Overview of the 70's construction systems applied in the residential settlement "Aerodrom" - Skopje

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Abstract

The intensive housing construction in the Republic of North Macedonia, which began in the 1960s, especially after the catastrophic earthquake in Skopje in 1963, was based primarily on the huge development of the construction operation, whose power and opportunities could not be expressed only in Macedonia, but with great success was carried out with the largest construction operations in the former: SFR Yugoslavia, Czechoslovakia, USSR; as well as in Germany, the Arab countries: Algeria, Iran, Iraq, Egypt and others.

According to the approved new urban plan of the city of Skopje, the most intensive building construction in Macedonia started in the seventies. New residential settlements emerged (Karpoš, Železara, Kisela Voda, etc.), which on a large scale began to give the physiognomy of the city. Also, the construction of the central city area with social, administrative and residential buildings started even more intensively (according to the project of the Japanese architect Kenzo Tange), designated as "city wall" and "city gates".

The growth and expansion of the city on a daily basis pressured the management structures, among others smaller ones, to start building the largest residential complex "Aerodrom". The buildings were built with inflexible technologies (with large surface and tunnel plates), where the possibility of changing the organization of the apartments is excluded, which was not the case with the buildings built with classical skeletal systems.

This paper aims to give an overview of the applied construction systems and technologies of construction and the correlation between the structure and the construction of the apartment and the structure of the family in the residential buildings from the settlement "Aerodrom" in Skopje, built in 1977.

Key words: *construction systems, technologies of construction, residential settlement, "Aerodrom" – Skopje*.

1. Introduction

The task of this research is to make a brief analysis of the basic urban plan towards the main project for the settlement "Aerodrom" in Skopje and analysis of the existing (built) condition, and the purpose of the research is to obtain knowledge about the characteristics of certain types of construction systems applied in residential buildings, as well as the characteristics of the technological systems of realization.

Each of the systems applied in the settlement is analysed separately:

- the system "REMO" of large surface plates with chairs,
- the "REMO" system of tunnel plates and
- the frame system, to complete this research by comparing all the previously mentioned systems in terms of construction dynamics.

Several scientific research methods have been used to design this study according to the nature of the problem and the field of research: analysis, own field research, comparison, synthesis of the results. The research was performed with the help of data obtained from the operational plans for the implementation of the neighbourhood units and the technical documentation for them.

After the synthesis and comparative analysis of the data collected and the results of the analyses, the basic principles and conclusions were announced at the end of the paper, as a good basis for possible future similar research.

2. Analysis of the basic urban plan for the settlement "Aerodrom"

The "Aerodrom" settlement is a mass housing neighbourhood situated in the eastern part of Skopje. The first residential units on the territory date back to the post-war period, representing a logical extension of the city towards east. However, what today could be recognised as the most distinguishable built structure within "Aerodrom" was constructed during the late 1970s and 1980s in order to meet the housing needs and much of the predicted/expected growth and development of the city after the earthquake in 1963 (Bulletins on the condition of the housing construction, regarding the realization of the medium-term program and the program for 1978 and 1979).

The catastrophic earthquake of 1963 in Skopje was a turning point in the history of the city. Between 1000-1100 inhabitants died, 70% of the housing area was destroyed and 150.000 inhabitants or three quarter of the population of the city were left homeless. There was a need for a quick response to find ways and forms to meet the housing needs for a large number of people (Bakalchev at al., 2021, p. 215).

At the same time, it presented an opportunity to raise the standard of living. With the growing number of residents and the policy of an 'open city', the demographic analysis predicted 154.000 new inhabitants whose housing needs were to be met by the early 1980s. The new "Aerodrom" mass housing neighbourhood, was supposed to meet more than half of the projected needs (Milovanović at al., 2022).

The Basic Urban Plan of Skopje from 1965 is made under the auspices of The United Nations, where a special trust fund is formed and the whole operation is about humanity and solidarity from countries from all over the world, and due to this unfortunate circumstances, it brought worlds' attention to Skopje and it is known as "the most famous urban plan of Skopje" (Lazarevska, M. and Markovski, B., 2019, p.64).

The Basic Urban Plan for the residential area "Aerodrom" - Skopje, was the basis for step-by-step preparation of detailed urban plans and implementation, as an integral part of the general conception of the city. The preparation of this important urban plan for the citizens of Skopje was entrusted to the Institute of Urbanism and Architecture - Skopje, which was the executor of the basic plan of the city. The Institute for Urbanism and Architecture - Skopje, as the holder of the task, in its execution cooperated with the Yugoslav Institute for Urbanism and Housing from Belgrade, which was the winner of the award of the competition for the settlement "Aerodrom" – Skopje (Basic urban plan "Aerodrom" – Skopje, 1976). The Consultative Board and other participants such as local communities, the Association of Architects, interested communities, who through suggestions and consultations contributed to its successful completion, had a great contribution in the process of preparing and following this important and complex task (Review of conceptual-architectural projects of the residential area "Aerodrom" – urban units A1 and A2, 1977, p. 12).

