

ABSTRACT

Today, in the 21st century within the context of the neo-liberal market, architecture has become a tool of capital, demanding minimal investment with maximum spatial and environmental performance. Permanent changes that follow the rapid development of an information-based society imply an infrastructural take on the architectural composition, which has become increasingly programmatically unstable and market driven. Therefore today, an architectural composition traditionally understood as a set of part to-whole relations on three basic levels: form, function (program and its performance) and structure, can be perceived through the relations between volume, program range and infrastructure (which integrates the structural and performative aspects). Beginning with the hypothesis that socio-economic changes alter the conceptions of infrastructure in the design process, and understanding ways to transform the architectural composition, a set of key historical moments and relations are established between the development of: architectural tools and methodologies, norms and policies of spatial and energy efficiencies, and understanding infrastructure as an omnipresent element within the architectural composition. In urban design and architectural design, two terms can be distinguished: *infrastructural ground* – a term that brings infrastructure closer to the architecture scale, and *infrastructural tenets*, which are methods in the design process used to evaluate the spatial efficiency and the capacities for programmatic change, determining the relation between transformations within the design process and those of a completed project. Therefore, a new design approach is needed to define the capacities of programmatic transformations that can follow different models: flexibility, performativity and process, while maintaining the optimal spatial efficiency.

The research showed that the choice of a transformational strategy depends on the program and envelope typologies to determine a project-specific *infrastructural tenet* – the layout of infrastructural elements which is located and quantified

using the basic spatial efficiency parameters and indicators. As a launching point for further research, a theoretical matrix is proposed for four envelope typologies and three dominant program typologies, followed by a list of basic spatial efficiency parameters to loosely describe their infrastructural layouts.

Keywords: Infrastructure, infrastructural tenet, architectural composition, spatial efficiency, infrastructural ground.

АПСТРАКТ

Данас, у оквирима неолибералног тржишта 21. века, архитектура је постала инструмент капитала, захтевајући минималне инвестиције, а максималне просторне и енвајронменталне перформансе. Константне друштвено-економске промене које прате брзи развој информационог друштва иницирају нови приступ поимању архитектонског склопа који, вођен тржиштем, постаје програмски нестабилна категорија. Стога, разумевање архитектонског склопа који подразумева однос делова и целине на три основна нивоа: форме, функције (програма и његовог перформанса) и структуре, данас можемо посматрати кроз односе: волумена, програмског опсега и инфраструктуре (која интегрише структуралне и перформативне аспекте).

Почевши од хипотезе да се са друштвено-економским променама мењају и концепције инфраструктуре у процесу пројектовања, као и разумевање могућности постизања промена у архитектонском склопу, успостављен је низ историјских момената развоја: (1)архитектонских алата и метода, (2) норми и препорука везаних за просторну и енергетску ефикасност, (3) разумевања улоге инфраструктуре као свеприсутног елемента у архитектонском склопу. У областима урбанистичког и архитектонског пројектовања успостављена су два појма: *инфраструктурно тло* и *инфраструктурни принципи*. Први појам инфраструктуру приближава размери архитектуре, док други означава методе у процесу пројектовања – помоћу којих се врши евалуација просторне ефикасности и капацитета за програмске промене у архитектонском склопу, одређујући однос могућих промена у процесу

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пројектовања и након реализације пројекта. Стога, неопходан је нов приступ процесу пројектовања који би одредио опсеге програмских трансформација пратећи различите моделе: флексибилности, перформативности или процесног модела, истовремено одржавајући неопходне нивое просторне ефикасности.

Истраживање је показало да стратегије трансформације склопа које зависе од програмских и волуметријских типологија детерминишу пројектно специфичне *инфраструктурне принципе* — распореде инфраструктурних елемената који се лоцирају и квантификују помоћу основних параметара и индикатора просторне ефикасности. Као полазна тачка за наставак истраживања предложена је теоретска матрица са четири типологије опне (волумена) и три доминантне програмске типологије праћене листама основних параметара просторне ефикасности помоћу којих се могу оквирно одредити њихови инфраструктурни распореди.

Кључне речи: инфраструктура, инфраструктурни принцип, архитектонски склоп, просторна ефикасност, инфраструктурно тло

## INTRODUCTION

The research begins with the condition of the architectural profession today, based upon the theoretical standpoints of Stan Allen and Reinier De Graaf, who both recognized the crisis in the architectural profession two decades after the fall of the Berlin Wall. Since the '70s and the Postmodern movement, the process of planning and governing cities has been taken away from the hands of architects and planners and placed into the hands of engineers and investors (Allen, 2000). This process culminated in the '90s when the omnipresent process of privatization brought a constant rise in real estate values, which turned architecture into a means of financial revenue, and the architect's position further declined (De Graaf, 2017). In the present time, when the global market, investment funds and real estate agencies demand minimal investments and maximum spatial and energetic performances, architects are downgraded to a peripheral, consultative position. This implies that the space for action of the profession has been narrowed down, and design can be conveyed within the boundaries of spatial efficiencies only by using necessary infrastructural components which make the building functional, performative and therefore profitable.

Considering the fact that fast social changes are influenced by the development of information technologies and overall technological improvements, introducing changes within architectural objects is distinguished as one of the most prominent themes in contemporary architectural discourse. Introducing changes has substituted historically appreciated durability and strength (*Firmitas*). This new situation creates opportunities for the architectural profession to partially recover its position by designing and cultivating infrastructure

that enables changes, extends life-cycles and boosts the performativity, as well as profitability, of architectural objects. This can be accomplished first on the scale of a building, considering the fact that the role of an architect in planning the city infrastructure is even more indirect and limited by the interests of large capital systems or complex decision mechanisms. Changes within architectural objects are problematic in general, since reconstructions in which reprogramming happens are rare and most often not feasible on a larger scale for various reasons: legal (ownership structure, zoning laws), economic (lack of profitability, so an increase of surface area is always needed) or infrastructural (lack of infrastructural capacities, or an unsuitable and not upgradable infrastructural layout).

The research problem aims to determine the role of infrastructure within the architectural composition of the 21st century and the ways in which it enables changes to be achieved within built architectural objects. By striving to incorporate infrastructural tenets within the design process, the research aims to develop a series of typological relations which could be used to evaluate infrastructural elements in relation to their spatial impacts, as well as their performativity and the changes they could support within the architectural composition. The scope of this paper incorporates the theoretical background of the research problem, and discloses the methodology and the initial findings.

The first part of the problem refers to establishing infrastructure as a term on the scale of architectural composition, by forming clear relations and a hierarchical structure relative to the current understandings of the term in the realm of urban design.

The second part of the problem refers to determining the *infrastructural tenets* (Kipnis, 1996) as methodologies of the design process. Infrastructural tenets are defined as sets of relations between elements and systems on one hand and the generic envelope (volume) (Zaera Polo, 2008) and program typologies on the other.

The third part of the problem refers to drawing causally-consequential connections between conceiving architectural compositions based on their infrastructural tenets and the potential for changes that could be achieved following the models of: flexibility, performativity and process (unfinishedness).

Within the scope of this paper the first segment of research will be presented through the analysis of theoretical papers written mostly between 1989 and 2018. The research starts with the works of Rayner Banham and Alison and Peter Smithson, which preceded the previously mentioned period, when the problem of infrastructure on the architectural scale had just been announced, while the main discourse to be scrutinized starts from 1989 and comprises the works of Bruno Latour, Jeffrey Kipnis, Stan Allen, Rem Koolhaas, Jeremy Till and Tatjana Schneider, Alejandro Zaera-Polo and Reinier De Graaf et al. After introducing the key terms based on their relations (infrastructure

and architectural composition), the paper will: 1) follow the how the understanding of infrastructure evolved together with the evolving design process within four established historical periods (I 1914-1989, II 1989-2000, III 2008-2012, IV Contemporary period 2015-), 2) provide an overview of the role of infrastructure within three transformational strategies (flexibility, performativity, process strategy), 3) suggest a model of how infrastructure could mediate the typological relations between volumes and different programs.

