be placed freely and independently, which allows for creation of rectangular forms, as can be seen in Figure 5 a,b. As is shown in Figure 5c, we ensured that during curve modifications the designer is given all information about the future shape of the curve, before the decision to change a shape is made.

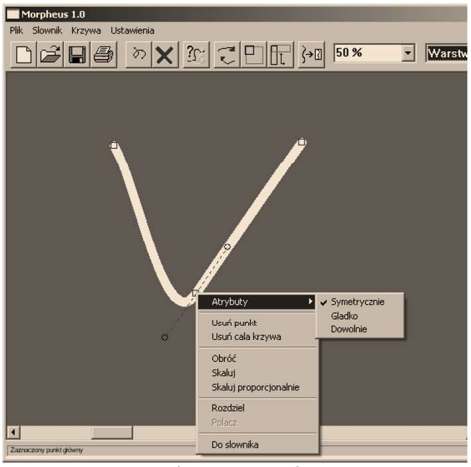

Fig. 60. Step 0: Three ways of joining curves.

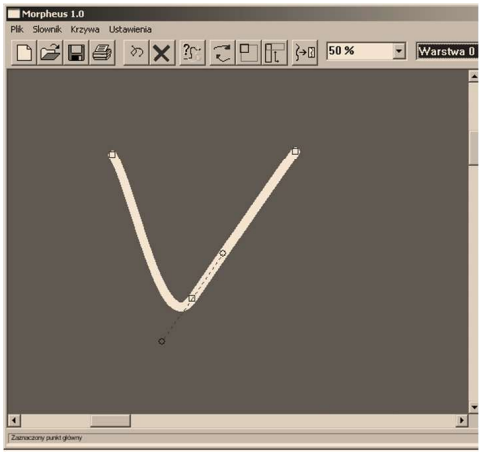

Fig. 61. Step 1: Symmetric displacement of directrices.

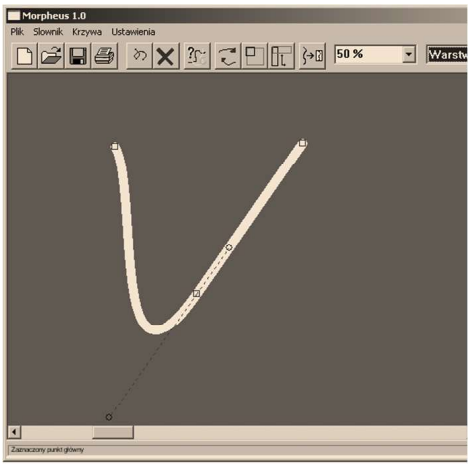

Fig. 62. Directrices in one line.

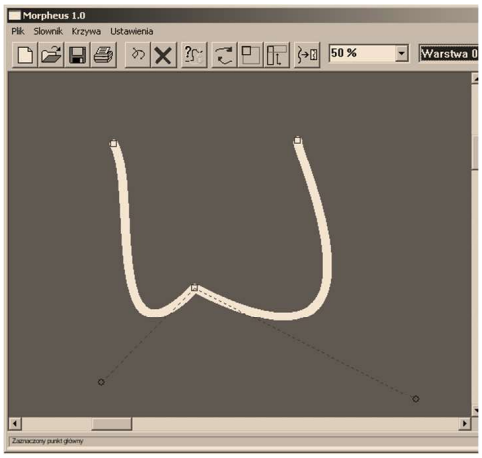

Fig. 63. Position of directrices arbitrary, arbitrary curve.

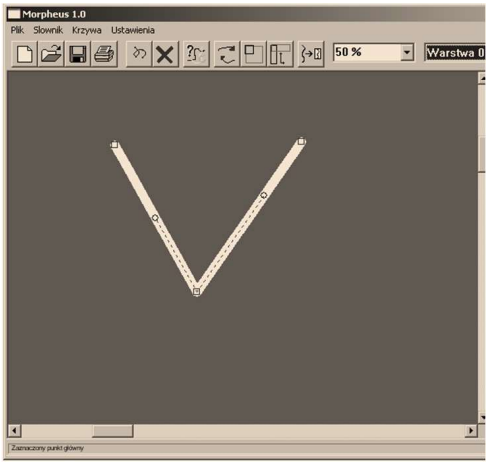

Fig. 64. Position of directrices arbitrary, rectangular forms.

