ARCHITECTURE OF BUILDINGS AND STRUCTURES. CREATIVE CONCEPTIONS OF ARCHITECTURAL ACTIVITY

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A MULTI-DIMENSIONAL GRID AS AN ARCHITECTURAL SPACE AND FOUNDATION FOR COMPETENCIES IN ARCHITECTURAL TRAINING

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Statement of the problem. Inconsistent data on architectural space should be made more comprehensible in order to account for all the major properties of an artificial architectural medium. A connection between two aspects of designing architecture should be employed, i.e. architecture as a physical body and form-making factors of its geometry. This kind of information is instrumental in professional competencies in architectural training.

Results. An approach to accounting for the geometric properties of architecture using a system of sociocultural, technical, environmental and artistic factors of form-making has been developed. A topological structure, geometric design of the configuration and positioning in an architecture project are accounted for using five major causes of architecture. They are: 1) privacy and publicity of premises and locations; 2) architectonics as an art in an architectural space; 3) a topological structure of arranging movement in an architectural space; 4) a spatial grid as a tool of communication and architectural composition; 5) mass and void in a spatial gird as a landscaping tool.

Conclusions. A multi-dimensional grid is a model of an architectural space. The parameters of the cells and connections in a spatial grid are foundations of mutual connections of the geometry of an architectural space and form-making factors. An architectural space is capable of resonating to develop sociocultural, functional and aesthetic processes in an architectural medium. Prosperity and degradation in these spheres are associated with the arrangement and humanistic content of an architectural space. The obtained results are a foundation of the competencies in architectural training.

Keywords: a multi-dimensional grid; architectural space; form-making factors in architecture; mutual connections in the geometry of the quality of an environment; spatial factors as the competencies of architectural training.

Introduction. The primary goal of architecture is to design premises. Premises is a cell of an artificial environment that is necessary for human life or a small social group. A cell cannot be on its own unless it is designed for an isolated person. Even if it is a family, they need a

house to live in with a few cells in it. If it is an apartment building, a system of adjoining premises is crucial. Regardless of a functional purpose, they include major, intermediate, technical and adjoining ones. Large cells with the flight of 18 × 18 m and more are called living-rooms. The major cells and adjoining connections have to comply with the requirements for elements of an artificial environment.

A multitude of cells and a system of connections between them make up a spatial grid. Its definition is set forth. A spatial grid is a geometric location of points made up of the basic elements, i.e. cells. The general method of obtaining a grid out of cells is as follows: 1) copying cells (in a flat grid these can be squares, dots). 2) modification of the copied cells according to the size, angles of the intersection of the ribs, enveloping structures according to a set of rules. 3) a shift of the cells towards the directing lines resulting in a flat package filling an available external space. The second process might be missing, then the cells are multiplied by repetition or cloning. If a grid is grown accompanied by the modification of each cell (continuously), we get a parametric design of architecture [Schuhmacher]. An important role in further functioning of a spatial grid is played by adjoining premises, i.e. halls, stairs, atriums, galleries, passageways. The spatial approach currently dominates architecture.

Problem. Despite the fact that space is a central category of architectural thinking, *there is no single accepted and viable model of architectural space that would take into account the geometry of architecture as well as social, cultural and landscaping factors of the geometry.*

Knowledge of architectural space was set forth by a lot of researchers. Aleksandr Georgievich Gabrichevskiy [9] proposed a heuristic model of space as a couple of mutually connected mass- void values. Mass is dense structures of a building. Void is premises and their parts in the plan of a building. Studies by Jacob Chernikhov [23], architectonics by Kazimir Malevich and “prones” by El Lisitskiy become known as the foundations of the theory of modern architectural composition. Bill Hillier [30] work out and developed the theory of spatial syntax where the main tool was the theory of graphs and its application to analyzing the connectivity and centrality of street networks. Yelena Gennadievna Lapshina [16] set forth the concept of dynamic architectural space that has an advantage in that it acknowledges motion as the most important factor of forming architectural space. Mikhail Valerievich Shubenkov [24] gave a wide review of studies of architectural space where the major focus was parametric modeling. Practical parametric modelling as a foundation of architectural design was most pronounced in artistic works by Zaha Khadid [31]. Some theoretical summaries of the experience were presented by P. Schuhmacher [37].

Christopher Alexander [1] dealt with spatial situations of a building and city as examples and systematically described them. Artistic significance of architectural space was dwelled upon by Camillo Sitte. Social factors of architectural and city-planning design were investigated by Z. N. Yargina [25] and A. V. Krasheninnikov [13]. The landscaping factors of forming city-planning space were studies by Ian McHarg [33], Nefedov Valeriy Anatolievich, Krasilnikova Ellina and the author of the present paper [3], [4] . I am also interested in the problem of modelling architectural space considering a variety of factors that influence this space.

The objective of the paper is to systematize and generalize fragmentary approaches to modeling architectural space by comparing the geometry of a spatial grid with social, technical, environmental and artistic factors of architectural environment.

The object of the study are the properties of architectural space as the result of embracing humanistic values.

Novelty. It is for the first time that important but significantly varying assumptions of the theory and practice of architecture have been connected into a spatial grid as a universal model of architectural space into a single system.

It is for the first time that the law for the dependence of the directions of the modification of a spatial grid on the factors of architectural environment has been identified.

It is for the first time that a chain of the major theoretical assumptions of a relatively architectural space has been presented as a foundation for the competencies in architectural training.

Results

1) *Privacy and publicity of premises and locations*

Architecture emerged historically as people needed space. A secure space is formed in the world outside, i.e. the prototype of artificial environment. Dolmens are an architectural example of such first cells that date 5 thousand years back. Dolmens largely had a sacred significance. The oldest residential buildings in Russia that were designed for the purpose and are still here today are considerably newer compared to dolmens. However, a house in 13a Krepostnaya Streeet was built in the 16th century. Its useful area is 40 sq.m.