### **Infrastructure and the architectural composition**

In the 21st century, infrastructure as a term has become problematic, considering the fact that it is used to describe lots of things, so it has become a part of the everyday language of economists, IT and traffic engineers, politicians and others. The term is usually related to the technical structures which support society and its production and distribution of goods and services to the market, together with the commodities and services that the social community needs, be it in the country, city or another area. The word itself originates from engineers' circles of 19th century France, but it did not enter into everyday use until the end of WWII, as internal slang in the NATO military alliance, where it was perceived as fixed installations necessary for the operation of the armed forces. In the domain of the political economy, the term *base* (Marx, 1859) is interpreted as today's infrastructure in its broadest sense – as a mechanism that regulates socio-economic relations. In fine arts, the *infrastructure of a painting* is mentioned as a methodological tool in the abstract paintings of Braque and Picasso. In the realm of social sciences, the term social infrastructure encompasses two notions: the first one relates to the institutions and facilities that provide social services (schools, hospitals, prisons etc.), and the second to people's communities gathered around specific goals.

In the field of architectural and urban design, the term was introduced in the '60s, with avant-garde architectural collectives such as *TEAM 10*, *Archigram* and others, but it was not further elaborated during the whole postmodern period until the turn of the century, when Kipnis, Allen and others activated the topic again. This research considers the infrastructures of architectural objects as the following elements that relate to: movement (stairs, lifts, ramps, escalators, foyers and so on), comfort (active and passive HVAC systems, openings, illumination and ventilating systems), and the division and distribution of space (subdivision walls, shades, structural elements). It is expected that different configurations of these elements are dependent on the typologies which are applied, to suggest regularities which determine the architectural composition.

Architectural composition is one of the key categories of the architectural design process, because it integrates a multiplicity of different yet complementary aspects that together make a whole. The word *composition* means the synchronized relation of a part to the whole. In architectural analysis, as a part

of the design process, a composition is developed whereby pre-elaborated elements (typical units) are connected into a functional unity which represents the essence of a future object. Architectural composition traditionally includes several different aspects: form (appearance and perception), function, and structure (Arnheim, 1977). The functional aspect of an architectural composition is traditionally determined by the program and activities of the future user of the architectural object, which is manifested by defining and correlating the functional spatial units within. However, today's functional segment of an architectural composition is far more complex than the program and includes multiple performance-related factors: comfort, energy efficiency, spatial efficiency, flexibility, and potential for change.

Since the programmatic aspect of an architectural composition in the 21st century has largely become an economic category, compositions are often driven by the laws and flows of the market. Information technologies and technologies in general are omnipresent in today's architectural objects, so architectural composition has become more and more complex, and infrastructure has become an integral part of it – be it physical or informational. Infrastructural components and systems have overcome their original functions of channeling different flows through a building (air, water, energy, people and so on), and for a long time they have already impacted the programming of spaces (bathrooms, kitchens, laundry, server rooms and others). Its performativity is subject to constant evaluation, adjustment, management, and optimization – a process whereby infrastructures obtain their shapes and forms, which are sometimes translated into the overall scale of the object, indicating both the presence of and the solution to a problem which their presence had initiated.

### **Goals, hypothesis and methods**

The general goal of this research is to improve the design process towards integrating the transformative capacities for architectural compositions and to extend the life cycles of buildings by designing them as functionally neutral. This goal can be approached by understanding the possibilities and limits for the changes within an architectural composition.

Assuming that the elements of infrastructure are crucial for this, both during the process of design and during the lifetime of a building, two hypotheses can be raised to show that:

-Changes in socio-economic conditions initiate the new methodological conceptions of infrastructure in the process of architectural design, oriented towards intensifying land use potentials and spatial efficiency through changes within the architectural composition.

-The typological relations between volume and program indicate the choices of infrastructural layouts and typical plans, and therefore the possible strategies and scopes for programmatic transformations.

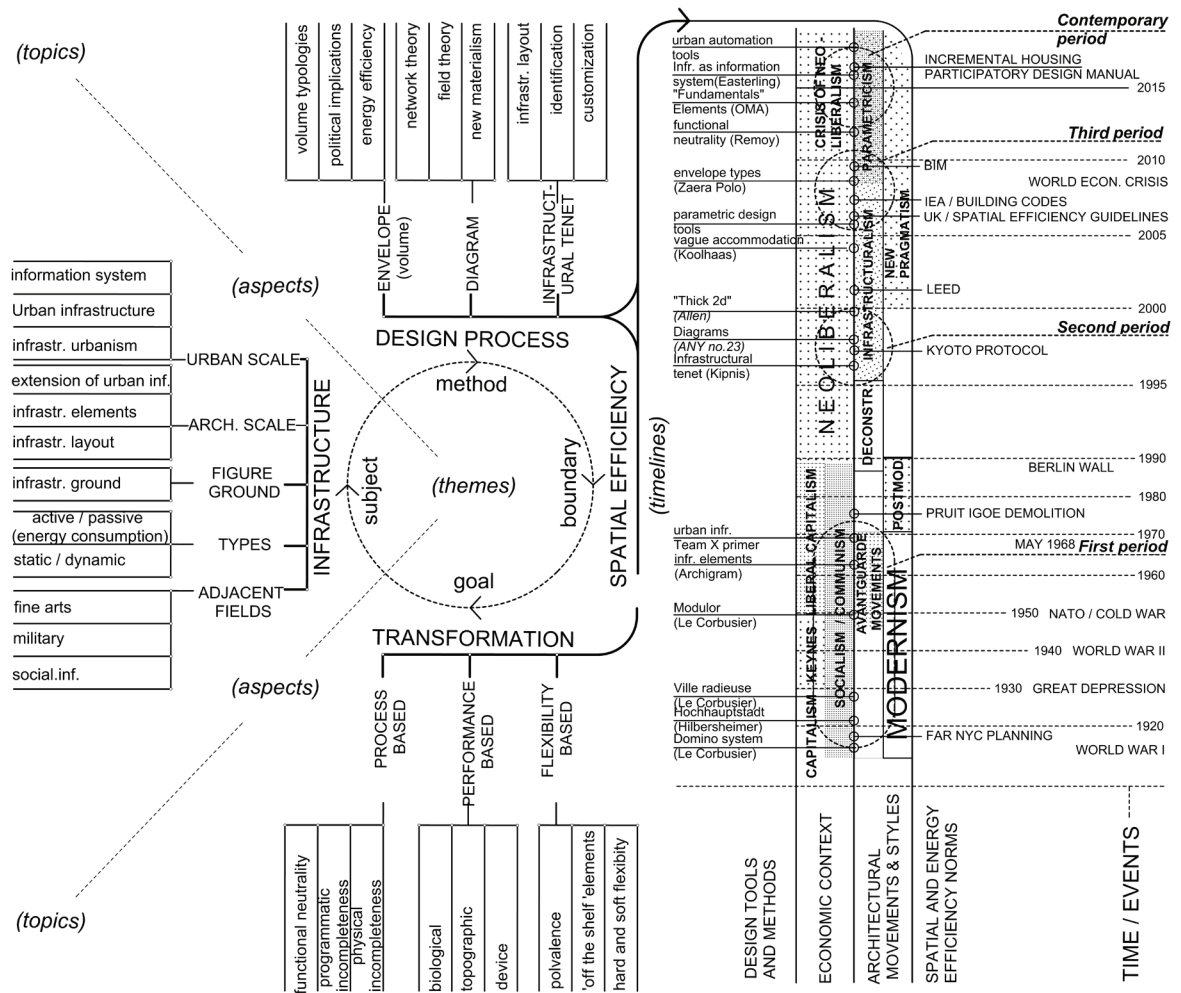


Fig. 1. – Chronological discursive map / Сл. 1. – Хронолошка дискурзивна мапа

For this, the theoretical part of the research, several methods have been used to bring the topic of infrastructure to an architectural scale. The research started with the analysis and systematization of sources, using a chronological discursive map as a graphical engine that organized the scope of the research through four branches: 1) infrastructure (subject), 2) design process (method), 3) spatial efficiency (boundary), 4) and transformation (goal). Branches related to the design process and spatial efficiency are merged into one theoretical segment and elaborated through multi-variational analysis of the historical context (Figure 1), while the other two segments related to infrastructure and transformation are elaborated through the procedures of critical analysis and selection and logical argumentation (Fig.1).