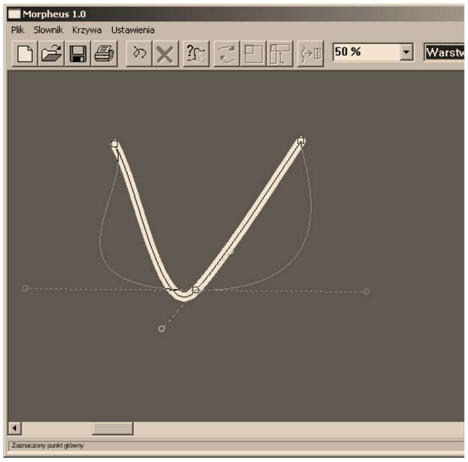

Fig. 65. Example of further modification of an arbitrary curve

The presented tool gives the designer a number of powerful features to facilitate a creative architectural process. From the technical point of view the program allows for harvesting interesting and inspiring shapes (forms) from any kind of graphics, creating a library of forms that can be later used in and extended during the design process. Our tool allows a designer to freely reuse, modify, and join various forms during the creative architectural design work. The presented program is the first one that makes it possible to assist in a computer-based way the first phase of the creative architectural process; this phase was generally recorded by the designer, in the classic approach, in the form of freehand sketches. Design decisions in this program are made by the architect.

Design operations in the program are methodically and technically assisted, basing on imitation of the architectural design activity of Le Corbusier, what provides for their technical realization in the form of an architectural project.

The technical and methodical differentiated qualities of the program, adapted to the requirements of the architect-designer, are obtained by connecting elements of the method of morphological analysis and the technical possibilities assured and presented thanks to the use of Bézier curves.

The program improves capabilities of architectural creation in the phase of creating the vision of the spatial solution, by intensifying that vision and assisting it in intellectual and technical sense. Through imitating the artistic and architectural activity of Le Corbusier the creative opportunity of designing forms of the architectural spatial solid is assured to the designer, according to his/her free will. The example of not automated methodical operations in the creative activity of Le Corbusier is a factor convincing of such possibility and simultaneously is a proof thereof. By imitating the design activity of Le Corbusier the program assures collecting a dictionary (library) of forms and next its creative utilizing through recombination and modification of forms selected from the library. Such creative operations assist new projects to come into being. The program is characterized by technical qualities for multiplying, combining and modifying determined arrangements of forms earlier found to be interesting by the designer. Operations of such type are constant elements in the creative process of architectural designing.

The application of the program in the designing practice of the architect can lead to facilitate creative architectural processing and render it more efficient in the first phase of the composition of the architectural spatial solid form. The presented program does not limit the creative capacities of the designer but assists and improve them by imitating the procedure of design activity of Le Corbusier.

Le Corbusier who was dealing in the morning with painting puristic pictures (or plastic art forms), and in the afternoon with designing new, from the point of view of the world in those times, spatial forms of modern architecture, basing on the painted in the morning artistic plastic forms [7], has twice changed in the 20th century the direction of development of architecture. This program, elaborated by imitating his real design activity allows the designer to create in a methodical, thus efficient way, on the basis of selected forms, new architectural forms and to modify them according to given architectural needs. In the program possibilities are assured for the designer to undertake design operations according to his/her creative will and his/her skills with maintaining in the being created project the original esthetic features of the earlier chosen set of forms.

As intellectual tool that intensifies the creative and technical operations of the designer, the program does not constrain the possibilities of expression of the architectural achievement but assists the designer in solving different, conditioned in a many-sided way, problems of composition of the architectural spatial solid.

This program improves, from the technical point of view, the architectural creative process in its preliminary (preparatory) phase and assures the opportunity of a richer realization of the creative capabilities of designers-architects.

Perhaps, with this program it will be possible to design more efficiently than hitherto a more and more beautiful modern architecture, e.g. pro-ecological architecture.

SUMMARY

The present–day civilization development is associated with acquiring new and surprising systems knowledge, use of informatics and computer science, of design methodology and also methodology of architectural design. The traditional comprehension of knowledge concerning designing as well as designing architecture does not fully correspond to the growing complexity of the being designed objects. In connection therewith it is necessary to search for new ways that facilitate and improve the design and increase its creative and technical possibilities.