A traditional Russian house was made from logs. Opolovnikov A.V. provides an architectural analysis of the Lykovs house in Arkhangelsk region [17]. A primary cell of such a house is a framework, or cage. Depending on the length of the logs (up to 7 meters) the size of frameworks ranges from 4 to 7 meters. A cage alone is not enough for a family. Therefore several cells are used to assembly a house (Fig. 1). In this case there are six of them. Two narrow frameworks make up a long hallway. Three living-rooms in the first floor are located below

the same roof with a lower floor where there was a hallway, household premises. In the façade there are two floors, a household lower floor with no windows. The structure of the house overall consists of adjoining premises (a hallway), residential and household ones. The house is private. Fig. 1, 2.

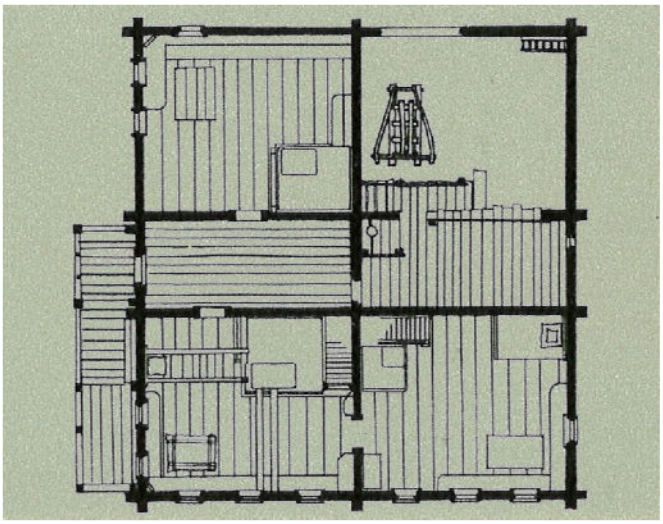

Fig. 1. Grid consisting of six ground floors. A residential house of the Lykov family in Arkhangelsk region. According to A.V. Opolovnikov

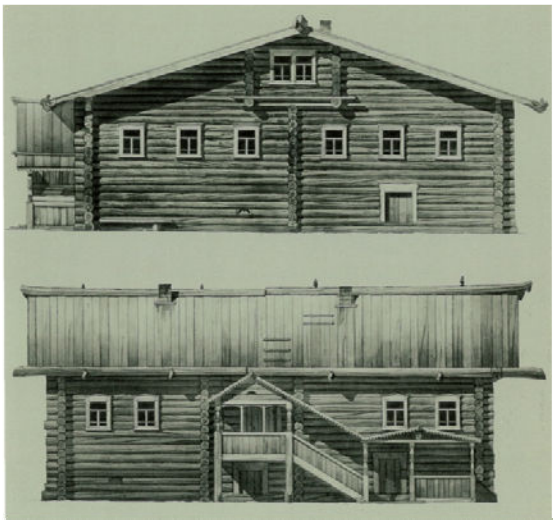

Fig. 2. Façade of the Lykovs house using a high ground floor

A high degree of privacy – confidentiality — was achieved in the architecture of a residential house in the old Sanaa, Iemen's capital. Some houses were built in the 11th century [7]. They are amazing and built from airbrick but they are up to 9 floors tall. They are intended for one family. A traditional demography and ethnic culture is expressed in a large-family community. In the ground floor there is cattle, in the first floor there is a storage for grains and dry fruit. From the second floor up there are residential premises. The parents' bedroom and sometimes a harem — is the most private part and it is designed for limited access. If it was time for an older son to get married, an upper floor was added as the father-in-law was not permitted to see his daughter-in-law without a burka. Residential quarters are not separated by streets but are blocked with houses bordering the property. There is no way for a passer-by to use the address signs to navigate the street. It is impossible to get inside the harat without the host's invitation. The confidentiality and the right for privacy were elevated in Sanaa [7]. Simultaneously a tribe (a large-family community) has a public space for meetings, weddings, funeral, celebrations, i.e. a sakhat — as well as a semi-private garden, i.e. a bustan — where vegetables and fruit are grown and mothers walk with their children.

Fig. 3. Residential house in Nantes, France. Architect Antonini Darmon

A spatial grid of the house can be regular and homogenous. It is obtained by repeating a basic element. In this manner typical Soviet housing was designed. The same can be seen in a house of the architect Antonini Darmon in Nantes (France). For ensuring differences in the insulation, some of the cells are enclosed with blank separation partitions. Fig. 3.

2) *Architectonics as an art of resisting gravity*

An architectural object is in a continuous space. Bodies are discrete and a field is continuous. At each point of the continuous space a force or value of interest can be identified. E.g., each point of the atmosphere is characterized by illumination, force and direction of the wind. I.e. values can be scalar and vector (with directions in space). Continuity and gradient of the properties is a major characteristics of a field. A potential (force) of the field decreases as it moves away from the force center and its mass drops. Some fields can be indefinitely extensive, e.g., gravitation force.

Classical architecture is called an art of resisting gravity. It is challenging to create an insulating void (cell). An overlapping, which is heavy in itself and carries a load, does not fall down and collapse the void only because there are special architectonic conditions for the walls and frame, which are sufficient and necessary properties of overlapping structures as wells the geometry of overlappings. The Parthenon has an entasis, i.e. extension to the lower third of the column as well as differentiation of power of a section in the major beams (architraves) and secondary ones (triglyphs). Fig. 4. Unlike engineering construction, architectonics not only identifies necessary sections but also shows how a form works while resisting a load. Therefore in cathedral construction a thrust of domes and spires is transferred into the geometric properties of these structures resulting in flying buttresses, abutments. In a cross-dome Orthodox cathedral transitions from a dome to a barrel, then under a sail ring and finally cylindrical spires show a system of adjoining forms that implement architectonics in this type of buildings. Fig. 5. In modern architecture by Santiago Calatrava [12] showed art of architectonics in modern architectural forms, cable bridges, shells, modern interpretations of supports. In architectonics it is shown what is carried by what and what geometric properties distinguish bearing and born elements.