The contributions this paper is aiming to provide consider: (1) understanding infrastructures on the scale of architectural compositions, (2) identifying the inter-relations between evolving socio-economic context and the design process, and (3) positioning infrastructural tenets as a design methodology that enables programmatic transformations following the models of flexibility, performativity and process.

## INFRASTRUCTURE – FROM URBAN TOWARDS ARCHITECTURAL COMPOSITION

The term infrastructure as a global phenomenon in urban space is theorized by Kwinter (2000), who considers infrastructure as “every aspect of technology and rational administration which regulates life”. Infrastructure space is discussed on a global, territorial and city scale by Easterling (2014). In her opinion, infrastructure space is an informational medium – an operative system that shapes a city. Easterling claims that active forms of space in infrastructure have substituted aesthetic ones, and the design of an infrastructure space is based on the disposition determined by the actor himself. For her, architecture has been dead and had no influence for a long time, but it could be reincarnated by disposing and managing information within the infrastructure space of the global city. The question of infrastructure in the field of urban design was never the subject of theoretical discussion until the big interventions on the reconstruction of European cities such as Barcelona (Cerdà, 1858) and Paris (Haussmann, 1870). After the period of industrialization, infrastructure became an important factor in the urban planning of modern cities, which can be illustrated by the urban proposals of Le Corbusier and Hilbersheimer.

In the late modern after-war period in 1958, Yona Friedman, with the *GEAM* group, presented the concept of spatial urbanism, aiming to achieve the maximum freedom of inhabitants within a stable infrastructure (Busbea, 2007).

A decade later *urban infrastructure* as a term was introduced into architectural theory as a title for one of the chapters in *TEAM X Primer* (Smithson, 1968). The Smithsons offer a set of recommendations by means of several points, some of which consider new infrastructural approaches, both for urban and architectural design. The first of these aims “to develop the road and communications systems as the urban infrastructure” and “to realize the implication of flow and movement in the architecture itself” (ibid., 1968:48). The second aim is to “rethink accepted density patterns and location of functions in relation to the new means of communication” (ibid., 1968:48). The third aims “to understand and use the possibilities offered by *throw-away* technology, to create a new sort of environment with different cycles of change for different functions” (ibid., 1968:52) by employing the industry of mass-produced building elements to enable different life styles through a flexible plan which would follow the changing needs of families and users. The chapter ends with a quote from Van Eyck: “The time has come to conceive of architecture urbanistically and urbanism architecturally” (ibid., 1968:73).

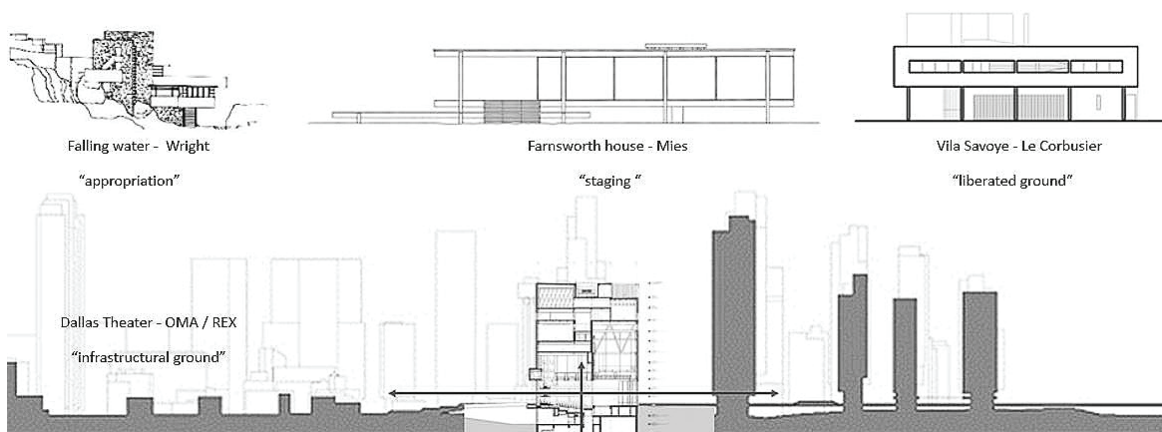
Many of the TEAM 10 recommendations and speculations of Archigram, Archizoom, Metabolists and others who worked towards mobility and flexibility were modified and partly integrated into architectural practice. As time has passed by, buildings have become more and more complex and technologically better equipped, while the infrastructures within the architectural composition have started to integrate both the program and the structure (Steiner, 2005). Hence, Banham famously asked if we actually need buildings or just the systems of service infrastructure (Banham, 1965). With the paradigm change and the rise of post-modernism, infrastructure was temporarily pushed out from the discourse of architectural design, until Allen revisited the topic in his essay “Infrastructural

Urbanism”, aiming to re-establish infrastructure as the subject of architectural design. He sees infrastructure as a possible way to instrumentalize the *diagram* as a methodological tool, in which an architectural object is considered a transformable category, both throughout the design process and during its use.

Infrastructures are flexible and anticipatory. They work with time and are open to change. By specifying what must be fixed and what is subject to change, they can be precise and indeterminate at the same time. They work through management and cultivation, changing slowly to adjust to changing conditions. They do not progress toward a predetermined state (as with master planning strategies), but are always evolving within a loose envelope of constraints. (Allen, 1999: 55)

Some years later, architect and theorist Gilles Delalex supports Allen’s findings and suggests the next step through establishing a direct connection between the urban and architectural scale. He sees architecture as an extension of urban infrastructure that also contains infrastructural elements in itself (Delalex, 2006). The observations that Delalex presents in his book are useful for formulating a new term which establishes a scalar connection between the urban and architectural scale – an infrastructural ground – a place of transition between urban and architectural infrastructures, but also an old/new *figure-ground* condition which can be connected with Allen’s understanding of field intensities – *a thick 2D*. The topic of *infrastructural ground* has recently been used by Jerković-Babović et al. (2020:36-39) as an indirect reference to Delalex, to explain the “loss of physical and perceptual boundaries between architecture and infrastructure”, exemplified mostly with projects as *spaces of flow* (such as transport terminals, concert halls and sports venues), where this blend is formally obvious. In contrast, this research addresses more conventional building typologies where the boundary may still be perceptually present. Every architectural composition appropriates urban flows and infrastructures, and infrastructural ground is its expanded ground zone - much more than the ground level, a zone that

Fig.2. – Infrastructural ground / Сл.2. – Инфраструктурно тло



multiplies the flows and intensities of use through its volume, which becomes a manifestation of ground capacities indexed through urban parameters and zoning laws (Fig. 2).

The impact of infrastructure is well illustrated by Koolhaas in the essay "Junkspace", in which he claims that capitalism has appropriated all the scientific, technological and design achievements of modern architecture. According to him, it is infrastructure that has enabled junk-space which is "...a product of the encounter of escalator and air-conditioning" (Koolhaas, 2004: 162), an enclosed space of consummation based on a hidden structure and infrastructure and exposed decoration and finish.