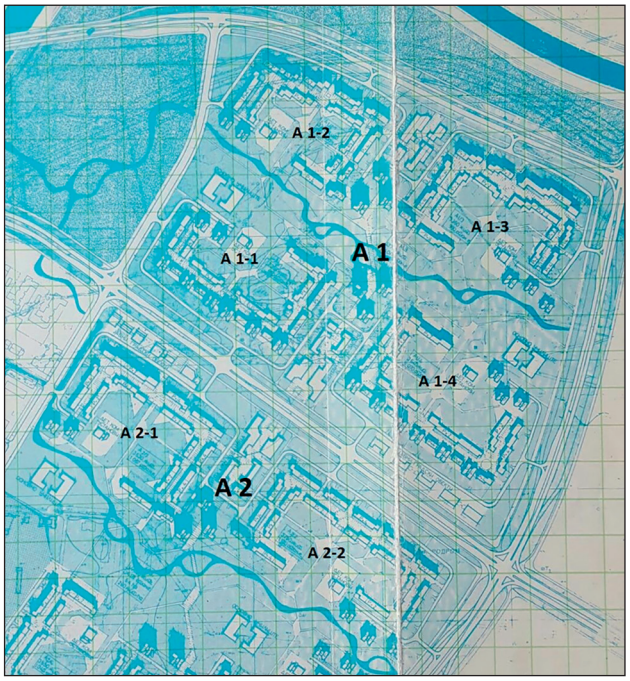

Figure 1. The urban plan for the residential area "Aerodrom" – Skopje (Detailed urban plan of urban units A1 and A2, 1975).

The specific situation and the demands from the investor to approach immediately the construction of two local communities, required inverse planning work: determining the basic elements for the urban system for the settlement, elaboration of two local communities, and then defining the spatial organization of the remaining part of

the settlement, including the regional center: commercial, business, sports, entertainment and other content (AS + 2000, 1974, p. 12).

The definition of the basic elements of the system included: housing, green and water areas, traffic and central contents.

The first stage for the realization of the area "Aerodrom" were the local communities A1 and A2 which in the west reach the existing built part of the city, and in the east extend to the boulevard "Serbia" and occupy a net area of 105ha (Figure 1).

- Concept of spatial organization

The organization of housing is based on a hierarchical division of urban units, resulting from a fairly solid urban typification, as follows:

– area-settlement for about 100.000 inhabitants
– local community for about 12-14.000 inhabitants
– residential community (urban unit) for 6-7.000 inhabitants
– residential group (neighborhood unit) for about 3.500 inhabitants (Review of conceptual-architectural projects of the residential area "Aerodrom" – urban units A1 and A2, 1977, pp. 1-6).

Green and water areas have a separate function in environmental terms, to reduce the harmful effects of very large pollutants, industry located north and south of the settlement (iron industry, chemical and cement industry), as well as to improve the micro-climate (increasing the degree of humidity, better regulation of outside temperatures in the settlement, etc).

In that sense the system of greenery is concentrated, dominated by wide green belts that extend continuously, along the residential tracts in the settlement. The main green belts are broken down into double combs and penetrate deep into the housing clusters, providing a closer connection between the apartment and the greenery.

The traffic, in importance, is spatially organized in such a way as to form approximately equal squares in which the local communities are organized as basic planning units.

Along the longitudinal boulevards "Jane Sandanski" and "ASNOM", arterial city traffic takes place, and in the transverse streets of lower order, the flows are divided and collected.

The internal traffic in the local communities is organized in such a way that the space is maximally reduced, and it is functionally maintained along the perimeter, touching the housing that is organized semi-atrium along the pedestrian streets, in the form of a horseshoe.

The central contents are organized longitudinally in the space, placed transversely in the direction in which the settlement extends, interrupted by green belts and to some extent decentralized in the hierarchy of urban units (schools are situated in residential communities, and children's institutions and playgrounds, as well as the supply points - in the residential group-neighborhood).

The regional center is also decentralized.

The main part (commercial, business, cultural, administrative, educational, catering and other contents) is situated somewhat eccentrically in relation to the center of the settlement, drawn in the direction of the city center along the boulevard "Jane Sandanski", on both sides organized with a center of gravity drawn in the direction of the existing settlement Lisiče.

- Local community

Each local community can accommodate about 13.500 residents in approximately 3.800 apartments of different sizes, organization and features that best suit the structure and desires of the households living in them.

The local community is conceived as a basic planning unit that integrates the socio-political concept and the urban-spatial concept for housing organization, understood as a complex urban function, which in addition to housing (in a narrower sense), includes a number of daily and occasional functions important for life and the work of the inhabitants. It is also unified in the spatial-physical sense, which enables efficient and rational housing and communal construction.