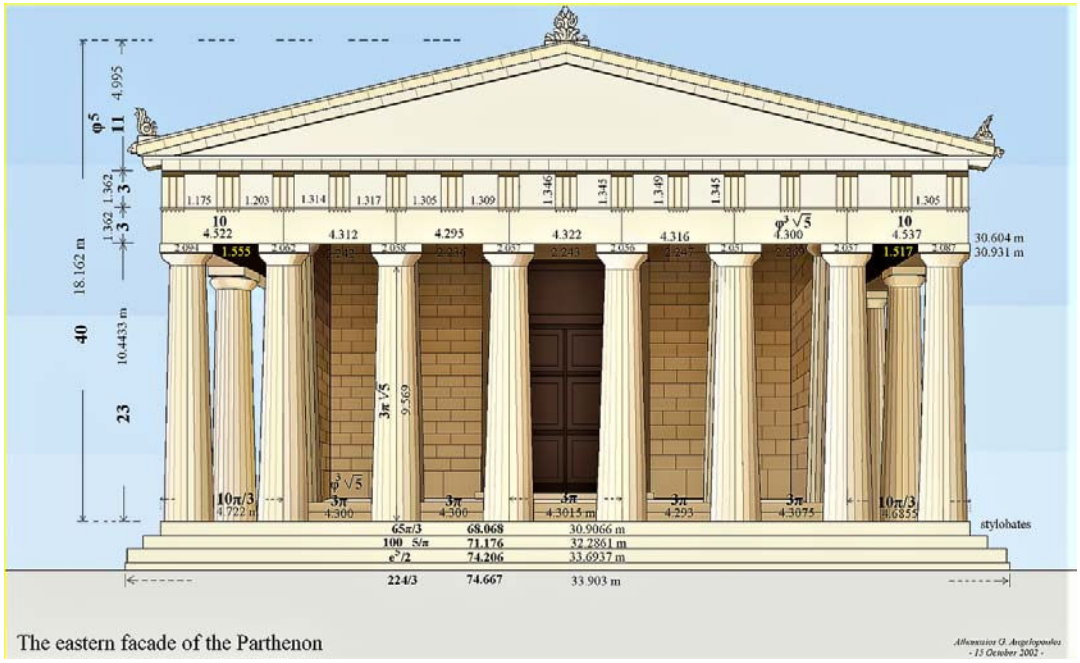

Fig. 4. Architectonics in the architecture of the Parthenon

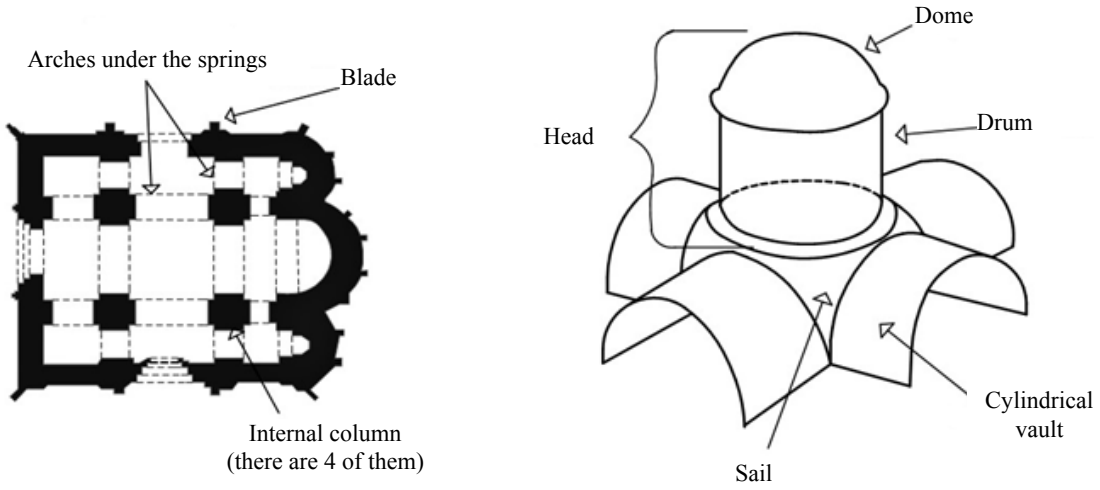

Fig. 5. Transferring a spire with a dome into vaults, columns and walls in an Orthodox cross-dome cathedral

3) *Topological structure of motion in architectural space*

Each cell is characterized with a certain functional or environmental resource. In their daily lives humans need to utilize various environmental resources and conditions. Therefore a consumer moves from one point (cell) to another. While being inside premises, humans circulate inside a cell as there is furniture or industrial equipment that is used at certain periods throughout the day. While moving from one cell to another and one district to another, individuals or social groups travel around. Due to easy or limited walking access A. V. Krasheninnikov [13] was able to distinguish micro-, meso- and macrospaces of walking access as special social and urban-planning units in a city. An urban square is attractive for a

certain geometry and functionality of a space [5]. A field in architecture can be defined by motion (circulation or moving around), its intensity, flows, direction, distribution of flows. According to N. A. Bernstein [2] and Ye. G. Lapshina [16], from the standpoint of utilizing a space, humans use their kinetic senses and capacities to locomotion and synergy (types of motion). Architecture creates conditions for optimizing motion with its form and system. This is called ergonomics at a building level and logistics at a city level (Bill Hillier, spatial syntax). Fig.6 shows a plan of Belgorod with the differention of streets according to how central they are, i.e. the intensity of flows taken by each segment of a street while moving from one location to another to a certain destination [27].