Kipnis is maybe Koolhaas's first critic to understand the intention to liberate architecture from all the unnecessary ingredients (style, language, decoration, appearance) and to welcome the intention that architecture should be completely based on its performativity and the elements that support it – space, structure and infrastructure. He observes that Koolhaas imported urban infrastructure inside his buildings in a set of projects: Tate, Jussieu, Miami and Cardiff opera (Kipnis, 1996). He characterizes the OMA practice as driven with an infrastructural tenet (*ibid.*, p. 32), even claiming the existence of *infrastructuralism* as a left-wing architectural agenda which tries to maximize and provide accessibility to the *event-structure* for the maximum amount of people. Contrary to this, Kipnis talks about the other – the right-wing stream of *new minimalism*, whose reductivist approach to design seeks the best visual and sensory effects of architecture that can often be seen in architectural photography in which no people are present.

After the Venice Biennale in 2014, Koolhaas and OMA published *Elements*, in which almost all the elaborated elements of architecture were essentially infrastructural elements (Fig.3). The publication's intention was to remind us that in the epoch of permanent crisis and growing social inequality, we can only rely on proven achievements, and many of them have not been adequately incorporated into architectural theory but have been radically changing architectural practice for a long time.

#### EVOLUTION OF THE DESIGN PROCESS AND CONCEPTIONS OF INFRASTRUCTURE

The second chapter elaborates the four historical periods and the interconnected relationships between infrastructure, architectural movement and design process methodologies on one hand, and the impact that socio-economic circumstances have on developing rules, regulations and spatial and energy efficiency guidelines on the other.

#### First period, 1914-1989. The rise of liberal capitalism: Modern movement and the tight-fit plan

In 1914 and 1915 Le Corbusier presented *the Domino system* which, together with the mass implementation of the automatic elevator, established itself as a tool that boosted the start of mass production of multi-storey buildings. Not long afterwards, in New York in 1917, a new urbanistic parameter was set – *FAR (floor area ratio)*, by regulating the maximum build-up, as the perception of Manhattan had changed, almost as depicted in the drawings of Hugh Ferriss from 1919 (Koolhaas, 1978).

Fig. 3: OMA - *Elements* at Venice Biennale 2014. / Сл. 3: OMA- *Элементи* на Венецијанском биеналу 2014.



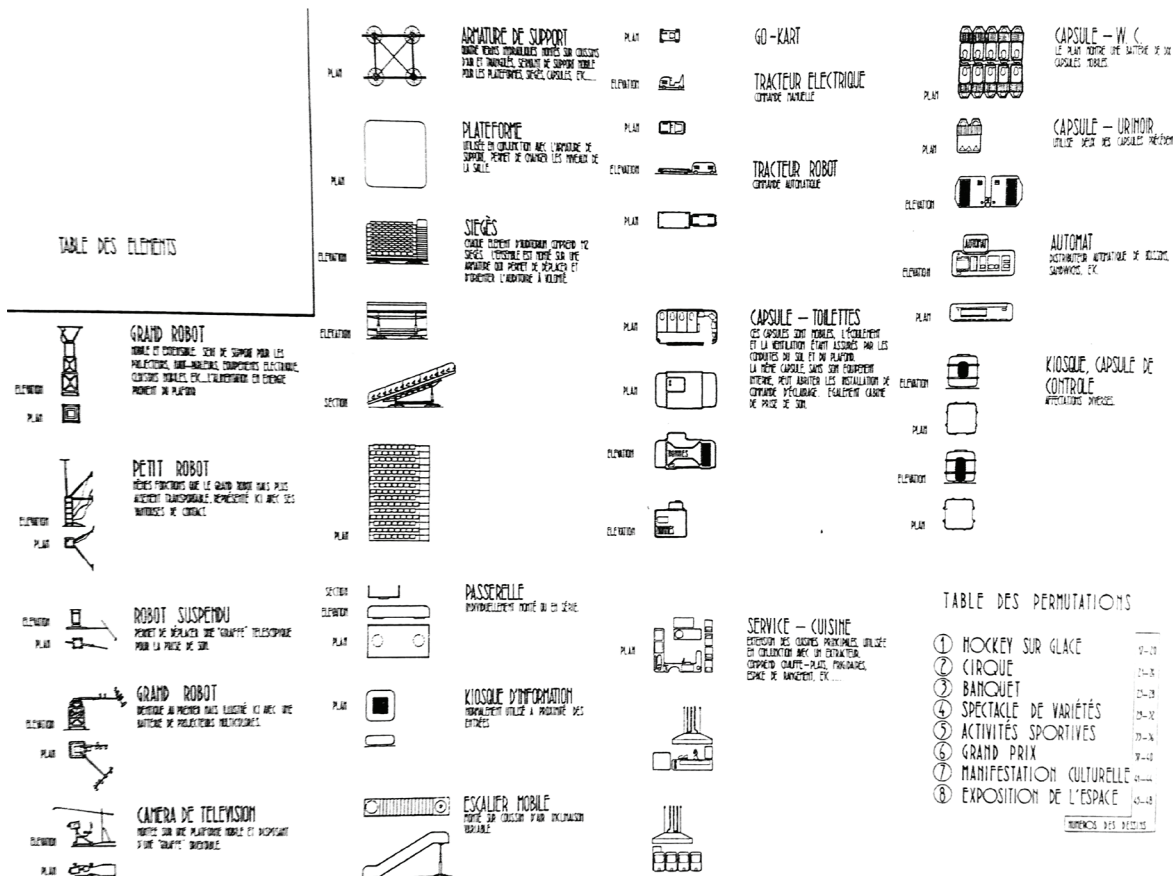


Fig. 4: Archigram - Monaco Entertainment center, catalogue of elements / Сл. 4: Архиграм – Центар забаве у Монаку, каталог елемената

The FAR parameter, combined with plot occupancy, is still today the starting criterion in real estate investment. The fast implementation of the Domino system through western metropolitan cities in the post-war reconstruction period launched new solutions in urban design throughout the plans of Le Corbusier and Hilbersheimer, so infrastructure found a new domain after the period of industrialization, in which it had mainly been an engineering subject. The period after the Great Depression was marked by Keynesian economic discourse, which had the same ideological roots as modern architecture (Tafuri, 1980). In *Ville Contemporaine* (1925), Le Corbusier anticipated a programmatic division: *City*, *Industrial City* and *Garden City* (Corbusier, 1971), while in Hilbersheimer's *Hochhauptstadt* (1924) this division does not exist and the city is considered to be developed programmatically and heterogeneously through the interaction of urban infrastructure that supports the non-typological generic block. In the time of mass production, it was Corbusier's model that prevailed, with the typologically zoned *top-down* design process and the tight-fit model of spatial efficiency which did not leave a lot of possibilities for change within the architectural composition.

After the Second World War, Le Corbusier published *Modular*, as a base for the new upcoming period of regeneration and mass-produced housing, which was followed by the prefab technologies and regulation which standardized most of the typologically determined building elements. At the beginning of the '60s, mass architectural production became oversaturated, so new avant-garde groups like *Archigram*

protested that new architecture still aims at durability and suggested an ephemeral and disposable concept which uses "off the shelf elements" which followed the current tendencies in the rise of consumerist society in liberal capitalist countries (Steiner, 2005). Not long after, *Archigram* published a project for an amusement center in Monte Carlo in 1969 (Fig. 4), with a first catalogue of infrastructural components which aimed to be a tool to achieve the maximum flexibility, changeability and vitality of the project, a first step towards conceiving an infrastructure supported transformable space.

### Second period, 1989-2000. The fall of the Berlin Wall: New pragmatism/Diagrams and Loose-fit plans

As the Berlin Wall fell down, the victorious euphoria of the neo-liberal economic model at first brought the expansion of worldwide construction and a boom in the real estate market, but also the first environmental consequences manifested by global warming. So, it was the first limitation that followed the massive expansion in 1997 after the Kyoto protocol had been adopted.

