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Table of Contents

The importance of variability (flexibility) in multi-family apartment buildings

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Abstract

The variability of building structures can be achieved from the outside and inside, as well as with extensions or partitions. The degree of variability is proportional to the independence of the primary from the secondary structure.

The relationship between the structure and the role of installations in the practical application of flexibility has been considered in a number of studies (SAR method, etc.), and all come to the conclusion that it is necessary not only to differentiate the primary from the secondary structure, but also to make the installations less fixed.

However, differentiation does not mean that development can be inconsistent. The main mistake of the current development in construction technologies is in fact that there was a lack of relation to the secondary structure and that the connections in the construction process were not defined. Thus, the development of technology has limited the growth of the quality of housing, rather than improving it.

Today the primary structures are built very quickly, their durability is practically unlimited, but if we compare them with the first beginnings of the application of the skeleton in residential construction with "endless possibilities", burdened with various restrictions and regulations, today we have extremely unadjustable constructions, which do not allow nor minimum flexibility (similar to structures where a massive building system with load-bearing reinforced concrete walls is applied).

This paper aims to provide a historical overview of research closely related to the importance of flexibility in multi-family apartment buildings in general, with reference to and analysis of experiences in the construction of flexible housing in the former SFR Yugoslavia.

Key words: *flexibility, multi-family residential buildings, variability.*

1. Introduction

Among all human needs, the needs related to housing are one of the most complexes, because they are repeatedly conditioned by a number of factors (psychosocial, biological, integrative, individualized, etc.).

So, the apartment is not a "housing machine", but a space that should allow complex processes to take place, whose shapes are practically unpredictable.

Therefore, it is necessary to possess the spatial solution which enables at least partial adaptation of the dwellings to different and unpredictable needs.

Instead of a permanent unchanging organization of the apartment, based on "infallible" rational functionalist assessment, one should strive for open solutions, unfinished, which will give the space accommodation, i.e. it is necessary to design a "changeable" (flexible) apartment. The word flexibility has the etymological root of the Latin adjective "flexibilis" and the noun "flexibilitas", which translates as easily foldable, easily changeable, adjustable (for a person).

There are different definitions of the term flexibility when it comes to living space. Numerous authors use the term "development" to fully denote the variability and adaptability of the apartment.

The interest in flexibility is not as new as it sometimes appears. The dilemma: whether and what kind of functional determination of the apartment is constantly present in the activities of the prominent protagonists of the so-called functionalist architecture. Somewhere, the very tradition of building has long pointed to flexibility.

For example, it is an American tradition for the house to never be considered finished and unchangeable, unlike in Europe where, on the contrary, there is an attempt to define the future need (meaning family construction), which naturally means resistance to flexibility.

In 1927, the architect Miss van der Rohe in the Weisenhof residential area stands for an "elastic house" and achieves the application of flexibility.

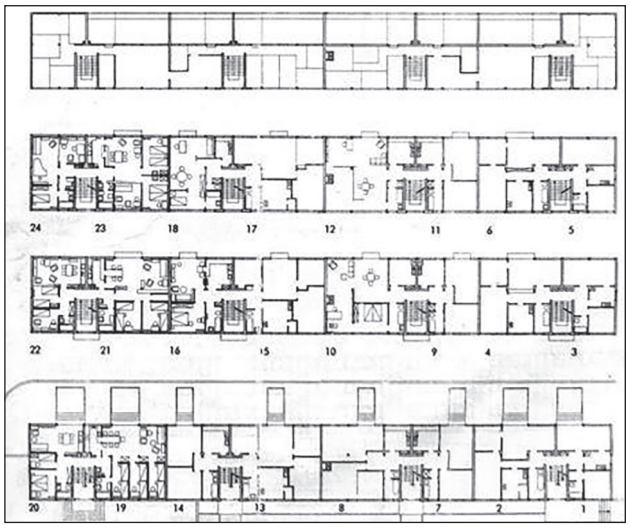

Figure 1. Miss van der Rohe: Weissenhof residential area, 1927, one of the first examples of a flexible organization. [1]

In this Weissenhof apartment building (Figure 1), designed in 1926, Miss begins to address the contrast between structure and form with the meaning of the steel frame, the first time he has actually applied it to one of the projects or to a realized structure.