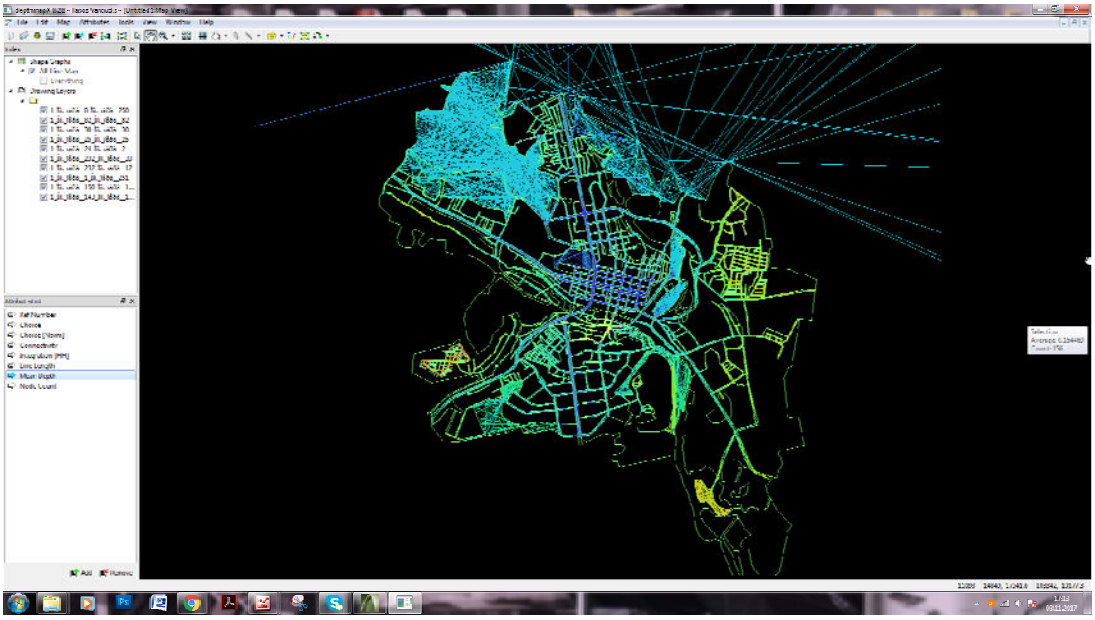

Fig. 6. Map of a degree of cen-trality and intensity of flows along the streets of Belgorod. The work is executed by K.Rodyashina using the Hillier method

4) *Spatial grid as a tool of communication and architectural composition*

Information field in the architectural and city-planning aspect is cognitive properties of architecture as well as its capacity to render and interpret philosophical, scientific or social and cultural messages. Architecture renders messages about the purpose, cultural significance, construction and engineering foundation of a building, reactions to the climate, lifestyle, financial status, importance of a function. A big role in informational potential of architecture is played by a composition as well as innovative ideas of natural scientific and engineering and technical directions. In Russian literature it was Invar Strautmanis (1978) who brought up the informational component of architecture [22]. Such a mathematical idea as continuity of a transi-

tion of internal space into external one using the example of the Möbius band was pioneered by Peter Isenman 1997 in his project of Reinhardt Haus (Berlin) (Möbius house) [29]. The idea caught on with Chris Prechtek in his project of expanding the Austrian National Library in Vienne [34] as well as Chao Weipzig, the major architect of the Beijing architectural designing Weiping, designed Phoenix International Media Center in Beijing, 2014. Fig. 7, 8. The Möbius band was a spatial idea in both projects. Interaction of external and internal space in architecture is an important issue where architecture showcases its capacity to interpret mathematical topological ideas.

Fig. 7. Phoenix Media Center in Beijing. The Möbius band principle. Architect Shao Weiping, 2014

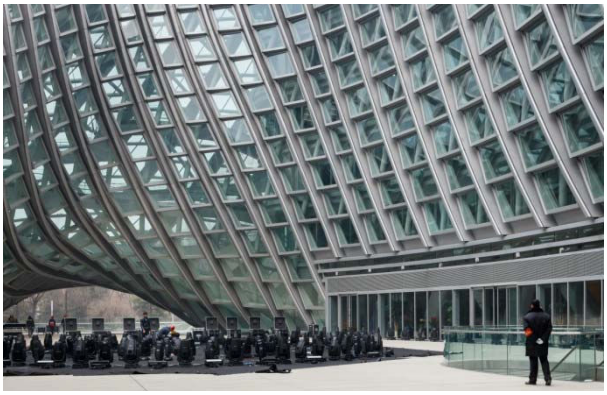

Fig. 8. The Phoenix Media Center. A backyard view. Modification of the cells of the building core

Architectural composition. In architectural composition it is not just about an artist's intuition as there is also rationale behind it. Firstly, architectural composition is always about order. In regards to a spatial grid, i.e. objective geometrical foundation of architectural form, it means that there are rules according to which its form is designed. Secondly, a simple order, e.g., a dotted notebook, or a spatial grid, consisting of dense identical cubes, or those fitted in between columns and beams positioned with the same step barely suggest any composition. Khrushchev houses used to have no such space as architectural composition. Thirdly, in a spatial grid there should be no less than two geometric themes that are different from each other or contradictory in their forms when looked at individually.

The art of architectural composition involves joining two (or more) different basic elements, e.g., A) a curved element and B) a rectangular grid, into a single system. A curved stain is put onto a rectangular grid. There should be joints between the specified figures at the adjoining spots. The elements of the joint will have the properties of the curved stains as well as the rectangular cells.