The existing and new appearing knowledge concerning: theory and practice of architecture design, technology, praxeology, ecology, systems theory, design methodology, informatics and computer science possesses an intellectual potential that denotes new possibilities of development of the architectural workshop and knowledge what concerns real, creative architectural activity. The modern architecture is really an effect of the interdisciplinary progress in knowledge and technology including building technology and building materials, ecology and informatics and computer science, architectural knowledge, design workshop of the architect as well as artistic creativity.

The being considerations, definitions and methodological analyses, presented in the monograph, concern the perception and analysis of creative design processes in architecture as being connected with possibilities carried by the modern development and progress. At present, the awareness that the human being him/herself is an element of the nature becomes more and more often the pra–reason of carrying on rational activities directed onto the environment of human's life, i.e. also onto the architectural and building environment.

In the work the idea of habitat has been analyzed [2–11, 97] as the architecture of the future that can, rationally and harmoniously lead to a safe, well–balanced development of the architectural environment as well as to the architecture it–self. That idea can conduce also to a harmonious coexistence, with the nature, of each human being, with integrating the natural and artificial environment, as an architectural environment on the level of micro– and macrostructure of these environments.

In examples of architecture being analyzed in the monograph, the architectural creation concerning the preliminary phase of the architectural process is connected with the humanistic vision of the world. For considering the methodological analyses examples have been selected indicating the importance of the preliminary phase in the architectural process and illustrating the creative possibilities of the architect and the builder.

Object of observation and analysis were the creative process of the following famous architects: Le Corbusier, L. Wright, F. Gehry and S. Calatrava. An intuitive use of elements of methods or of whole methods in the processes of designing the being analyzed architectural forms, e.g. of Villa Savoye of Le Corbusier. The presented analyses of artistic creations of architectural achievements concern mainly the preliminary phase of the architectural process.

The method used by Le Corbusier during designing the Villa Savoye is the method of morphological analysis that, being not a ready prescription, favors creativity and unconventional, innovative creative solutions. That method "delivers" the natural creative possibilities of the architect–designer, particularly in the preliminary phase of the architectural process. Analyses of elements of the architectural design process have been described on selected examples by the language of architecture, design methodology and systems theory, thus discovering the modern image of potential creative possibility of the architect.

Pro–ecological tendencies in the present–day development and progress cause that the development of architecture is drawing towards shaping an architectural object, an energy–saving one as the passive or intelligent house, or as the house of type "machine for living" according to the idea of Le Corbusier, a house improving the comfort of living [83]. The possibility of the realization of the architecture of the house: machine for living, i.e. an intelligent house is the effect of development of technology, art, energy–saving, passive building, together with the technology of gardens of the roof or technology of winter gardens. That ecological development and progress is also connected with the use of renewable energy sources, for instance the energy of the sun.

The carried–out, in the last years, examples of pro–ecological architecture allow hoping that the future ecological architecture of the XXI age, including the architecture of objects assuring the production of electric energy can be designed and realized in agreement with the natural environment and the nature of the human being, as intelligent houses or machines for living. The being discussed in this work, according to selected examples, pro–environmental way of carrying on the design process with e.g. saving energy and thus limiting the emission of greenhouse gasses leads also to decrease financial outlay necessary to realize energetically efficient buildings.

In the presented graph of the architectural process the possibility of creating many variants of the spatial architectural solutions according to the architectural and design–based conditions is assumed and analyzed. Methods, strategies and architectural conditions are analyzed in that decision–making graph. In the graph being a model of decision–making actions,

the assumption is made of a creative use of design methods or elements of methods and strategies with creating, for instance, an "a priori" solution and accepting that, among others, the architectural design is a function with relation "creator–need".

One of the goals of considerations, undertaken in this work, was to indicate the practical possibilities of rendering more efficient the architectural process through methodical and computer–assisted aid for carrying on the activity of the architect in his/her individualized creative process.

In the work methodological analyses of elements of creative architectural operations have been presented. Methodological assistance of the activity of the architect is a real task because many architects used and use, in their architectural process, partially intuitive and at last not consequently selected elements of methodological actions. The methodological design activity carried on intuitively by architects–designers, e.g. by Le Corbusier, assures a potential possibility of more efficient, and creative architectural designing being conscious and based upon existing systems knowledge and methodological knowledge. This is possible thanks to a methodical assistance of the creative invention of the architect–designer.