The exterior walls of the three-story apartment block consist of masonry, covered with smooth plaster, large windows, and glass doors. The steel frame was crucial to Miss's architectural vision for this project. He refers to the frame as the most appropriate system of construction.

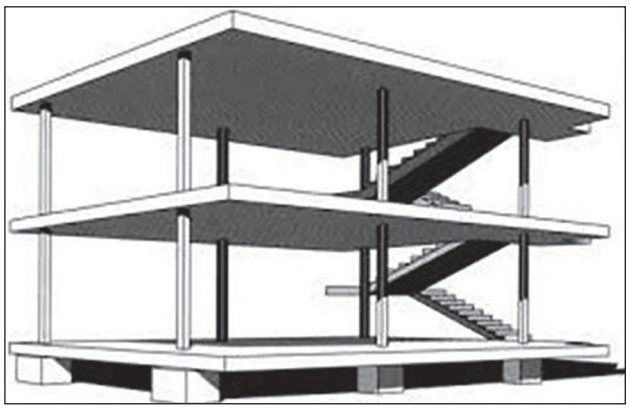

Figure 2. Le Corbusier, project for "Dom-ino" construction, 1941. [1]

"It can be produced rationally and allow any freedom for the division of the interior spaces. It enables him to limit the use of massive walls to divide the apartments, to introduce the partition walls, and to open wide facades with glass". [2]

With this initial belief, he remains faithful practically throughout his work, striving for adaptability not only to the residential contents (as in the towers of Lake Shore, 1951), but to a neutral, multiplicatively used space in the architecture of all contents.

Even (usually quoted as the most prominent representative of functionalism) Le Corbusier in his project "Dom-ino" (Figure 2.) gives a very specific proposal of flexibility with all the necessary assumptions (the structural system of the skeleton is completely independent of the solution of the apartment).

One of the most complete approaches, as well as practical results in the field of flexibility of the apartment and urban structures, was achieved by the organization SAR (Stiching Architecten Research), founded by the ten largest architectural bureaus in the Netherlands (started research in 1965 with only ten researchers). From this source arose a movement that encompassed several countries (Germany, USA, Austria, England, Canada etc.).

The basic characteristics of SAR systems can be defined as:

– systems developed on the basis of "classic" constructions, i.e. transverse load-bearing walls,
– on the basis of extensive surveys, it is suggested that there are two concepts in modular coordination: "tartan" (strip) grid and the concept of fitting dimensions in the horizontal and vertical direction [2]. It is a grid of lanes alternately 10 + 20 cm in both directions (Figure 3.) with 3M transmission module. The preferential 3M module is explained on an anthropological basis, as a natural measure found in all human movements and at rest (Figure 4.).

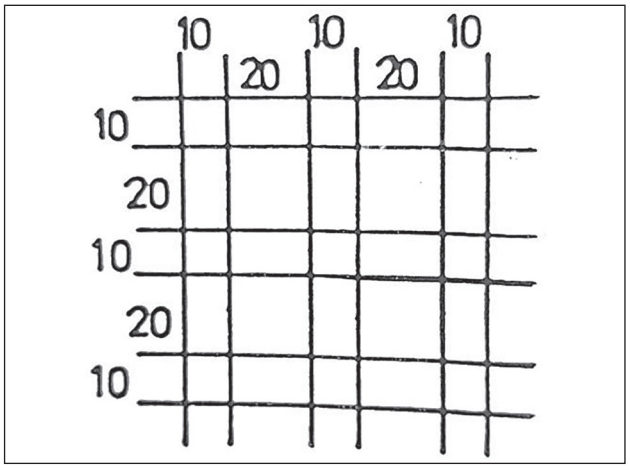

Figure 3. A grid of lanes alternately 10 + 20 cm in both directions. [2]

Of course, the most important conclusion and the basis of the SAR method is the division of the functions of the apartment according to the collective features, i.e. the division of "zones" and "margins" (intermediate lanes) and the claim that the differences between the apartments are obtained by varying within those features.