Chaos is not a composition as it is a noise. All elements are different and randomly connected. However, if, e.g., in relation to each element of a "chaos" set the rule of geometric similarity is applied and identical figures are built around the boundaries of chaotic figures but proportionately changed ones, there will also be a composition with maximum diversity as well as clear order. Repeated randomness builds up order. Quite the same principle of building a composition was employed using the Voronoi-Dirichlet partition [quote 18] see Fig.9. This is the idea behind the partition (of a flat grid). 1) There is a random set of cells put onto the plane. They are all close to one another and randomly far. 2) Those that are closest are grouped together. These pairs are joined with straight lines. These lines are then divided into halves with a perpendicular in the middle. 3) All the perpendiculars for the joining points are joined. As a result, there is a complex flat grid, or, more precisely, a network with the properties of a large diversity as well as clear order. This method (the Voronoi-Dirichlet partition) was employed by the Swiss architects Jacques Herzog and Pier de Meron [26] who designed the Beijing Olympic Stadium that was called "Eagle Nest" See Fig. 10.

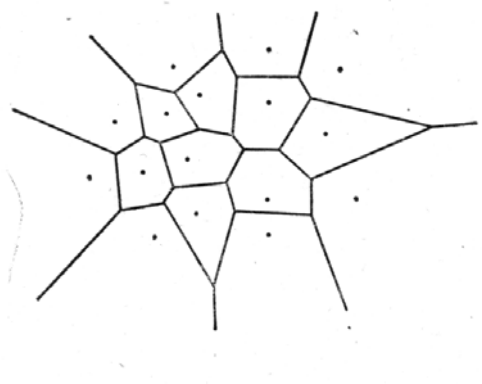

Fig. 9. Voronoi-Dirichlet division

Fig. 10. Use of the Voronoi-Dirichlet division principle. The Beijing Olympic Stadium. Architects Jack Herzog and Pier de Meron, 2008

5) *Mass and void in a spatial grid as a tool for connecting with a landscape*

Natural landscapes have a certain structure. It can be argued that the properties of the components of a landscape (a rough shell of rocks, soils, hydrosphere, atmosphere and biota) are naturally connected with a relief. A relief is a leading factor of differentiation of landscapes. In a relief there are three main locations: a peak, slope and lowland. B.B.Polynov [19], a Russian geochemist, in 1915 in his work on geochemistry of landscapes found that these locations are fundamentally different from one another based on their geochemistry. He gave them Latin names: peaks were called eluvial from the Latin word eluo, "I am washing away"; slopes were

called deluvial “I am washing out” and lowland if it was a drain valley was alluvial from the Latin word alluo “I am washing in”. The fact is that landscape material, i.e. fine soil (soil particles from a surface), soil, water, a ground air layer, soil organisms, seeds and spores moved downwards under the action of the gravitational force. An eluvial landscape yields down everything that comes from a material. A deluvial landscape, i.e. slopes, takes the material, sifts it and sends it further down. At the bottom at the foot of a slope there is soil, fine soil, water, soil organisms, seeds and spores accumulating with the ground air level going down here as well.

The following law was identified [3], [4]: resistance of a landscape to anthropogenic factors, pollutions increases upwards. This is due to a great self-purifying capacity of peak landscapes [19]. The environmental value of a landscape increases in the opposite direction, i.e. backwards. This is due to the improvement of fertility of soil and biological productivity of landscapes of lowlands and valleys. According to their value and stability, slope landscapes are in between and their properties depend on the altitude and orientation of slopes, intensity of slopes.

The following assumption made in 2003 is as follows: if we want environmental stability in city planning, intensity of urbanization should be maximum at peaks and medium at slopes. Minimum intensity of construction and traffic should be in a natural framework – in a valley or mouth of a river. This should be the core of a city’s recreational facilities. Fig. 11.