For architecture this implied a big turn towards the optimization of buildings on one hand, and on the other fast changes in society caused by the rapid development of information technologies creating a necessity to introduce transformable potential into buildings. A discourse which considers the inclusion of new information flows into architectural design began in the early '90s and culminated in 1998 in a series of essays published in

*ANY magazine* No.23, titled “Data Mechanics for a topological age”, which was almost entirely dedicated to diagrams as new design tools (this discourse has been named as a whole movement - *new pragmatism* (Lefebvre, 2017)). Allen explains that in the context of an architectural object, the performativity effects are just as important as its permanent existence, and that the diagram therefore represents a “graphical assemblage that specifies relationships between activity and form, organizing the structure and distribution of functions” (Allen, 1998). He characterizes diagrammatic architecture as a *loose-fit* relation of program and form channeled but not constrained by the architectural envelope.

After a sufficient length of time and the market already oversaturated with different interpretations of diagrams, morphogenesis and topological form, Bruno Latour and Albena Yaneva (2005) highlight that the information communicated throughout the graphic space, using contemporary computational 3D tools is not essentially richer than the Renaissance perspective. They consider an architectural object to be a moving project, a process with transformative potentials, which we are aware of, but unable to predict or manage. They raised the question of incorporating the ever changing and complex social, economic, political and other relations into the graphic space which they considered to be a “space in which buildings are drawn on paper but not the environment in which buildings are built - and even less the world in which they are lived” (Latour and Yaneva, 2005). They recognized that a large part of architectural production is driven by parameters that imply incorporating the ability for changes and transformation during the design process, but a final result often remains only the frozen image of that process.

In the essay “Field Conditions” Allen analyzes the changes within architectural objects together with the changes in the urban context as a wider field, suggesting the city’s infrastructural elements to be organized and shaped as open networks, as the most obvious examples of such a field. Allen offers several guidelines, which we can understand through examples from architectural practice. First, using the field example he re-defines the figure-ground relation, translating it through punctual and regional changes of densities and intensities, resulting in a thickened surface *a thick 2D* (Allen, 1999).

The organizational principles which Allen proposes suggest redefining the *parts*, and having alternative ways of understanding their inter-relationships in the design context, which means that if we design within a “directed field condition connected to the city or the landscape, a space is left for the tactical improvisation for future users, therefore a *loose-fit* is proposed between activity and enclosing envelope” (*ibid.*, 1999: 102.)

Diagrams were established as a design model, which promised to become the main tool that organizes an architectural composition and regulates the relation between the activity and form by organizing structure and function (Allen). The diagram also organizes the infrastructure that supports a loose fit plan which promises transformation and flexibility. However,

the architectural production that followed this model proved to be quite static in most cases (Latour and Yaneva), while a loose fit was possible only within field conditions (and a lot of available space in a plan), and therefore not applicable for most typologies emerging in cities.

### **Third period, World economic crisis 2008–2012: Parametricism, integral planning and spatial efficiency – a typical plan**

After the real estate boom and intensive construction in the '90s, architecture developed with the aid of advanced CAD tools and parametric design. The world economic crisis dramatically reduced hopes about the mass-market driven production of space financed by loans and unlimited expenditure of money, goods and energy. The consciousness about energy consumption, which had already previously been institutionalized, first through LEED standards before the crisis, was confirmed by “Energy efficiency requirements in building codes, energy efficiency policies for new buildings” (IEA, 2008). This consciousness influenced the optimization of the overall planning approach by introducing the new concept of integral planning enabled by the emerging network society. Energy efficiency standards were followed by the standards of spatial efficiency which supported the claim that “in the free market architecture equals real estate” (Koolhaas, 2003). In 2008, the first year of the crisis, Patrick Schumacher published an essay to promote a new style – *Parametricism*, which is based on a premise which treats all the elements of design as parametrically changeable and mutually adjustable. Schumacher claimed that this approach can be applied on all scales – from the city to furniture. In his later essay “Free market urbanism” Schumacher draws a connection between *parametricist* design methodology and the free market, whose self-organizing principles should define the most productive mixtures, and maximize the value and use of land. Douglas Spencer compares Schumacher’s standpoint on the social order with the natural processes of selection and self-organization, so to him the function of architecture that follows this standpoint is a “production of endlessly flexible environments for infinitely adaptable subjects” (Spencer, 2016: 4). Flexible space in neo-liberalism obtains new meaning by erasing borders between work, living, rest, education and entrepreneurship (*ibid.*, 2016), consumer culture and products, which results in the return of the typical plan that emerged in '70s office buildings in the US, which has become trans-typological in the new context. In the essay “The Politics of the Envelope: a political critique to materialism” Zaera Polo (2008) examines the relations between activities and the envelope typologies by elaborating their typical plans in a new neo-liberal context. He creates a polygon in which relations are drawn between architectural technologies on one hand and their social, economic and political implications on the other. By classifying and analyzing types of architectural envelope, the expected infrastructural elements are suggested according to the envelope typology, depending on the technical and political implications of its proportions, context and environmental characteristics. Four types of volumes are set as a framework



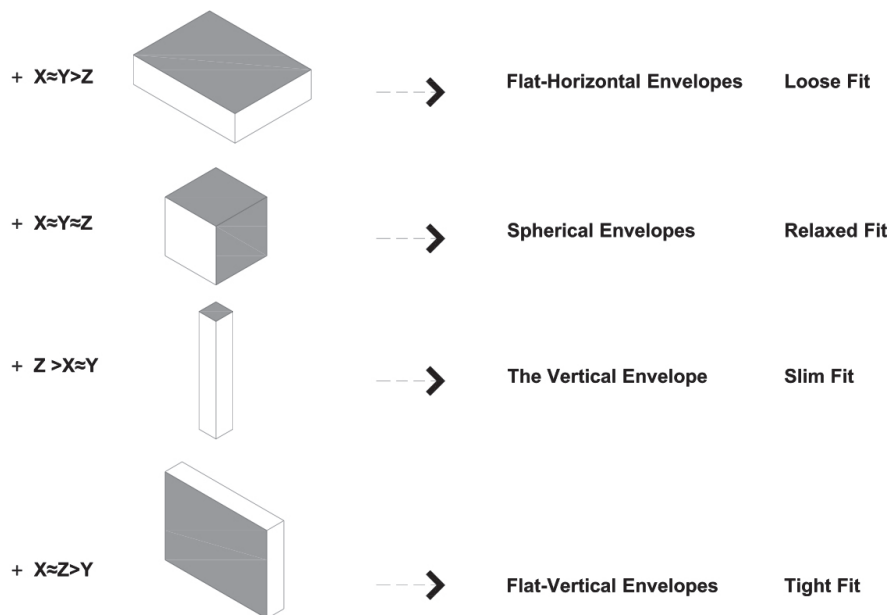


Fig. 5: Volumetric typologies – Zaera Polo / Сл.5: Типологије волумена по Заера Полу

which can be (but not necessarily) read programmatically: *flat horizontal*  $X=Y>Z$  (malls, factories – loose-fit); *spherical*  $X=Y=Z$  (HQs, public buildings-relaxed fit); *flat vertical* – tight-fit  $X=Z < Y$  (housing slabs); *vertical slim fit*  $Z > X=Y$  (office highrise) (Zaera Polo, 2008) (Fig.5). This classification will later serve as a framework for the case studies because it is expected that each type will bear its own specificities in the distribution of infrastructure.

With omnipresent free market urbanism (Schumacher), in which architecture equals real estate (Koolhaas), the necessity for program flexibility culminates in borders being erased between human activities (Spencer). In the free market, the necessity for spatial efficiency and the constraints of zoning laws determine the envelope (volume) typologies resulting in the return of typical plans related to them (Zaera Polo). This proves that the building environment is not endlessly flexible, as proposed by Schumacher, but instead it has a scope of flexibility determined by the volume typologies of buildings and their infrastructural capacities.