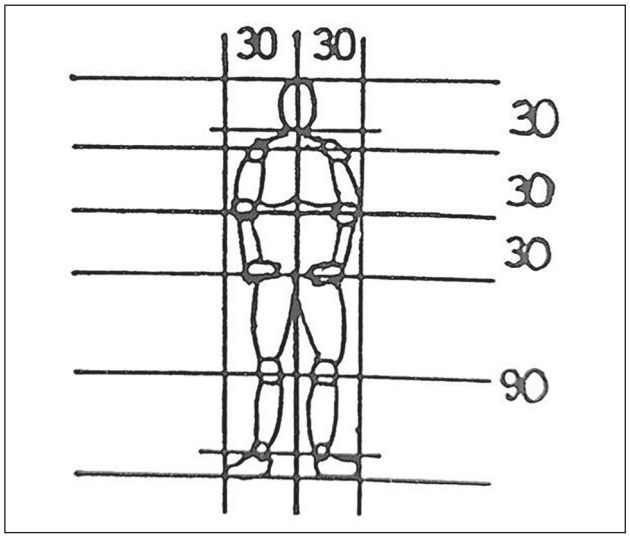

Figure 4. The preferential 3M module, as a natural measure found in all human movements and at rest. [2]

Partition elements, closets, installation lines are situated in the intermediate lanes. By connecting residential units across the intermediate lanes, it is possible to change the structure of the apartments at the time of planning, during the granting of use and during the process of use. It is sufficient to leave a door opening in the construction wall (temporarily or permanently walled) at the point of penetration of the inter-lanes and flexibility is possible in a relatively wide range.

2. Division and types of flexibility

The problem of flexibility is subject to the engagement of a large number of authors, which (taking into account of their initial attitudes and difference) they give different divisions.

However, this is only a matter of fundamental differences, so the division that is closest to the practice of realizing objects is adopted:

1. ***relative flexibility*** (some call it apparent),
2. ***absolute flexibility*** (some call it total),
3. ***enriched (increased) relative flexibility***.

Under item 1. is meant everything that is limited by the physical volume of the apartment, where changes are possible only inside a certain "shell".

This means that the relative flexibility can be internal (inside the apartment) and external (occupies the space outside the residential unit). External relative flexibility by volume can occupy two or more apartments, in one or two (rarely more) levels, so it is possible as "horizontal" and "vertical".

Under item 2. is meant that flexibility which is not predetermined by the physical volume of the building. It is flexibility that consists of physical addition or subtraction, flexibility that contains the possibility of self-construction or decomposition.

From the point of view of reality and operability, "relative flexibility" belongs to the needs of the moment, and "absolute flexibility" is in the domain of the strategy of development of construction, and especially of the development of housing construction.

Under item 3. means the relative flexibility which has limited possibilities for self-construction, so it is a rudimentary form of absolute flexibility, it is in fact a transitional form between the two basic types. [3]

2.1. Flexibility in relation to the apartment structure

The structure of the apartment is a very important and essential, objective problem in terms of family needs. It is directly determined by the activities that family members perform in the apartment.

By moving into the apartment, the users enter their social functions and oppose them to the functions of the apartment and the individual rooms of the apartment.

If the organization and structure of the space of an apartment successfully accepts all the functions of the family and individuals (those functions that people perform in an apartment) it is usually said that the apartment is functional, or vice versa. Therefore, the social functions of individuals and groups are correlated with the apartment as a specific organized space.

As the needs are changeable and dynamic, so people also expect a possible change in the organization of living space.

The apartment is a product that lasts the longest and its depreciation is a long period, during which

there are changes in the lifestyle, the standard and the perceptions of aesthetic values.

The interventions that come into consideration during the use of an apartment can be:

– improvement of living conditions by introducing installations and
– change of size and spatial relations in the apartment.

The problem of changing the spatial relations in the apartment is not a specific problem, but is of a general nature and also applies to the traditional way of building apartments.

It can be said that the prefabricated system has an advantage over the traditional one. Lightweight partitions, interior and exterior walls in the prefabricated system can be dismantled and moved.

If from the very beginning of the design of a residential building, its adaptability and the choice of the construction system are taken into account, very good results can be obtained.

In order to free the prefabrication from the ballast of rigidity, it is necessary to first allow more freedom in solving the floor plans of the apartments, and this mainly comes down to the problem of determining the optimal sizes and the optimal number of different types of elements, which can be combined. within reasonable and necessary limits, while further preserving the advantages provided by the prefabricated building system.

One of the most important factors contributing to the quality of housing, understood as an evolutionary process, is the variability of the disposition of the apartment.

In essence, this notion introduces a fourth dimension in architecture, i.e. - time component.

The variability of the disposition of the apartment, as a term, appeared as a function of the development of the family and its housing needs.