The local community provides rich urban equipment and a very studied spatial organization of the accompanying elements of housing, such as: trade, catering, crafts, primary schools, kindergartens, elements of health care, culture, sports, recreation and greenery. Many of these facilities are located in the center of the local community.

The local community of 13.500 inhabitants is a suitable size for the organization of socio-political life, for organizing large and well-equipped supermarkets, for elements of culture and health care, but for the organization of high schools, health center, recreation center, etc. it is still small, therefore, these elements are organized at the level of the city area "Aerodrom" within its center.

At the same time, for the elementary units of the education system - primary schools and child care facilities, the local community is too large, so each of the two local communities is divided into four neighborhood units.

- Residential community (urban unit)

The residential community has about 6.750 inhabitants with about 1.900 apartments.

It is an important urban housing unit of lower order, in which, in addition to housing, other daily needs are met, primarily education and recreation.

The importance of this unit is shown in the urban-spatial and techno-economic sense, because the unification and typification of the urban elements enables more efficient organization of housing under equal conditions and efficient housing construction.

In a social sense, it is important as an urban unit in which socialization is realized on a larger scale, such as the residential group (neighborhood unit).

- Residential group (neighborhood unit)

The neighborhood unit is an element of the local and residential community of about 3.400 inhabitants with about 850 apartments.

This unit is the smallest urban unit in which, in addition to housing, the most basic additional functions are met: babysitting, recreation for the youngest, first-class supply and services (kiosks, buffets, hairdressers, etc.). This urban unit is primarily important from a sociological point of view, because it carries out the first process of socialization of the inhabitants, through meetings and social contacts.

The housing function is dominant here and all the elements most directly related to housing are in it.

In terms of construction and height, there are three types of buildings:

– low-rise buildings (up to 4 floors) without elevator,
– medium-high buildings (up to 8 floors) with elevator,
– high-rise buildings (over 12 floors) with two or more elevators.

Each of these types is suitable for different constructions and construction methods, but also for different households (depending on which floor the apartment is located on).

High-rise buildings are primarily suitable for singles and employed married couples without children, so they are dominated by that type of housing.

Low-rise buildings are suitable for multi-child households that can climb stairs on their own.

3. Construction systems and technologies of construction in the settlement "Aerodrom" – Skopje

In the preparation for performing this largest construction venture in the field of housing construction in Skopje, the Self-Governing Interesting Community for housing approached with great responsibility, changing the existing principles of operation.

Unlike the previous agreements in the realization of individual residential buildings, the construction of the first part of this complex was agreed on the principle of "engineering" with the largest construction organizations in the city: "Beton", "Pelagonija", "Mavrovo", "Ilinden", "Granit", "Tehnika" and "Ratko Mitrović".

After the preparation of the organizational works, as well as the preparation of the entire technical documentation, on November 13, 1977 (the Day of the Liberation of the City of Skopje), began the construction of the largest residential complex in Macedonia. The settlement "Aerodrom" was one of the three most intensive residential construction sites in the former SFR Yugoslavia, where the entire Macedonian construction operation was occupied, which included about fifty other industries from Macedonia and the former SFR Yugoslavia (cement, steel, metal, plastic, wood, stone, plaster, etc.).

All the previously mentioned construction organizations, within the adopted technical documentation, were left with full freedom in the design, as well as in the application of the latest achievements in construction technologies, according to the specifics and possibilities of their construction operations (Filipovski, 1986, p.7).

As a consequence, three constructive systems are applied:

– System of monolithic reinforced concrete diaphragms - walls in two orthogonal directions, with mezzanine construction - flat reinforced concrete monolithic slab. The main feature of this constructive system is that there are no beams, except in parts of the diaphragms – above the windows and above the doors.
– System of load-bearing reinforced concrete walls and frames in transverse and longitudinal direction. The mezzanine structures are flat reinforced concrete slabs.
– System of reinforced concrete frames in both orthogonal directions.

The system of reinforced concrete walls and slabs is applied in the neighborhood units A 1-1, A 1-3 and A 1-4. The combined system of reinforced concrete diaphragms and frames is applied in the neighborhood unit A 1-2.

The reinforced concrete frame system is applied in the neighborhood units A 2-1 and A 2-2.

For the used structural systems, a dynamic analysis of the construction for defined seismic impacts at the locality "Aerodrom" was made and based on the seismic stability criteria, the equivalent seismic forces were defined. Spatial three-dimensional static and dynamic analysis of buildings was conducted.

In order to define the seismic impacts of the objects, a dynamic analysis for the action of a real earthquake was performed, where the mathematical model of the construction is presented with concentrated masses.

The nonlinear response of the structure is obtained in both directions with the following parameters: relative displacement, relative velocity, absolute accelerations, ductility factors and plastic excursions for each floor of the building, and it is concluded that the results are within the allowable values for reinforced concrete constructions.

Each of these construction systems provides a choice of different construction technologies.