### Contemporary period: Process based architecture – bottom-up plan

Since the '60s and '70s, participative art has been developing, inspired by the writings of Walter Benjamin and promoted by Guy Debord and the Situationist International, who envisioned the audience to be actively engaged in the creative process as a co-author and not merely an observer (Bishop, 2006). Lately, the participative model with an empowered social infrastructure has been moved from artistic circles towards architecture and urbanism through official government channels, the NGO sector, PPPs and other types of initiatives.

In the architectural production of neo-liberalism, participation represents a method which gives the system necessary and important feedback information, such as customer feedback in online sales. It is more optimization than innovation,

which can be illustrated through co-working and co-living concepts currently being developed worldwide by the *WeWork* Corporation. Still, the method of collaborative design and a bottom-up design approach have developed new concepts. An example is the incremental social housing projects by *Alejandro Aravena* that are based on the redistribution of urban infrastructure and the careful planning of housing infrastructure with respect to future needs and expansion plans of the end-users, i.e., the investors. On the other hand, we can observe the necessity for projective design for functionally neutral buildings designed also in a *bottom-up* fashion that can sustain programmatic changes. Changes within architectural objects are problematic in general, since reconstructions where reprogramming happens are rare and most often not feasible on a larger scale for various reasons: legal (ownership structure, zoning laws), economic (lack of profitability, so an increase of surface area is always needed), or infrastructural (lack of infrastructural capacities, or an unsuitable and not upgradeable infrastructural layout). It is assumed that the collaborative and bottom-up design approach can be based on infrastructural tenets which include several methodological steps: identification, customization, and infrastructure layouts guided by the projective plan of their functioning (that includes possible transformations). To apply this approach in universal practice it would probably be necessary to enable flexible reading of existing norms, regulations, legislation and urban parameters.

### TRANSFORMATIONAL STRATEGIES: FLEXIBILITY, PERFORMATIVITY AND PROCESS

This theoretical segment gathers the transformational concepts defined in architectural theory, aiming to show the ways the concept of transformation has been changing following the strategies of flexibility, performativity and process (Figure 6), and to determine the role of infrastructure within these strategies.

## Transformational strategies - flexibility

The flexibility concept is usually first discussed together with adaptability. Both terms were set by *Rabeneck, Sheppard and Town*, who criticized housing practice, which at the time was based on tight-fit functionalism. They stressed the importance of careful choices of structure and building techniques and the distribution of services and installations (Rabeneck et al., 1974). This was a subject from decades earlier through the work of Archigram, elaborated by Hadas Steiner, who offers a critical analysis of *Archigram magazine* No.3, "Expandability". *Archigram* promoted leaving the traditions of durable architecture by presenting an array of service (infrastructural) elements developed through projects of the epoch (Fuller, Smithsons and others), which they believed could enable the individual autonomy of movement and spatial arrangements. Steiner identifies Archigram's key elements, presented in ascending order: service cores (*Bathrooms*), parts of prefabricated houses (*Bubbles*) and *Systems*. Then, she discusses the projects where these elements were implemented in the context of flexibility and adaptability. She concludes that using technologically sophisticated service elements did not have much impact, since the construction and the systematic prefabrications of late Modernism have integrated services into cores as a kind of a compositional typology, which have since then been even more connected to the permanent and fixed urban infrastructure of supply and disposal (Steiner, 2005). Herman Hertzberger, in his book *Lessons for Architecture students*, criticizes the existing takes on flexibility, claiming that "flexibility signifies – since there is no single solution better than the other – completely negating of the fixed" (Hertzberger, 1991a). Instead of flexibility, Hertzberger offers the term *polyvalence*. For him, changes are not a subject of uncertainty on which most of the existing concepts were based; he considers the process of change as a permanent and static factor, which implies a polyvalent form and can be subordinated with different uses without changing the form itself.

Schneider and Till's proposal is set around the theme of flexible housing and discusses the concept of flexibility from several aspects: modernism, finance, participation, sustainability and technology. They determine flexibility in two ways: "as a built in possibility for adaptation" whereby the house is equipped for different social uses, or "flexibility which anticipates different physical configurations". 20th century housing projects are discussed from the viewpoint of *determined and undetermined design* and identifying the usage of *hard and soft systems*. Soft systems allow uncertainty and freedom for users, whereas hard systems predict and allow certain future configurations (Till and Schneider, 2005:157-166). After classifying the design approaches, the authors also classify the technologies used for flexible housing as hard and soft systems. The hard systems are programmed to enable flexibility, such as skeletal infrastructures with provisional filling of the *open building* movement. Soft systems enable flexibility in ways which are not completely under the control of building techniques; they are secondary infrastructure systems such as the small service

cores that enable the movement of bathrooms and kitchens within a certain radius. Till and Schneider are more supportive towards using soft systems and technologies during the design of flexible housing, and they conclude that it is possible to use them on different scales of: a room, apartment or a building. Thus, in most cases the solution is not a technocratic one, but is largely dependent on the design strategy and manipulating the infrastructural elements in the design phase.

Following the evolution of the flexibility concept, it can be observed that the main problem is not the lack of determination of what the design aims to achieve, but the scale of transformation it promises and its technological dependency. Therefore, flexibility as a transformative strategy uses several standpoints that complement each other and are mainly design related: polyvalence offers static flexibility as much as possible (Hertzberger) as a basepoint, carefully planned structure is offered as a framework (Rabeneck et al.) with provisional infill (Till and Schneider), and the use of soft systems (Till and Schneider) is directed towards particular operations.

## Transformational strategies - performativity

Since the turn of the millennium, and as digital technologies have become omnipresent in architectural design, a discourse about performative architecture has emerged in architectural theory, relying on the discourse of algorithmic and parametric design which dominated the '90s. Performativity is the central subjects in the book *Performative architecture beyond instrumentality* (ed. Branko Kolarevic, 2005), and we can understand it by using the two paradigms offered by David Leatherbarrow:

*Device paradigm* – anticipates an object with movable parts (mechanically or manually operated), and the position and the time lapse between usages define the role of a certain device. The success of this paradigm depends on the capacities and possibilities to adjust the device in relation to foreseen and unforeseen circumstances. The adaptability strategy is judged to be a first step towards performative architecture.

*Topographical paradigm* - focuses on the parts of the building that provide its static equilibrium, such as structural, thermal or material stability. The work that a building performs is measured with the effort needed to sustain the economy of the balance achieved while performing its role. The change in this case does not anticipate a change of position, but rather a change of condition. The relation between action and reaction results in a change in the physical body of the building, which demonstrates its capacities to react to different ambient conditions (Leatherbarrow, 2005:18).