The variability implies a dynamic concept of the disposition of the apartment. It assumes apartments built in an industrial way.

The variability can be:

- **internal,**
- **external** and
- **internal and external**.

Internal variability is the possibility for one or more changes in the disposition of a group of rooms or an entire apartment, provided that the total area is not changed and no changes are made in the structural system of the apartment.

External variability is an opportunity to change the disposition of the apartment in order to reduce or increase the total area, i.e. the number of rooms in the apartment, but also provided that no changes are made in the structural system (except partially in the facade walls and partitions walls between two apartments).

A third case is when both internal and external variability is possible.

The degree of variability depends on:

– the proper selection of the construction system,
– the number of fixed determinations - all constructive, dispositional and installation elements (front door, stair and elevator core of the building, kitchen installation block, sanitary facilities, floor structures, etc.).

Proper selection of the construction system is one of the first and most important prerequisites for variability, with the most important to meet the following two conditions:

– free disposition plan with vertical load-bearing elements, preferably in plane with the facade walls and
– flat floor construction without visible underlayments or other structural elements.

From the new construction systems, especially for large apartments, are suitable:

– system of hanging floor slabs and
– system of raised floor slabs.

Adverse systems that exclude any possibility of variability include:

– panel prefabricated system and
– cell prefabricated system,

Which today are most often used in industrial construction methods. It sounds overwhelming that these systems, which are based on industrial methods, exclude variability, which in itself is a method of industrial and prefabricated construction.

However, given the above and the fact that these systems with their rigidity negate the first and basic condition of variability - free disposition plan - these systems are a step backwards even

compared to traditional building systems. In terms of variability, these systems have no perspective.

Variability excludes arbitrariness and presupposes a certain discipline based on modular coordination. Apartments that have any variability will most often be able to meet the new needs of the family, and these are above all the apartments built in open systems. The systems that provide internal variability in the apartment, in addition to being able to respond to the always new needs and the changed family structure, only to a certain extent, such apartments provide quality of an important sociological dimension in housing, which is - the identification of the person with the apartment.

The identification of the person is possible through the direct contacts of the designer-user relationship, where the future user directly participates in the definition of the project task. This is the only way to get to know the individual desires and requirements (profession, age, affinities, desires, cultural heritage, health status, etc.), which further represent a direction for solving the residential space tailored to a particular person.

When designing buildings for individual housing, the identification of its user is enabled, while when it comes to multi-family residential buildings, contact of the future users with the designer is disabled, and the mediators are the organizations that define the needs of the future users expressed through numbers. We can not talk about the identification of individual characteristics of a particular person, which is of great sociological importance for the humane living of the future user.

Determining the desires and needs of users in multi-family residential buildings, due to diversity - does not lead to the goal, because it would be difficult to find at least two families with equal desires and needs, and in addition - they are subject to change over time. Thus, the possibility remains for the users in some real physical frames to create their own narrow living space.

The solution is in the separation of the collective and the individual sphere, ie the primary and the secondary structure.

By applying the above division we come to the concept of "open" systems, which in addition to providing internal variability - and production of components for a wider market, as well as the development of the industry for built-in components.

The primary sphere consists of the structure of the building with the load-bearing elements, communications and equipment devices of the building.

The physical boundaries of the individual sphere represent the contours of the apartment.

The layout of the premises, their connection and equipment are in the exclusive competence of the user, who thus subordinates the structure of the apartment to the structure of his family and his needs.

The user of the apartment is enabled to perform the equipment of his choice with built-in components, the so-called finalization packages. The elements should be compatible, i.e. they can be easily moved, supplemented and changed in the apartment. So, by forming the apartment, i.e. creating in their own way their living space, it can be rightly said that the user creates his "home".

3. Experiences in the construction of flexible apartments from the countries of the former SFR Yugoslavia

Open prefabrication systems that have been used successfully in the former SFR Yugoslavia are: the IMS system and the NS-71 system implicated in housing construction in the town of Novi Sad.

The "open" prefabrication is a building system with elements that are produced independently of a particular project and that can be applied in a number of combinations. The construction system is made of prefabricated elements, and other things such as: processing, equipment, installations, devices and finalization, are also made of prefabricated elements - specially made or interconnected. The modern prefabrication system tends towards an "open" construction system. This system includes the skeletal structural systems, as well as the panel system with a span between the walls greater than 6 meters.