Individually, the following construction technologies were applied by the previously mentioned construction organizations:

– "Beton" - tunnel plates
– "Pelagonija" - tunnel plates
– "Mavrovo" - combined construction system ("omnia" mezzanine structures and frames)
– "Ilinden" - large surface plates "REMO"
– "Granit" - large surface plates "REMO"
– "Tehnika" - classical construction - skeletal system (Dimkov, 1997, p. 4).

According to the selected construction technologies that are solved with the most commonly used building material - reinforced concrete, the problem of thermal and sound protection is solved differently by applying in most cases of "sandwich" constructions (hollow light-concrete and clay blocks, siporex blocks, colored reinforced concrete, facade fugue brick, in combination with thermal insulation plasters, gypsum boards, ie by fitting "demit" facades).

In all these "sandwich" constructions the coefficient of thermal conductivity ranged from the unfavorable K=1.57, to the favorable K=0.67; 0.78; 0.81 or 0.88, which is less than the allowed K=0.93W/m2K for the second climate zone.

• Analysis of applied construction technologies

Cast concrete technology is based on four basic components:

– transport of concrete,
– armature,
– cranes,
– mobile portable plates.

The industrialization of all these components enables high productivity in the production of rough construction works. For these reasons, most of the construction companies in the settlement "Aerodrom" decided to apply the construction technology with "REMO" plates.

With the large surface plates "REMO" the three principles for application of this plate can be realized, with certain additional elements.

The first principle is that with standard and non-standard vertical panels, large surface plates are formed, with the help of which reinforced concrete walls with different shapes and dimensions are made.

The second principle allows horizontal panels with sloping supports and stabilizers to be added to standard and non-standard panels. In this way, semi-shells are formed, which are a basic element of the tunnel spatial plates.

The third principle allows the standard and non-standard panels to be used as a cladding that carries prefabricated reinforced concrete mezzanine slabs and at the same time allows concreting of the walls.

1. System of large surface plates with chairs

Two construction companies opted for this way of construction:

– "Granit" which realized the neighborhood unit A 1-1 with 18 buildings and
– "Ilinden" which realized the neighborhood unit A 1-2 with 19 buildings.

Due to the economy of the construction, ie, depending on the amount of available quantity of the plate, the construction of one floor was realized in parts.

The construction of these plates enabled easy formation of all dimensions and shapes that the designer foresaw in the adopted plan for realization.

Once formed, the plate is used for the construction of the entire building, and with some additions it can be used for other buildings as well.

The contact surface with the concrete can be a wooden pressed plate (applied to the buildings realized by the company "Ilinden") or a steel plate (applied to the buildings realized by the company "Granite").

Wooden boards can be 3-15mm thick, and are most often used with a thickness of 8mm.

The dimensions of the standard elements are adapted to the modular system for residential construction.

The basic elements of the "REMO" system are vertical panels that are made in three standard heights: 2.5m, 2.6m and 2.75m.

The standard elements are made in lengths of 2.5m, 1.25m and 0.625m.

The mutual longitudinal extension of the panels and their bringing to the same level is provided by the joints.

The fine leveling of the panels by height is enabled by the built-in spindles in the threshold of the panel.

The panels with a length of 2.5m and 1.25m have two girders built into the threshold in which wheels can be mounted if needed.

Each panel has a built-in stabilizer, and if necessary, a working platform.

Front closures are used to limit the length of the wall.

The panels are connected to each other with anchor joints, and the distance between the panels is fixed with conical steel bushings.

The plate is placed next to the wall beginning which is 10-12cm high, and is performed together with the slab, or additionally.

The weight of the plate together with the stabilizer and the working platform is 75 kg/m^2 (Plates REMO - 275, manual, 1973).

After the construction of the vertical reinforced concrete walls, movable chairs are mounted for the construction of the horizontal slabs. The "chair" consists of a steel structure, longitudinal beams through which a wooden ("Ilinden") or steel cladding ("Granite") is placed.

During the construction of buildings constructed by the company "Ilinden", individual plate positions were made classically, which is a consequence of the adopted combined construction system and it affected the dynamics of construction.

For construction of 1m^2 of the building floor plan with such plate it took 8.05h/m^2, or for construction of one floor height with a gross area of 370m^2 with 30 workers it took 15 days (Table 1).

Table 1. Construction dynamics of the neighborhood unit A 1-2 performed by the company "Ilinden" (Operational plans of the contractors of the neighborhood units in the settlement "Aerodrom" – Skopje, 1978-1979).

work operation	walls	slabs	whole floor 370 m2	h/m2	labor					used mechanization
	required hours	required hours	required hours		highly skilled	skilled	low-skilled	electrician	reinforcement	
- montage - reinforcement - electricity	24	40	64	4,86	7	10	4	3	6	- crane - mixer - reloading basket - vibrator - ordinary basket
concreting	12	12	24	1,40						
dismantling	12	20	32	1,79						
TOTAL HOURS	48	72	120	8,05						

The company "Granit" achieved a performance dynmics of 6.28 h/m^2 floor plan, or for construction of one floor height with a gross area of 400m^2 with 40 workers it took 9 days (Table 2). The measurements attached to the attestation for this plate envisage a production time, with good organization and rigorous planning, of 7.17 h/m^2 floor plan.