The presented methodological considerations as well as the proposed innovative program of computer assisting of the creative architectural processes can become an inspiration of further searching for a conception of improving and perfecting in a methodological, systems–based way the creative processes of architectural designing, and thus perfecting the architecture and the architectural environment as being a fragment of the ecosystem. The discussed program of computer assistance of the creative architectural design has been elaborated according to the model of the being analyzed design operations, found in the creative activity of architects famous in the world: Le Corbusier, Santiago Calatrava, F. Gehry, and others.

The proposed program of architectural design can enable a more efficient creative design of architecture, for example an energy–saving and intelligent architecture according to the case of the processes of designing modern motor–car bodies. May–be in the architectural processes of the future synthetic, systems–based, technical and methodological ways of thinking will become important in addition to architectural knowledge and creative design architectural workshop.

The force of artistic creation of the activities and achievements of the following creators: Le Corbusier, L. Wright, F. Gehry and S. Calatrava is decisive what concerns the force, rationality and efficiency of the intuitive use of elements of methods or/and the methodical approach in architecture design. The undertaken as well as partially presented, in this monograph, methodological investigations of creative processes in architecture belong really to the sphere of fundamental research. Artistic, methodological and systems–based perception of present–day architectural and technical problems favors a more efficient design and innovation in the development of modern architecture, particularly of ecological architecture.

The generalization of the knowledge of design methodology and elements of praxeological knowledge among architects can have a significant practical influence on the improvement of the creative processes of architectural design. Such knowledge can enable, in the future, to design, in a more efficient way, a comfortable and ecological architecture taking into consideration, in a well balanced way, the plurality conditions of architecture, thus an architecture that conserves the aerodynamic balance of our planet and the survival of the human being.

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ABSTRACT

The monograph concerns problems of theory and practice of architectural design with taking in particular account the creative preliminary phase as well as the methodical design assumptions of many famous architects, creators of the modern architecture. In the contribution, the complexity of the world of architecture has been presented as being connected with interdisciplinary conditions and with ways of education and design.

That monograph is elaborated with destination for intellectuals, scholars, teachers, architects dealing with theory and practice of architectural designing as well for students of architecture. The problem scope, included in the work, is of a wide, multi–clue character.

The monograph presents a rational and analytical approach to an apparently inexplicable creative process and to the being observed, in such creative activity of architects, carried on design operations that are partially methodical actions.

In the first chapters of the monograph problems of the essence of architecture and architectural creativity are discussed as well as the fundamental, various definitions of architecture are presented and opinions concerning design problems, including particularly architectural design, creativity, design methodology, technology and science.

The work has been constructed in the way as to assure, independently of the order of precedence, to appeal and convince the Reader thanks to the presented rationality of the problems, methodological and design considerations being described as well the architectural art.

The being undertaken considerations concerning the general architectural knowledge and problems of creativity are related to methods, ways and processes of designing architecture and teaching architecture.

The presented contribution concerns the analysis of possibility of improving the processes of designing modern architecture with using the existing architectural knowledge, ecological knowledge and methodology of design as well building more beautiful, healthy, social environments of the human being, among others building habitats.

The architectural knowledge is presented, in the monograph, as partially know–how knowledge (I know how, but I cannot say it) and partially know–that knowledge (I know that).

The know–how knowledge is presented as being related to architectural craftsmanship and with acquiring experience in designing and its relations to real problems, or with designing practice. This problem scope has been completed by an analytical–reflexive and methodological vision onto difficult to be univocally formulated processes and procedures of real, creative architectural design, particularly in cognitive, spatial, culture–oriented, technical and time–based aspects.

Various approaches to creative processes in the preliminary phases, conditioned in a many–sided way, are presented according to examples of concrete architectural objects of great creators of modern architecture and of analysis of their methodic activity, among others of: Le Corbusier, Jorn Utzon, Frank Lloyd Wright, Santiago Calatrava and others.

In the contribution a trial has been made of carrying out an analysis of the design workshop according to the design practice of the architect and the contemporaneously existing architectural knowledge, systems knowledge, informatics/computer science, praxeology and design methodology.