In the "open" prefabrication, the architect assembles the apartment with elements - panels offered by the market, and whose dimensions are standardized.

These panels are the result of a research procedure that determines their degree of compatibility. The obtained assortment is checked through a series of solutions on the floor plans of the apartments.

Smaller elements are characteristic of "open" prefabrication. The rule "the larger the elements, the smaller the combinations" can not be avoided.

In the case of "open" prefabrication, first of all, a constructive module should be chosen, within which the sizes and shapes of the prefabricated elements will be examined, researched and selected.

In that sense, the design remains as a process that precedes for each different building, which allows to meet the different requirements conditioned by social, technical, economic and climatic differences, as well as habits that prevail in certain areas.

Architecture in general, and residential architecture in particular, is an overly complex activity that could survive without compromise. The "open" prefabrication in today's conditions represents that compromise. Only systems in which the structural elements are completely separate from the elements of the equipment, and that is above all the skeletal systems - have the prospect of maintaining the openness of the system. [1]

3.1. "IMS" system – Žeželj

The IMS system is a skeletal structure composed of prefabricated elements and was widely used construction technology in the former SFR Yugoslavia for industrial housing construction, and refers to areas of seismicity of 7° and 8°.

It is used in the construction of residential buildings, but also in schools, hospitals, administrative buildings, garages, shopping malls and buildings of light industry.

The IMS system was developed in the Institute for examination of construction materials of SR Serbia, based on the idea of prof. Branko Žeželj. In the former SFR Yugoslavia, the IMS system was applied by fifteen construction companies.

Figures from 5. to 9. show floor plans of characteristic apartments and photos of the realized residential buildings (built with the IMS system) in the residential settlements "Borik", "Hiseta" and "Starčevica" in Banja Luka, "Alipašino Pole" in Sarajevo, and "Lenin Boulevard" in Niš.

In addition (Figures 10. and 11.) are shown the characteristic floor plans of the buildings and a display of the flexibility of the apartments in one of the buildings, as well as photos of the constructed buildings from the residential settlement "Cerak-Vinogradi" in Belgrade.

Figure 5. Residential settlement "Borik"- Banja Luka. [4]

Figure 6. Residential settlement "Hiseta" - Banja Luka. [4]

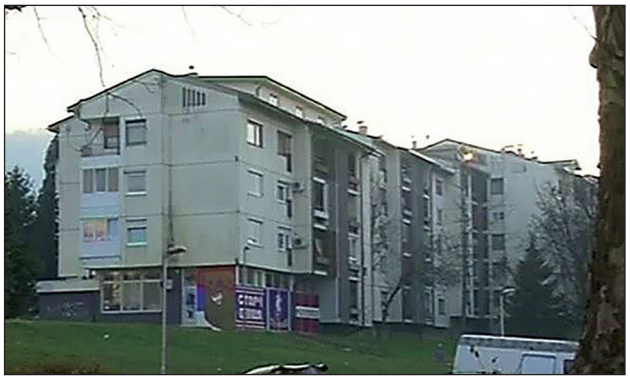

Figure 7. Residential settlement "Starčevica" – Banja Luka. [4]

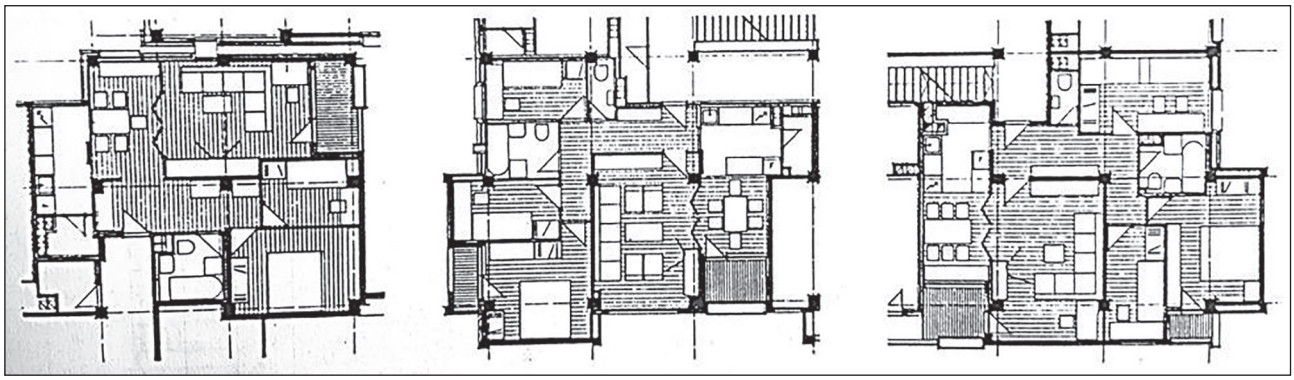

Figure 8. Residential settlement "Lenin Boulevard" – Niš. [4]