After Leatherbarrow, it was Michael Hensel who suggested a new biological paradigm on performativity. He elaborates the work of Frei Otto as a pioneer in considering the biological influence of the environment on architectural objects. Hensel's work also relies on the writings of Banham, who proposes a thesis that the interior space of an object is inseparable from the environment where it is located, since for him the environment is considered an active agent rather than a passive context. He

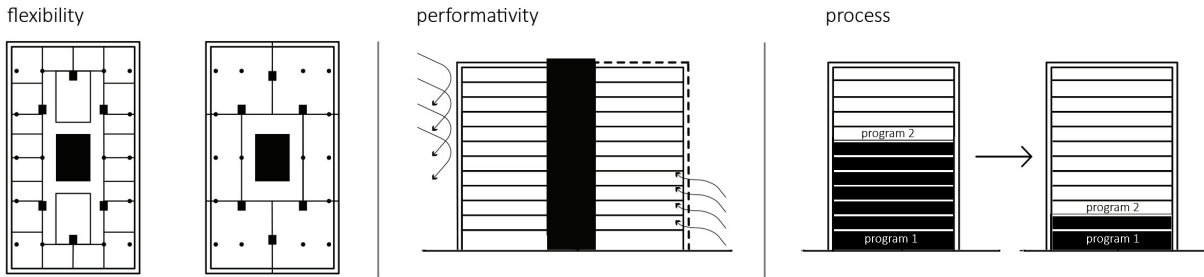


Fig. 6: Transformational strategies (illustration): flexibility, performativity, process / Сл.6: Стратегије трансформације (илустрација): флексибилност, перформативност, процес

claims that performative architecture can be positioned at the intersection of four domains: subject (inhabitant), environment, and complexes of spatial and material organization. Hensel embraces the work of Leatherbarrow, agreeing that the principles of performativity must be sought within the boundaries of the interaction between an object and the environment, rejecting the device paradigm as too technology dependent. He interprets the topographic paradigm as a way to integrate the environmental influences on a building as a material object which does not fight against the environment. Instead, it blends with it, taking the changes in environmental conditions as permanent (like the polyvalent spaces of Hertzberger). Directions for further research to follow the biological paradigm which Hensel suggests are: analyzing the passive approach to environmental developments throughout the architecture of pre-industrial times, and examining old/new design methods such as form finding and the material behavioral influence of biology and ecology.

The relation between objects and the environment which Leatherbarrow and Hensel talked about can be interpreted through the prism of the neo-liberal context in Koolhaas' *Junkspace*, in which infrastructure is a performative instrument that generates a new separate environment:

Junkspace exploits any invention that enables expansion, deploys the infrastructure of seamlessness: escalator, air-conditioning, sprinkler, fire shutter, hot-air curtain ... Because it costs money, is no longer free, conditioned space inevitably becomes conditional space; sooner or later all conditional space turns into Junkspace ... (Koolhaas, 2003:162)

The latter claim indirectly, but very clearly, suggests the possible classification of infrastructure systems as tools for interaction with the environment (or against it): 1) Passive systems – do not spend energy and money, these are one-off costs during construction, such as: staircases, corridors, atria, light catchers, natural vent systems. These are applied mainly in the public zones of the building (those which do not generate profit); 2) Active systems – spend energy and money, moreover their constant activity includes constant energy spending, so they are mostly introduced in the spaces for lease that can provide direct or indirect income – no matter whether they are public, private or privatized, these can be: HVAC system, lifts, escalators, travellers, air-curtains and others.

Performativity, unlike the other two strategies presented in this chapter, does not deal with any physical and programmatic transformation, instead it deals with infrastructure that mediates the changing relations mainly between the building and the environment (outside), or user comfort (inside). Therefore, Koolhaas' statement can be understood in the sense that all three paradigms need to complement each other with respect to the particular program section of the building using an active or passive approach.

### Transformational strategies – unfinished architecture, a process strategy

A significant portion of architectural objects which were built since the beginning of the Third millennium are in a way only partly finished. After being built, their program or physical structure changes over time. When presenting "Inertness modified", Koolhaas (2003) suggests that today's production of space, enabled by the domino system, is a homogenous structure able to receive non-specific and variable programs which imply flexibility, even before being first deployed. The expression vague accommodation, which works together with the typical plan, is an important term suggesting unfinishedness and non-specificity, because in the context of the neo-liberal free market, spaces are less defined by the architect, and more often by the clients, operators and tenants, who complete most of the interior spaces by themselves by doing so-called fit-outs. In housing projects, finished apartments are less and less popular and are being replaced by infrastructurally equipped volumes. Public and communal spaces have been left to be designed by architects, together with the infrastructure layouts of private/leasable spaces, which have been redirected towards consulting engineers (civil, MEP, fire engineers and others). In the context of infrastructure, we can identify this situation as a type of programmatic incompleteness which anticipates developing a technical system of infrastructure that can cover multiple (often similar) programs which, although not determined yet, can be supported.

The second type of incompleteness is a physical one that anticipates the possibility of a physical change and expansion of a structure, which was proposed in the '60s in projects like Plugin city and Spatial city, which were conceived as infra-mega structural systems. This approach was first implemented by Hertzberger for Diagoon housing projects in Delft in 1978, where he offered a naked structure to inhabitants and allowed them to define their apartments themselves, and to partially

participate in the architectural design process as well. Besides the character of the open structure, these houses did not allow unlimited combinations, but offered a space frame and an indication of the possible configuration – a productive tension between the aim of the architect and the user’s control (Hertzberger, 1991, b). Aravena’s incremental housing projects work on similar principles, but through more advanced process of defining the necessary infrastructures as building portions, together with the community of clients – the end users. Aravena’s projects prove that the process defining the optimal use of building infrastructure depends on a multitude of context-related factors: natural, social, economic and cultural, hence the activities that the designers claim to predict and plan need infrastructure adapted to the context and the changes performed within it.

The concept of functional neutrality (Remoy and Van der Voord, 2014) can be also considered as based on a process strategy It anticipates that buildings could be built to have the integrated possibility of changing the program; However, obstacles to this are that the cost of that possibility is carried by the first owner, while the benefits would go to the future owner, therefore this model could be applicable for actors who want to own and maintain a building for a long time, such as governmental organizations, pension funds and rental-oriented real estate developers.

This overview presented the possible understandings of unfinished architecture in a physical, but more often a in programmatic way, which corresponds to the concepts of vague accommodations and functional neutrality. As all concepts are oriented towards designing a process of building exploitation, unfinished architecture, they should be designed using a process strategy based on planning and designing infrastructure with respect to the current and the future needs of the users and clients (individual or corporate), preferably included from the very beginning.

#### INFRASTRUCTURE – FROM A GROUND CONDITION TO A DESIGN TENET

The current research of the theoretical background and framework on the role of infrastructure in an architectural composition has resulted in two findings: a theoretical one in which “infrastructural ground” is introduced as a new term, and a methodological one highlighting “infrastructural tenets”. As the scope of work of the architect generally revolves around the connections between the urban and architectural scale, the new term connects these two scales – infrastructural ground. This term integrates the theoretical positions of Allen, Delalex and Kipnis: as an understanding of the field intensities – a thick

Tab. 1: Evolutionary periods of the design process vs. infrastructure / Таб.1: Еволутивни периоди процеса пројектовања у односу на инфраструктуру

Period	Economic context	Norms & Policies	Typical plan
Modern period 1900 -1989	Liberal capitalism Keynesianism	FAR (Floor area ratio)	Tight - fit plan
New pragmatism 1989 - 2000	Neoliberalism	Kyoto protocol LEED	Loose - fit plan
Parametricism 2008 - 2015	World economic crisis	IEA Int.en.effic.build code Spatial efficiency guidelines	Slim - fit
Contemporary period 2015 -	Crisis of neoliberalism	BIM Implemented into building codes	Process plan Functionally neutral plan

Tab. 2: Transformational strategies matrix / Таб.2: Матрица трансформационских стратегија

Typical plan	Volume Envelope typology	Program related transf.	Transformation strategy
Tight - fit plan	Flat vertical (slab)	Reconfiguration	Flexibility
Relaxed - fit plan Loose - fit plan	Spherical (cube) Flat Horizontal	Reprogramming Intensification	Polivalence, Flexibility
Slim - fit	Vertical	Reprogramming Reconfiguration	Performativity
Process plan Functionally neutral plan	All typologies	Expansion, Reconfig. Reprogram. Intensification	Process strategies Functional neutrality