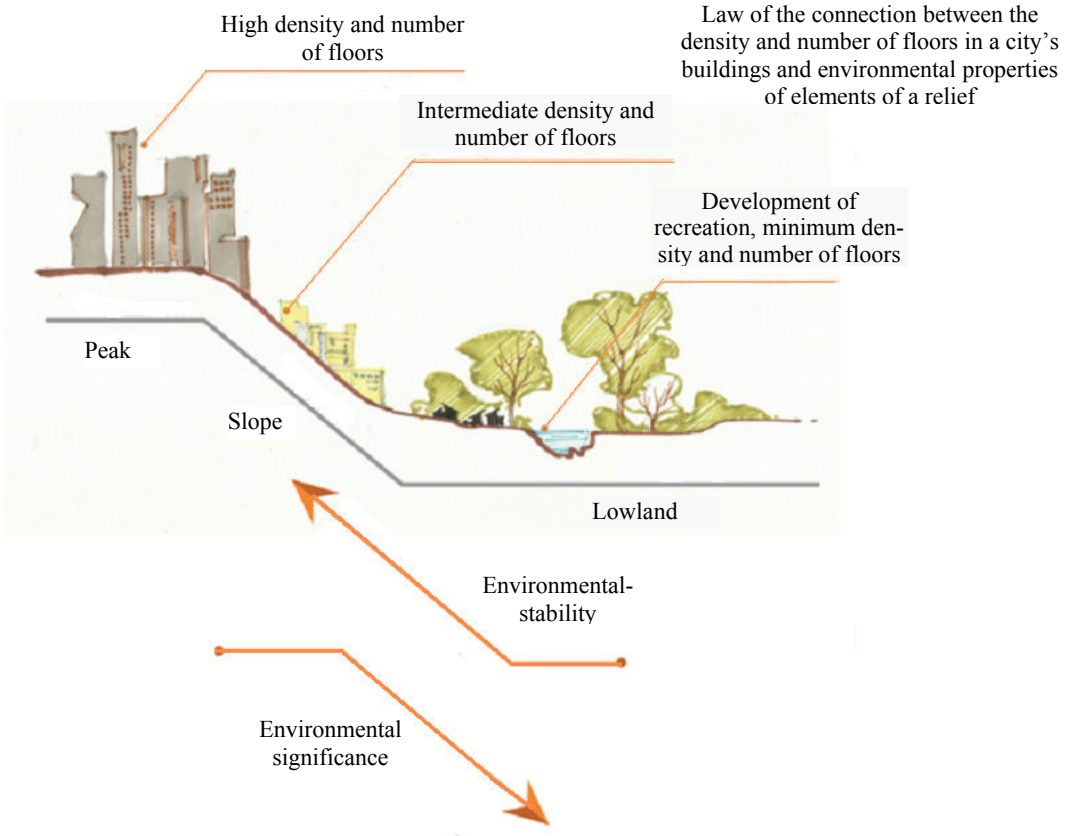

Fig. 11. Principle of landscape conformity in vertical urban zoning

In fact this might be totally different and here is why: development of a particular area is driven by a commercial interest but not environmental imperatives. It is about minimizing costs and maximizing profits to boost a country's economy.

Sustainable development. The above view was shared by my teachers: V. V. Vladimirov [8], Jan McHarg [33], Ye. M. Mikulina [21], Z. N.Yargina [25], G. I. Lavrik [14]. Recultivation and use of disrupted territories in city-planning has been long investigated by I. V. Lazareva [15]. Now the paradigm of sustainable development due to the global climate change threat is embraced by a multitude of Western city-planners.

One of the movements is New Urbanism headed by Andreas Duany and Elizabeth Plater Zyberk. E. E. Krasilnikova leads the way in Landscape Urbanism in Russia. V. A. Nefedov used to work in urban environment design.

Landscape conformity of architecture. In regards of morphotypes of architecture that react to the environmental factor, Christopher Alexander, American architect who developed a fundamental study called A Pattern Language that was translated into Russian in 2014 [1]. The first edition was published in 1977 in the USA talking about a pattern of using an area for building a house. Alexander argues that if you have some land for construction and you see microlandscapes of different value, the question would be: which microlandscape do you use to build a house — the best or the worst one? The answer is the best one. Therefore following the construction you are going to have a house with the worst landscape or land. Obviously, this mentality should be maintained and construction should take place in the worst place in order to get a house, a great land and a landscape as a result.

This holds true in any situation. E.g., we have the Baikal region. Would you build in the best or the worst, remote landscape? There is a tendency to build at the coast resulting in cellulose plants and monocities, wide technical railway and federal highway corridors and pipelines that are destroying the Baikal polluting it and leaving it with no omul and spirogyra.

If the construction moves away from the water conservation areas and there are no more parking spaces for hundreds of thousands of cars at the beaches, bays and conservation forests, our ancestors will be able to enjoy the beauty and cleanliness of the great lake.

The shape and location of a multi-dimensional grid depends on the properties of landscape locations in the following way. A. elements of void, i.e. green recreation, squares, parks, riverside boulevards, are valleys, thalwegs, mouths, feet of hills. Elements of mass construction depend on the location and properties of elevated (eluvial) elements. B. Geometry of a relief influences a volumetric-spatial solution of an architectural object. C. for placing construction the worst area is chosen and the best area is preserved as a landscape environment.

6) *Contextual designing*

The problem is to identify a comprehensive spatial structure of quarters based on their existing construction and to include a modern building into a context. Quarter № 22 in the historic center of Irkutsk is examined. Those quarters might first seem random and not related in their composition. The orientation of structures in the quarters might be along the external perimeter or randomly inside the quarter forming (non-convex) spaces [1]. Internal open spaces are rarely represented by clearly limited yards with construction along the perimeter. The authors of the study assume there are hidden, not expressed with composition laws and inconsistent quarters. In order to identify integrity and subtle laws, it is necessary that each of them is regarded in a narrow context, i.e. as a spatial grid. The pattern of the grid in each quarter is unique and sensitive to all the elements that it contains. One of the key factors influencing continuity of city-planning texture is positioning of its elements, i.e. identification of the location of buildings and structures in relation to one another, contours of a quarter, street, square, etc. By projecting the contours of buildings onto the boundaries of a quarter and other buildings projection traces of the buildings onto the quarter plane are identified, which is our systematic composition justification. This is a complex flat grid [10]. Vector (projection traces) sketch only the major contours of buildings and boundaries of a construction spot placing a new object into a system of coordinates of an existing city-planning texture. A composition matrix of a projected area is formed. A complex flat grid is a tool of dividing the entire quarter spot into parts.

A grid is filled with continuous mass where cells of voids are cut along its structure. A graphic language is formed with black, white and grey. The existing buildings are painted black. The cells of the void are showed white and a potentially possible connecting gradient texture of the construction where new objects must be fitted in certain places is grey see Fig. 12.

This graphic method gives a clear picture of the relations between an object and surroundings. For a building that looks like a “figure” a background is a space and texture [36]. The texture and construction are a background for a spatial grid. Isolation of the grid is a foundation of the rules of modeling the integrity of city quarters [11]. A designed object is an essential part of an integral spatial grid of the quarter, its mass (texture) and void (space). This means that the configuration of a designed object in its geometric contours is already specified with a spatial grid of the quarter where the object is integrated. Its contours from the grey field only have to be identified.