Table 2. Construction dynamics of the neighborhood unit A 1-1 performed by the company "Granit" (Operational plans of the contractors of the neighborhood units in the settlement "Aerodrom" – Skopje, 1978-1979).

position		ways of working	hours spent	workers	h/m	labor structure			mechanization used		h/m2 gross
						highly skilled	skilled	Σ	type	number	
walls	reinforcement	REMO large surface plates and mesh reinforcement	8	4	0,33	5	8	13	- crane - pervibrator - reloading basket - pump	1 1-2 1 1	1,08
	montage		8	3	0,25						
	concreting		8	2,5	0,21						
	dismantling		8	2,5	0,21						
	electricity		8	1	0,08						
elevator		REMO plates	8	2	0,16		3	3			0,16
stairs		prefabricated	8	1	0,08						0,08
slabs	montage	the plate is with chairs, and the reinforcement is with mesh	8	8	0,67	5	19	24			
	reinforcement		8	4	0,33						
	concreting		8	4	0,33						
	dismantling		8	8	0,67						
			8	40	3,32	10	30	40			3,32
			8		2,96						
					6,28						

2. Tunnel plates system

The neighborhood units A 1-3 ("Beton") and A 1-4 ("Pelagonija") for the construction of the structural system which is spatial, used special equipment - spatial tunnel plates.

Standard elements of the tunnel plates are half-shells composed of vertical and horizontal panels joined at right angles. The length of the shells fits into the modular raster, the height approximately corresponds to the light height of the space between two mezzanine slabs, and the width approximately halfway between the load-bearing transverse walls.

The construction of all panels is entirely steel, ie on steel sheet with a thickness of 3mm (base surface in contact with concrete), serially welded "omega" profiles for hardening of surfaces.

Spatial rigidity is achieved with sloping tube supports, on the connections of which, on a vertical or horizontal panel, there are spindles that enable regulation of both panels, formation of a right angle and montage, ie. dismantling of the plates. All vertical panels at the base are equipped with saws and wheels that allow easier dismantling and transfer of the plate. The interconnection of the semi-schools is done with special closures that do not allow the cement milk to flow out of the plate.

Supporting elements of the plate are working and auxiliary platforms that solve the basic issue of the manner and direction of dismantling the tunnel plate, and also provide protection at work. The system of their fastening does not include any anchors in the concrete structure, but only a pin between two mezzanine slabs.

The thickness of the wall is achieved with the help of plate connections, ie. with hard "juvidur" pipes or steel bushings.

Temporary steel frames for forming openings in the walls and mezzanine slabs, with their construction enable adjustment of the dimensions in height and width and simple installation and dismantling without damaging the concrete edges.

By combining two essentially different procedures - concreting the walls and concreting the mezzanine slabs, the otherwise necessary delays are eliminated, which enables continuous work. With the help of this plate, precision in the performance is achieved, flat and smooth surfaces.

Flexibility, ie. possibility to change the spans is provided by supplementing the mezzanine panels on the tunnel plate.

To center the walls and squares vertically, concrete wall guides are used to support the wall plate on the next floor at a certain height, and are usually performed with a special plates at the same time as concreting the bottom slab.

The highest weight of the standard elements of the plate is 60-70 kg/m^2, ie it is lighter than the wooden plate.

With proper handling and maintenance of the plate: cleaning of concrete, smearing with appropriate coatings, use of cast concrete with minimum vibration; it can be used 500-800 times. The economy will come to the fore if the dismantling of the plate is done in the shortest possible time.

To accelerate the increase in strength of concrete, it is heated. The required amount of calories, ie. heat, is realized by heating the air in the closed spaces of the tunnel, on the basis of infra-red rays from a gas tank with various radiators. In the process of heating the concrete, protection is provided from the upper side of the slab with polyethylene foil. The construction company "Beton" with this system of spatial plate performed one floor with an area of about 332m^2 with 28 workers in 4-5 days, or about 2.31hours/m^2 floor plan (Table 3).

Table 3. Construction dynamics of the neighborhood unit A 1-3 performed by the company "Beton" (Operational plans of the contractors of the neighborhood units in the settlement "Aerodrom" – Skopje, 1978-1979).

work operation	I part 187,57 m2	II part 144,38 m2	whole floor 331,95 m2	h/m2	labor					used mechanization
	required hours	required hours	required hours		highly skilled	skilled	low-skilled	electrician	reinforcement	
- montage - reinforcement - electricity	225	75	430	1,30	3	8	5	4	8	- crane - mixer - reloading basket - vibrator - ordinary basket - gas heaters
concreting	64	64	128	0,39						
dismantling	115	95	210	0,62						
TOTAL HOURS	434	234	768	2,31						

The construction company "Pelagonija" realized one floor with an area of about 312m^2 with 29 workers in 5 days, or about 2.49 hours/m^2 floor plan (Table 4).