Figure 9. Residential settlement "Alipašino polje" – Sarajevo. [4]

This urban plan has been awarded the "October Prize" of the city of Belgrade for 1981. [4]

The same technology (IMS system) has been applied to a greater or lesser extent in Italy, Hungary, Austria, Cuba, Egypt, Angola, China and the former USSR. In order to more easily understand the concept of the IMS system, the elements can be divided into three categories:

- primary elements - parts that carry the loads of the structure: columns, floor structures, retaining (rigid) walls, etc.
- secondary elements - non-bearing parts: facade panels, partition walls, kitchen and bathroom units, etc.
- tertiary elements: finishing, carpentry, etc.

An important feature of IMS construction technology is that a relatively small number of industrially produced elements can be used in order to build a skeletal structure for buildings with different purposes. There is complete architectural and urban flexibility of the system.

The prefabricated prestressed reinforced concrete skeleton system IMS contains all the features of a monolithic skeletal structure, which offers designers a large and wide field of freedom in selecting the plan of the building, an aspect that is more an exception when it comes to prefabricated structural systems. [5]

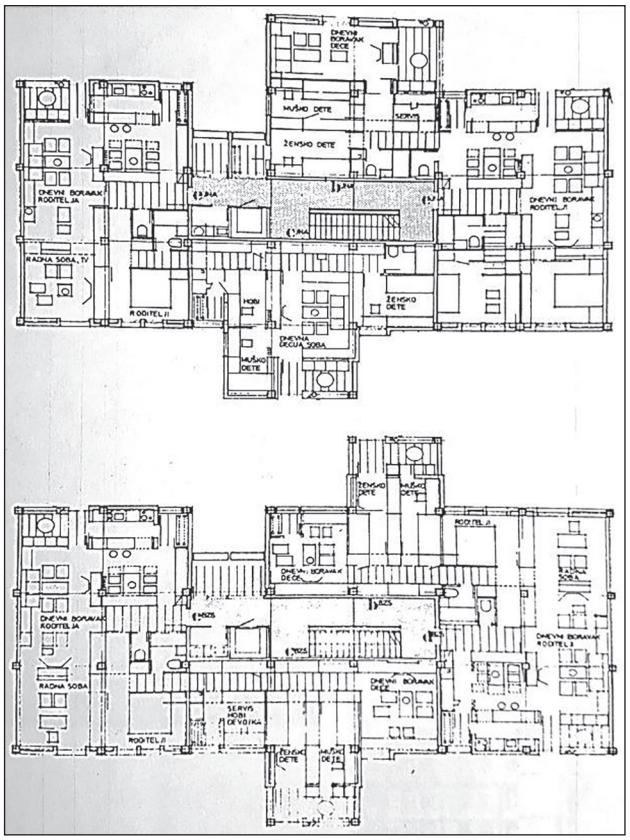

Figure 10. Residential settlement "Cerak-Vinogradi" in Belgrade, an example of internal variability of apartments with a change in the disposition of a whole group of rooms, without changes in the structural system, and with a small change in the total area of the apartments achieved by adding 1/2 module in one and a whole module in the other apartment. [4]

Figure 11. Residential settlement "Cerak-Vinogradi" in Belgrade, photos of realized buildings. [4]

3.2. System "NS - 71"

The system for industrial production of apartments "NS-71" is a fully-installed and at the same time "open" system.

The constructive conception is a skeletal system with modular spans from 3.00m to 5.40 m, from prefabricated hollow profiled columns with modular dimensions 60/60 cm and floor elements with ready-made ceiling.