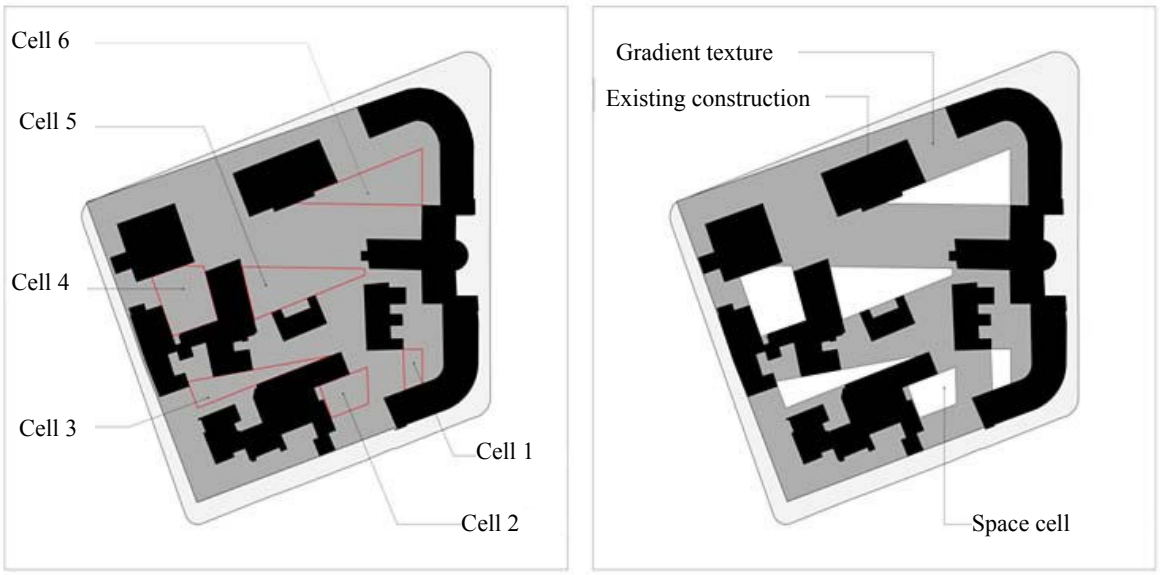

Fig. 12. Identification of the laws of a grid based on an existing construction of the quarter [20]

Fig. 13. Designing a new object in the context of the existing quarter [20]

7) *Theoretical assumptions on architectural space as a foundation for the competencies in architectural training*

The idea and formation of architectural space is the major content of architectural training. At the architectural school of Irkutsk Technical University students have been trained since 1973. Since 2007 a specialist's degree was awarded and in 2007 a bachelor's as well. Let us

omit the significant differences between the State Educational Standards for architectural training for specialists and bachelors and emphasize that theoretical assumptions on architectural space that have been discussed above are a foundation of knowledge and skills that bachelors at an architectural school are expected to acquire. Below is a table that explains the mutual connection between the competencies of training and their level and the assumptions of architectural space where a multi-dimensional grid was used as a universal model.

Table

Stages of a training program, bachelor's knowledge and skills and level of generalized competencies of a designing architect

№ of a stage	Name and idea of a stage	Knowledge, skills	Levels of attained competencies
1	2	3	4
1. year	**Introduction into the profession. Architectural graphics.** History of the architectural art	Knowledge of the history of the world and Russian architecture	• Shows knowledge of the major epochs and their architectural difference in Russia and the world
		Architectural graphics for sketching, drawing and descriptive geometry	• Singles out a monument of the order architecture. • Designs and singles out a coloured signature composition. • Conducts a structural and spatial analysis of an architectural monument and singles it out in colour (facades, cuts, plans)
2. year	**Spatial foundations of the profession. Architectural composition.** Styles of architectural art	*Mass and void*. Knowledge of the features of the relations of mass and void. Knowledge of the laws of architectural composition	• Conducts a mass-void analysis in a plan and façade of an architecture monument.
		Knowledge of the styles of architectural art	• Performs a comparative analysis of the styles of monuments of different epochs
		Composition 1. Designing a volumetric-spatial, plane, frontal, profound composition	• Designs sketches of a volumetric-spatial, volumetric, plane, frontal, profound composition

End of Table

1	2	3	4
3. year	**Ideas of architectural designing. Foundations of informational provision of spatial schemes. New buildings.** (foundations of the architectural theory, function, landscape, city-planning situation, legal justification, architectural physics and material studies, SPDS, BIM technologies)	*Architectonics.* Knowledge of the foundations of construction of buildings	• Designs a sketch project of a residential building with an average number of floors. • Shows the architectonical properties of an object on the façade and cut
		Motion. Knowledge of social and functional processes as the foundation of structuring the space of a house	• Shows a scheme of pedestrian and vehicle traffic in a general plan
		Image. Spatial grids. Composition 2. Ways of conveying architectural information. Composition of a public center of a town	• Designs a general sketch (sketch, 3D computer model) and identifies a volumetric-spatial composition of a public center of a town. Knowledge of the laws of designing multi-cell spatial grids
		Architecture and information field. Expresses the architectural and compositional essence of a place	• Combines order and structural diversity of elements in the composition of a structure in a spatial grid of a town according to their functional purpose and spatial significance
		Landscape conformity. Knowledge of the foundations of designing construction complexes and area planning of small towns in a landscape. Knowledge of the foundations of city-planning and architectural ecology. Making intensity, density, scale and structure of an architectural object agree with the properties of a landscape	• Designs a general plan of a town with the population of 2000 people in a landscape with a clear relief in a river valley. • Shows how a construction, functional zoning, transport scheme and landscaping of a town agrees with environmental significance and stability of the location of a relief
		Computer designing. Skilled at using architectural designing software. *Knowledge of the foundation of the BIM – technology.* Using the SPDS rules for sketching	• Knowledgeable in utilizing avtocad, archicad, revit
		Engineering. Knowledge of architectural physics. Designing a model of spatial grids	• Knowledge of the foundations of heating engineering, acoustics and lighting technology. Designs sketches according to the SPDS rules