Table 4. Construction dynamics of the neighborhood unit A 1-4 performed by the company "Pelagonija" (Operational plans of the contractors of the neighborhood units in the settlement "Aerodrom" – Skopje, 1978-1979).

work operation	I part 177,61 m2	II part 135,06 m2	whole floor 312,67 m2	h/m2	labor					used mechanization
	required hours	required hours	required hours		highly skilled	skilled	low-skilled	electrician	reinforcement	
- montage - reinforcement - electricity	250	170	420	1,34	6	6	3	4	10	- crane - mixer - reloading basket - vibrator - ordinary basket - gas heaters
concreting	64	64	128	0,41						
dismantling	120	120	240	0,74						
TOTAL HOURS	434	354	788	2,49						

With measurements made on a building in New Paris, with this plate, one floor with an area of about 370m^2 with 12 workers was performed in 4 days, or for about 1.17 hours/m^2 floor plan.

The difference in the construction dynamics between the companies "Pelagonija" and "Beton" is due to the technological variant in performing the works with tunnel plates (the company "Beton" took out the tunnels from two sides, and the company "Pelagonija" from three sides).

3. Construction in a classic way with skeletal system

The system of reinforced concrete frames in both orthogonal directions is present on the buildings in the neighborhood unit A 2-1 (construction company "Mavrovo") and in the neighborhood unit A 2-2 (construction company "Tehnika").

In the company "Tehnika", the frames are performed classically, with cladding and pouring of concrete on the construction site. In the company "Mavrovo", the frames are performed classically, and the connecting beams are semi-prefabricated. Up to a certain height (above the neutral axis) they are pre-cast, and after mounting the cross-section is completed. The mezzanine constructions in some of the buildings constructed by the company "Tehnika" are flat slabs cast on the construction site, and in another part are "omnia" slabs, which are partially present in the buildings constructed by the company "Mavrovo".

"Omnia" slabs

The construction of the mezzanine structure with "omnia" slabs consists of pre-cast prefabricated slabs with a thickness of 4cm and with installed one-way bearing reinforcement, which consists of mesh reinforcement obtained by static calculation, and of triangular reinforcement bars used for connection of both layers of the concrete slab, for transporting and lifting the slabs and for carrying the lower reinforcement.

The second layer of concrete is poured on the spot over the prefabricated slabs after placing the distribution reinforcement. The prefabricated slabs rely on the ends and the middle, at a distance of maximum 2m and actually serve as a plate for the second layer of concreting.

The construction company "Tehnika", which constructed the buildings in the classical way, performed one floor with an area of about 300m^2 with 14 workers in 16 days, or 1m^2 floor plan in 6,40 hours (Table 5).

Table 5. Construction dynamics of the neighborhood unit A 2-2 performed by the company "Tehnika" (Operational plans of the contractors of the neighborhood units in the settlement "Aerodrom" – Skopje, 1978-1979).

work operation	chairs	beams + slabs	whole floor 300 m2	h/m2	labor	used mechanization
	required hours	required hours	required hours			
- montage	8	24	32	1,6	14	- crane - mixer - reloading basket - vibrator - concrete pump
- reinforcement	16	32	48	2,4		
- concreting	8	16	24	1,2		
- dismantling	8	16	24	1,2		
TOTAL HOURS	40	88	128	6,4	14	

The construction company "Mavrovo" achieved faster construction dynamics, because certain elements were prefabricated, ie one floor with an area of about 420m^2 with 22 workers performed in 12 days, or achieved a coefficient of 5.03 hours/m^2 floor plan.

Comparing the coefficients of the achieved performance dynamics in all six neighborhood units (Table 6), it can be concluded that the highest construction speed of the structures is achieved using the tunnel plates.

Table 6. Comparison of the achieved results in all six neighborhood units (Operational plans of the contractors of the neighborhood units in the settlement "Aerodrom" – Skopje, 1978-1979).

	coefficient of construction dynamics					
neighborhood unit	A 1-1	A 1-2	A 1-3	A 1-4	A 2-1	A 2-2
contractor	"Granit"	"Ilinden"	"Beton"	"Pelagonija"	"Mavrovo"	"Tehnika"
required hours for realization of 1m2 floor plan	6,28	8,05	2,31	2,49	5,03	6,40

4. Overview of the performed types of wall constructions and materials for their construction

Internal partition walls, external facade walls as well as their facade processing, in each neighborhood unit is solved in a special way. The review of separate housing units according to the technical documentation for the received projects and the actual situation is as follows:

1. Neighborhood unit A 1-1 (construction company "Granit", project company "Granit" and "Makedonijaproekt").

– The construction system has reinforced concrete walls (with a thickness of 15cm) in both directions.
– The facade processing of these reinforced concrete walls is covered with: EPS 4cm, plastic mesh and plaster of 1-1.5cm.