The discussed in the monograph questions of design methodology concern complicated and various design decisions made in the innovative preliminary phase of the creative architectural processes, for example the a priori decisions.

The elements of architectural actions being analyzed in the work, e.g. of the famous architect J. Utzon and other architects–creators do enrich and put in order the knowledge concerning the preliminary phases of creative architectural processes, but do not exhaust that knowledge.

For example, in the work a discussion has been carried on concerning the importance of free–hand drawings and of the a priori idea in preliminary architectural creative processes and an analysis has been performed of the design activity of the architect.

The process of architectural design has been presented as being an interdisciplinary process. Thus, this process has been conceived in the form of a systems based process of decision making actions of the architect, and determined as being a decision making graph.

In the work, an elaborated, creative prototypical program of computer assistance of the preliminary phase of the architectural process has been presented.

On the basis of the carried on methodological investigations of the design workshop of the architect an innovative program has been proposed of computer assistance based upon Bezier curves. This creative program of computer assistance of architectural design concerning Bezier curves allows creating sets of architectural forms in an arbitrary way, i.e. creatively selected way by the architect. These forms are inspiring forms for the architect, with possible further free modification in the process of architectural design of a selected concrete object or/and architectural environment.

In the first chapter of the monograph problems of the role of the architect dealing with designing and harmoniously shaping, as well as improving the quality of the being designed buildings and the architectural environment are carried on and discussed.

In the second chapter the fundamental problems of architecture as being a discipline of knowledge are discussed. Selected definitions of architecture are also presented.

In the third chapter analyses of selected buildings of famous architects are presented, among others of A. Gaudi, J. Utzon as well as the architectural processes which assured the possibility of these buildings to arise. Methodical architectural sketches of J. Utzon, of the building of the Opera House in Sydney are presented.

The fourth chapter concerns a methodological analysis of architectural activity in the preliminary phase of the process of architectural designing. The methodological analysis is discussed according to the case of sketches performed by Le Corbusier for the architectural project of the Carpenter Center, with a message for the next generations of architects.

In the fifth chapter considerations of the significance of free–hand sketches in the creative architectural process are presented. This analysis has been carried out according to the example of numerous historical drawings – free–hand sketches of Le Corbusier and present–day free–hand sketches of Santiago Calatrava.

The sixth chapter concerns the problem scope of various habitats as being a possible, i.e. acceptable ecological architecture of housing estates in the future.

In the seventh chapter the methodological assumptions and possibilities of improvement/perfection of present–day innovative architectural processes already in their preliminary design phase are analyzed.

In the eighth chapter considerations have been undertaken concerning the architectural idea of the house – machine for living, as being an idea of the house of the future. The analysis is carried on according to examples of energy–saving architecture and building engineering

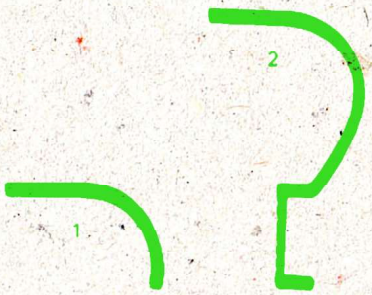
In the ninth chapter the methodological analysis of practical architectural activity in the design process is presented. In that chapter analytical, systematical and systems–based considerations of architectural activity as well as of their elements are carried out. These analyses have been undertaken according to the existing knowledge concerning methodology of design, praxeology and systems theory, designing theory and designing practice of the architect.

In the tenth chapter the creative design process is described as being a methodical graph. That graph is a methodical description of decision making operations of the architect. Architectural operations in that decision making design process are analyzed in a methodological, praxeological and systems–based way. In the graph actions being characteristic for and used by architects– designers are taken into account, e.g. iterative actions.

In the eleventh chapter a prototypical and innovative program of computer assisted preliminary phase of the architectural process is proposed. That creative program is proposed on the basis of not presented as well as of presented methodological analyses of concrete architectural creative processes of selected creators of architecture.

When creating that program architectural knowledge, knowledge of design methodology and informatic/computer science knowledge is put to a good use. That program is realized

thanks to the cooperation of the architect–designer (the author of the work) with the (computer science) programming specialist. The presented program creates and describes real possibilities of shaping and modifying architectural forms of modern buildings, e.g. according to modern car bodies.



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