Of the non-constructive elements, the system uses the following:

- brick or "sandwich" railings with various materials with facade cladding and thermal insulation from the inside,
- exterior walls of "keramzite" concrete with a height of one floor, with appropriate facade processing,
- wall curtain as a variant of the external facade walls at a height of one floor,
- internal partition walls of "keramzite" concrete d=7cm, between two apartments d=20cm or some other material,
- sanitary cabin with built-in installations and equipment,
- ventilation and smoke ducts with built-in "shunt" elements, at a height of one floor,
- carpentry - windows, doors, closets, etc.

This system takes care of adapting it to different architectural solutions by enabling the system to design in a grid with the most diverse combinations of standard spans.

The specificity of the system is in the way of installation, the reduction to a minimum of the installation of concrete on site and the use of "dry" installation. This installation indicates a rationalization in terms of time and labor, because concreting is reduced to a minimum, and medium-heavy and heavy-duty mounting elements generally have a small number of joints.

The system "NS-71" enables a variety of applications of rational spans, as well as a great opportunity in shaping and playfulness of apartment blocks vertically and horizontally.

Figure 12. Residential settlement "Limak 3" in Novi Sad, photos of realized buildings. [4]

The first buildings constructed in this system were: Block 3 in Novi Sad and blocks 2, 3 and 4 in the new residential complex Liman 3 also in the city of Novi Sad (Figure 12.). The designers of these buildings, who are also designers of the system, paid special attention to the selection and artistic processing of the elements in order to cre-

ate opportunities for the construction of special types of buildings.

The goal of the designers was clear and unique: to create a variety of ambient content that, despite the typification, will not be monotonous, and in the architectural expression will correspond to each other based on equally treated and important artistic properties. [1]

4. Conclusion

The fact that housing construction is becoming more of an economic than a technological problem is becoming undisputed. There is a misconception that the basis for economically rational housing construction is the condition that the elements of the apartment adapt to the conditions of industrialization.

Today, however, the technological system of industrial construction is more important than industrialization itself. Some possible preventive measures to eliminate the negative consequences of the mass application of standardized structures:

1. Recognizing that mass housing construction can not only aim at satisfying the quantitative and physical-qualitative needs of the inhabitants of the new settlements - and also encountering organizational and economic difficulties, many countries have opted for an "open" system that can be defined as mass, specialized and balanced industrial production of all building elements and subsystems whose compatibility is ensured.

The process of industrialization, in addition to increasing productivity in production, construction efficiency and achieving economy, must meet the requirements for aesthetics and high quality of human living space.

2. The flexibility of the internal and external elements of the apartment is praised as much as attacked: both as a principled approach and as a functional-technical method for solving certain problems arising as a result of the mass construction of standard apartments.

However, regardless of the (un) principled views of the professional experts: on the essence and methodology of flexibility in housing - the fact remains that the "ordinary" user of a serially built apartment (as well as any other) has, and will have, indisputable needs for adapting its basic environment to its specific needs.

"Closed" building systems with their incompatible primary and secondary structures (and "closed" economics), even when they could, did not provide such opportunities - so there is reason to believe that "open" systems of primary structure and with a greater degree of freedom for the secondary structure, and with a greater technological connection, would be significantly more suitable for it.

In the evaluation of the apartment and the settlement, the users in the first place, even in terms of aesthetics, will put their functional values, the general atmosphere in the settlement, rather than, the architecture of a separate residential building or a larger ensemble of buildings.

Therefore, architecture as a creative discipline, should be fully in function of these social requirements and enable us to build both rationally and close to the needs and desires of users.

The ultimate goal of a settlement in our time is to provide the inhabitants with a creative and inspiring environment in which they live. Creative means a settlement with great diversity, which enables freedom of choice; that settlement in which there is the most vivid connection between the inhabitants and their surroundings.

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Tables have to be numbered and shown by their order, so they can be understood without having to read the paper. Every column needs to have title, every measuring unit (SI) has to be clearly marked, preferably in footnotes below the table, in Arabian numbers or symbols. Pictures also have to be numbered as they appear in text. Drawings need to be enclosed on a white paper or tracing paper, while black and white photo have to be printed on a radiant paper. Legends next to pictures and photos have to be written on a separate A4 format paper. All illustrations (pictures, drawings, diagrams) have to be original and on their backs contain illustration number, first author last name, abbreviated title of the paper and picture top. It is appreciated if author marks the place for table or picture. Preferable the pictures format is TIF, quality 300 DPI.

USE OF ABBREAVIATIONS

Use of abbreviations has to be reduced to minimum. Conventional units can be used without their definitions.