On the facade there are walls of Siporex blocks 20cm with a facade painted with synthefas, colorfully solved.

Walls with hollow ceramic blocks 25cm, built in extended mortar, are also used as facade walls.

– The inner partition walls are made of Siporex blocks 10cm, coated with wallpaper or ceramic tiles in the toilets.
– Between two adjacent apartments are walls made of Siporex blocks 20cm coated with wallpaper or are reinforced concrete walls with a thickness of 15cm, coated with plasterboards on both sides.
– The walls towards the stairwell are reinforced concrete with a thickness of 15cm, lined with tervol 3 cm and plasterboards on the side of the apartment.

Project company "Makedonijaproekt":

– The construction system has reinforced concrete walls in both directions.
– The external processing of the reinforced concrete walls is by siporex tiles with dimensions 60cm / H (floor height 280cm) / 10cm, with a facade of plastic mortar Teraplast.

There are also facade walls of Siporex blocks (60/25/175cm or 60/25/20cm) with a facade of plastic mortar Teraplast.

– All internal partition walls are made of Siporex blocks 10cm coated with wallpaper, and in the toilets lined with ceramic tiles along their entire height.
– Between two adjacent apartments, the walls are reinforced concrete with a thickness of 18cm, lined with wallpaper.
– Towards the stairwell, the walls are reinforced concrete with a thickness of 18cm. On the side of the living space they are covered with wallpaper, and towards the stairs they are plastered with Jumper plaster.

2. Neighborhood unit A 1-2 (construction company "Ilinden", project company "Institute of Urbanism and Architecture" and "Ilinden").

– The construction system has reinforced concrete walls in both directions with a thickness of 15cm or 20cm.
– Reinforced concrete facade walls are lined with "sandwich" from the outside. The "sandwich" consists of a 7cm concrete part and 5cm thermal insulation.

Walls of hollow ceramic blocks 25cm, plastered on the outside and lined on the inside with plasterboards, as well as facade brick walls with the same interior treatment, also appear as facade walls.

- The inner partition walls are made of Siporex blocks or gypsum blocks with a thickness of 10cm.
- Between two adjacent apartments, the walls are reinforced concrete, lined with plasterboards on both sides.
- The walls towards the stairwell are reinforced concrete with a thickness of 20cm and lined with plasterboards on the side of the apartment, and towards the stairs plastered with Jumper plaster.

3. Neighborhood unit A 1-3 (construction company "Beton", project company "Beton").

- The construction system has load-bearing reinforced concrete walls in both directions with a thickness of 18cm.
- The exterior walls are reinforced concrete with a thickness of 18cm coated with facade elements on the outside, consisting of Okipor 3cm and concrete slab 6cm. On the longitudinal facade walls, facade "sandwich" elements are placed, consisting of an 8cm concrete wall, a 3cm Okipor and a 6cm external reinforced concrete slab.
- The inner partition walls are made of gypsum blocks 7cm, and the toilets are made of Siporex blocks 10cm.
- Between two adjacent apartments there are reinforced concrete walls with a thickness of 18cm lined with wallpaper on both sides. There are also walls composed of: Siporex blocks 10cm, air gap 10cm and again Siporex blocks 10cm.
- Towards the stairwell, the walls are reinforced concrete lined with wallpaper on the side of the apartment, and painted with coatings for concrete walls on the side of the stairs.

4. Neighborhood unit A 1-4 (construction company "Pelagonija", project company "Pelagonija").

- The construction system has load-bearing reinforced concrete walls with a thickness of 15cm.
- The external reinforced concrete walls from the outside are treated with: EPS 4cm, polymer mortar with glass mesh and painting with acrylic coatings or by spraying.
- All internal partition walls are 10cm thick, made of wooden substructure and plasterboards. Between the boards is placed 4cm glass wool. The same type of walls is applied to the toilets.
- Between two adjacent apartments the walls are reinforced concrete with a thickness of 15cm.
- The walls towards the stairwell are reinforced concrete with a thickness of 15cm, processed towards the stairs in the same way as the facade walls.

5. Neighborhood unit A 2-1 (construction company "Mavrovo", project company "Mavrovo").

- The construction system is mixed, with the application of vertical reinforced concrete walls and load-bearing beams in one direction.
- All facade walls are made of Siporex blocks 25cm. The Kalkan walls are reinforced concrete with a thickness of 16cm, walled on the inside with a brick placed on a ledge. The facade is made of plastic mortar.
- The inner partition walls are made of Siporex blocks 10cm. In the toilets, the walls are made of: hollow ceramic blocks 10cm, air gap 20cm and again hollow ceramic blocks 1 cm.
- The walls between two adjacent apartments are made of Siporex blocks 25cm.
- Towards the stairwell, the walls are reinforced concrete with a thickness of 16 cm, and inside are walled by a brick placed on a ledge.