End of Table

1	2	3	4
4. year	**Improving creative methods of architectural designing. New buildings and reconstruction** (historical and cultural context, city-planning space, construction, technology of construction production, foundations of engineering provision of buildings, typology of buildings and structures, social and economic differentiation of architecture)	*Spatial grids. Composition 3. Social justification of space.* Profound knowledge of the laws of designing spatial grids considering the social and functional requirements to a place	• Knows the functional and spatial layout of a microdistrict. • Designs a microdistrict (quarter) considering original data, developing a technical task and complying with the foundations of the City-Planning legislation (SP-42, City-Planning Code)
		Sustainable development. Skilled at designing modern architecture in a historic context. Knowledgeable about the foundations of architectural identity of a city. Knowledgeable about the methods of ensuring ecological safety for developing a city	• Designs a residential microdistrict considering the requirements for ecological sustainability and landscape conformity • Designs a residedntial microdistrict considering identification of an existing genetic code of a surrounding area
		Contextualism. Knowledgeable about the interaction of new architecture and historic architectural environment	• Designs reconstruction of a historical quarter considering a historic and cultural context
		Architectonics in the conditions of reconstruction. Profound knowledge of the laws of interaction of an architectural form and architectural construction in the conditions of reconstruction	• Utilizes construction solutions to enhance harmony of an existing as well as valuable historic construction in designing projects
		Architecture and information field. Improving the skills in organizing and diversifying architectural composition as a foundation of idea communication of architectural essence. *Composition* in a set of circumstances of a place, social and engineering requirements	• Utilizes an innovative approach to materials, construction, environmental, fire and seismic safety in designing a residential house with a lot of floors • Designs a school in compliance with the normative and methodological and innovative regulations

End of Table

1	2	3	7
5. year	**Preparing for professional architectural practice** (Specialization: city-planning, landscape, public buildings, residential buildings, reconstruction of buildings and fragments of an urban environment), final research paper	*Innovations*. Knowing innovative methods of modern global architecture. Familiarized with technical regulations and designing technologies for large buildings	• Displays knowledge of modern achievements in architecture on the topic of a final research paper
		Profilization. Knowledge of the typology of residential, public buildings. Knowledge of the foundations of city-planning. Knowledge of the foundations of landscape architecture. Knowledge of the foundations of reconstruction and regeneration of a historic urban environment. Comparing and solving complex architectural tasks. Profound analysis and solutions of profile tasks in accordance with a final research paper	• Designs a sketch project of a public center in a historic environment considering architectural, historic and cultural, landscape, social and functional values and grouping them according to the evaluation of an existing condition of an area, design organization of transport, functional zoning, scheme of design planting, preservation of historic and cultural heritage, scheme of pedestrian traffic, architectural and planning structure. • Designs a sketch project of reconstruction of a university campus considering the effect of planning and construction of a campus on the quality of instruction; developing sections for architectural and planning structure of a campus, technology of instruction, transport and pedestrian scheme, designing parking, planting and improvement schemes • Designs a sketch project of a hospital (another public building) while developing sections of a project covering economics, construction, environmental protection, technology of a functional process, city-planning organization of land. • Designs a sketch of a (guest) house while developing sections of city-planning organization of land, construction, economics, heat supply (of the major moments), specification of the applied materials, landscaping design of public spaces, fire safety

End of Table

1	2	3	4
			• Use of legal guidelines and technical regulations on the topic of a final research paper. Economic calculations on the topic of a final research paper
		Economic and legal justification of architecture. Knowledge of economic laws of a city's investment development. Knowledge of a legal basis of architectural designing	

Conclusion

Formula of a multi-dimensional grid as architectural space.

In the modification of cells and connections of spatial grid under the effect of form-making factors we have identified five major functions or dependencies.

Function 1. *Cell and connection.* A geometric shape of a grid is a function of: A. a number, size (cell or hall) and configuration of cells; B. form and connection of cells by means of halls, streets, squares, stairs, atriums, vestibules, passageways, galleries; C. Rules of designing a silhouette, façade, plan of a building (smooth compact, amplitude with a developed perimeter); D. compliance of a city-planning plan with a rough relief.

Function 2. *Privacy and publicity.* The dependence of a geometric form of a grid on A. a factor of publicity of premises, planning elements; B. a factor of privacy of premises, planning elements.

Function 3. *Fields of gravitation, motion, information.* The dependence of the shape of a grid on A.a factor of interaction of gravitation on architectural construction of a building; B. a factor of dynamics of pedestrian flows, their distribution, centrality; C. The dependence acts towards an increase in connections in a network as well as disruptions and irrational contacts of cells.

Function 4. *Quality of composition.* The quality of a composition depends on a combination: A.of arrangement, rules of designing a spatial grid using modified cells; B. Random locations, configurations and divisions in a resulting spatial grid of an architectural object.

Function 5. *Architecture and landscape.* Shape and location of a multi-dimensional grid depends on the properties of landscaping locations; A. elements of void are green recreational areas, squares, parks, riverside boulevards are valleys, thalwegs, mouths, feet of hills [25] Elements of mass depend on the location and properties of elevated (eluvial) elements. B. The geometry of a relief influences a volumetric-spatial solution of an architectural object. C. for location construction for designing a building the worst area is chosen and the best one is saved for a landscaping environment [1].

Function 6. *Architectural object and context.* In a historic city addressing reconstruction tasks is particularly important. While doing so, it must be borne in mind that no ensembles that join historical and modern buildings should be disrupted. The method suggested in this paper implies that A. the laws and features of a flat complex grid of a quarter are identified; B. a grid contains existing buildings as support nodes of a grid; strips of perspective gradient (transitional) construction that are traces of projecting masses of existing buildings on the surface of a quarter. Crossing projection strips specifies a contour of a spot of an original new building.

The above theoretical assumptions on a multi-dimensional spatial grid as a model of architectural space are at the heart of professional competencies for a bachelor in architecture.

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