6. Neighborhood unit A 2-2 (construction company "Tehnika", project company "Makedonija-proekt").

- The structural system is skeletal with frames in both orthogonal directions.
- All external walls are made of hollow ceramic blocks 25cm facade with plastic mortar.
- The inner partition walls are made of hollow ceramic blocks 10cm.
- The walls between two adjacent apartments and towards the stairwell are made of hollow ceramic blocks 25cm.

5. Conclusion

The fact that housing construction is increasingly becoming an economic rather than a technological problem is indisputable.

Investments that directly affect the economic efficiency of the project, are determined by the value of construction, craft and installation works on average around 50 - 60%. Such a high share of investment costs in industrial projects gives recognition to every effort to reduce construction costs.

In housing construction, these values are the dominant financial item in the total investments. On the other hand, the duration of the realization of the construction works affects the final price of the building, so the planning of the undertaking is an integral move important for the overall efficiency of the project realization process.

The participation of engineering disciplines, especially in the field of architecture and construction, in the realization of the investment undertaking during the whole life of the project, has a characteristic of direct impact on the efficiency of the construction process (in the period of design, preparation and realization) and indirectly - in period of exploitation.

The dynamic plan for performing the planned works (and accompanying activities) is the basis for planning the provision of financial resources by time and amount. The tunnel and large surface construction systems, applied in the residential settlement "Aerodrom" - Skopje, represented a high degree of industrial housing construction. However, these systems, although giving a low cost of basic construction work and construction (and thus reducing the cost at the very beginning of construction), by themselves do not provide a flexible functional solution for the apartments in the buildings.

The role of typification of apartments is much more important for enabling industrialization of finishing works, installation and equipment. Industrialization primarily means production and installation of serially standardized elements (such as: Facade walls, mezzanine structures, toilets, stairs, etc.).

Although industrial housing construction will shorten construction deadlines and reduce production costs, this cannot be achieved without mass construction of a large number of apartments on a large site (such as the "Aerodrom" residential area in Skopje).

The basis for the efficiency of a certain construction lies, of course, in its technical solution itself - but with significant influence are the other factors: the quality of production and installation - under constant and efficient control.

However, we should not forget the fact that the efficiency of a certain standardized construction largely depends on its proper application - that is, on the design solutions.

Disadvantages of mass application of typed constructions

The problem of the negative sides of the mass application of industrialized constructions, especially in mass residential construction - can be viewed from two basic points of view: technical-economic and human.

The main danger from the mass application of a certain functional-technical solution, from a technical-economic point of view, is the possibility of multiple repetition of one or more mistakes. The accident is that, not the rare, but the massive repetition of certain mistakes, makes them clearly visible - and then it is either very difficult or even impossible to effectively correct or remove them.

As a result of the great need for housing and for a more rational use of construction land, industrialized construction has been used in the construction of large apartment blocks and single-family homes, which, due to their uniformity and grayness, have a repulsive effect on the people who live in them.

This led to a tendency to identify efficient production methods with a dehumanized residential environment, to which the uneven quality of artisanal finished works contributed to a large extent.

This fact points to the danger of dehumanization in mass housing, realized only after many settlements had already been built - and when the disillusionment and dissatisfaction of many of their residents became apparent.

It is true that poorly executed finishing works affect the poor final result - but the fact is that even the best craftsmen are not able to successfully cancel the bad effects of the work of their "industrialized" predecessors.

On the contrary, many European residential areas are known for their extraordinary architectural solutions obtained by combining different systems and storeys to avoid these negatives. However, it

should be clearly emphasized that the issue of humanity in the construction of new residential settlements is not the only or primarily technical problem - so it cannot be solved on that level alone.

Some possible preventive measures to remove the negative consequences of the mass application of typed constructions

Realizing that the mass construction of housing cannot only aim to satisfy the quantitative and physical-qualitative needs of the inhabitants of the new settlements - and encountering difficulties of an organizational and economic nature, many countries opted for the "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 the productivity of work, the efficiency of construction and the realization of economy, must also satisfy the requirements for aesthetics and high quality of the human living space.

Realizing the inadequacy of the building procedures at that time - the "open" building system became a "social determination". There is reason to believe that "open" systems of primary structure and with a greater degree of freedom for the secondary structure, and with greater technological connectivity, would be significantly more suitable.

In the evaluation of the apartment and the neighborhood, the users will put their functional values, the general atmosphere in the neighborhood, rather than the architecture of a separate residential building or a larger ensemble, in the first place, even from an aesthetic point of view.

Therefore, architecture as a creative discipline, should be fully in function of social requirements (functional values of buildings, the general atmosphere in the neighborhood) and to allow it to be built rationally and close to the needs and desires of its inhabitants.

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