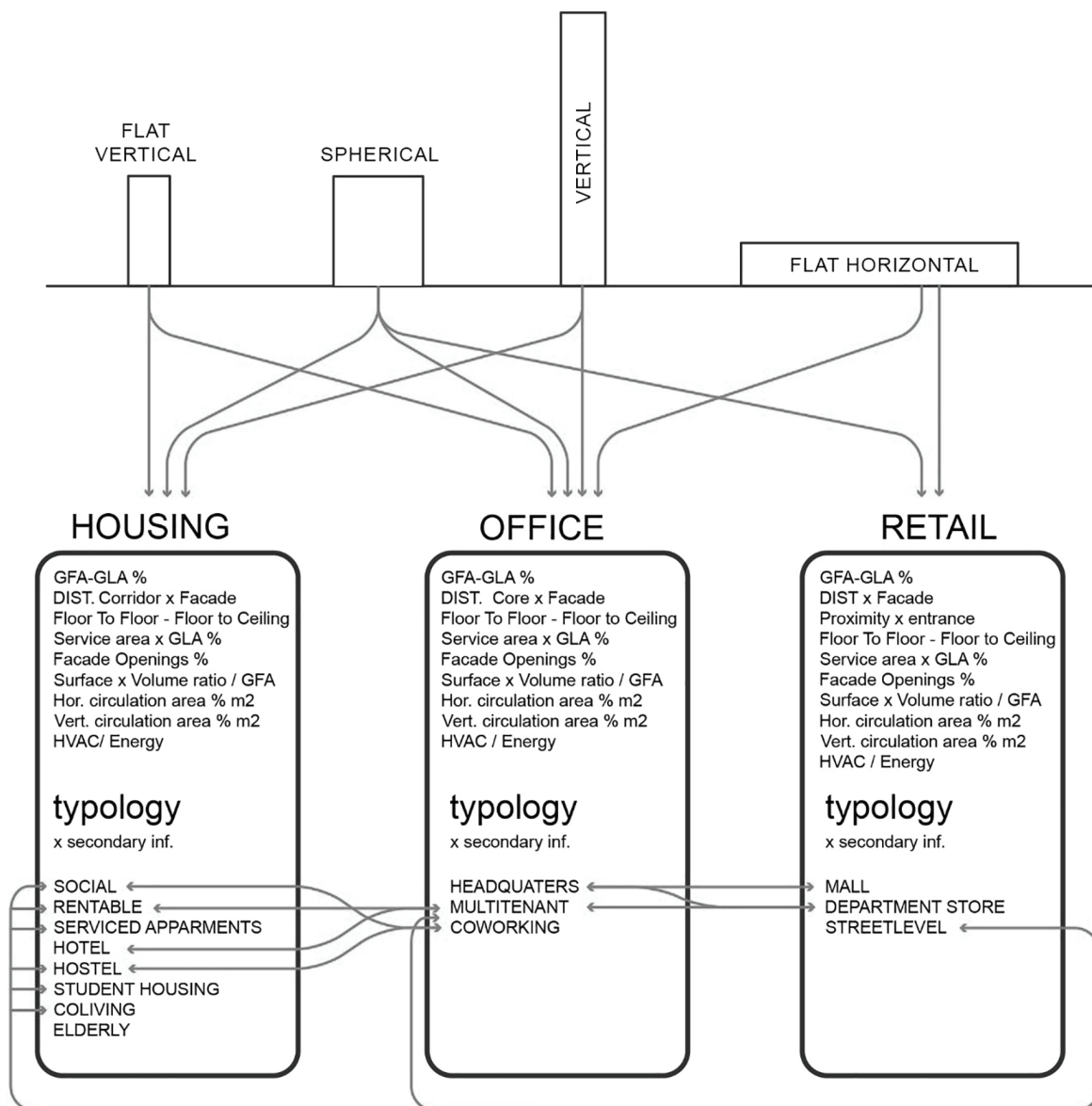


Fig.7: Program typologies vs. Volume typologies / Сп.7: Однос програмских и волуметријских типологија

2D (Allen), and as an extension of the urban infrastructure in the building (Delalex, Kipnis). Infrastructural ground is a figure-ground condition which considers the plot area of a building, a space where the capacities of urban infrastructures provided by the city converge into the architectural composition, determining its potentials and boundaries, including the scope of its possible future transformations.

During the process of research, it became evident that an infrastructural tenet is actually not a singular methodological procedure as Kipnis presented it. There are actually multiple tenets as sets, aiming towards different performative effects and sometimes even transformational outcomes. Infrastructural tenets integrate infrastructural ground and infrastructural elements, both in terms of the object positioning and infrastructural ground condition, and in terms of the distribution of infrastructural elements within the architectural envelope as layouts that organize an architectural composition, together with its possible future transformations.

Infrastructural tenets are not something essentially new. They have been evolving with the development of professional technology and the economy. A comparative historical analysis shows that each of the historical periods, marked by an economic discourse, have brought new understandings of the typical plan, not as a reaction to a previous style, but rather to the changes and crises in the socio-economic sphere, and these are followed by changes in norms and legislation. The evolution of typical plans influences the conception, evaluation, and distribution of infrastructure. This anticipates, as the technology advances, a permanent inclusion of the new and rethinking the existing infrastructural elements and their layouts (Tab.1).

The aforementioned plans do not necessarily relate to programs. Rather, they relate to envelope (volume) typologies, which were used as a framework to define the transformational possibilities, strategies and capacities and the infrastructural tenets that will organize the composition capable of performing these changes (Tab.2).

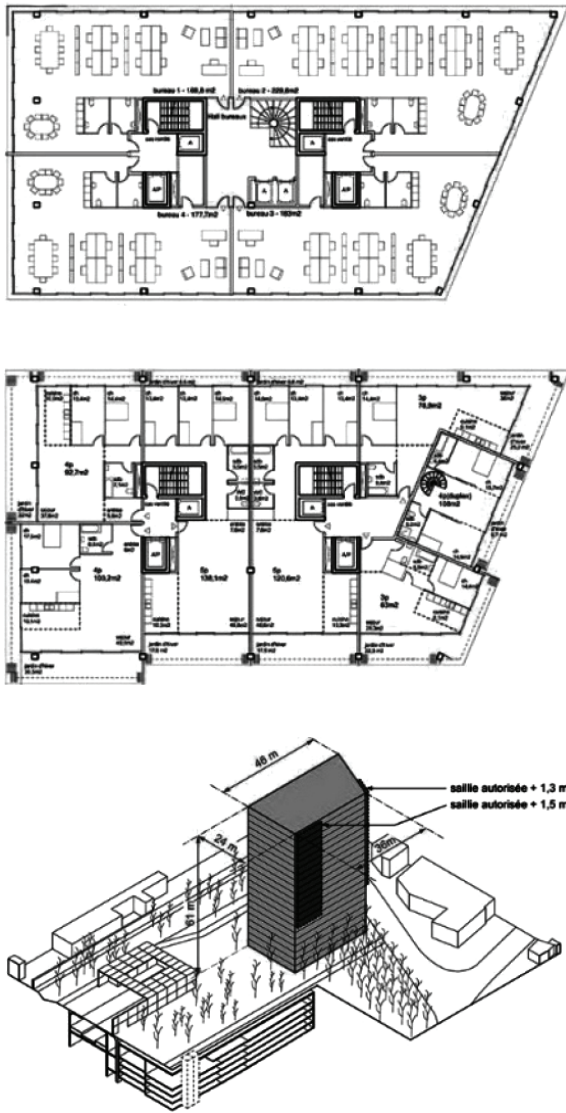


Fig.8: Typical plans for Tour Opale, Geneva, Lacaton & Vassal  
 Сл.8: Типске основе за Кулу Опал, Женева, Лакатон и Васал

Both the envelope (volume) and program typologies of a building will imply different possible models of programmatic transformations such as: reconfiguring, reprogramming, intensifying, expanding, conditioning, and sometimes several models at the same time. In this respect, the following design strategies are defined to achieve these programmatic transformations: flexibility (and polyvalence), performativity and a process strategy based on unfinishedness, which carries the possibility of integrating the previous ones.

The choice of a transformational strategy (with respect to the intended model of change) depends on the program and envelope typologies that determine a project specific infrastructural tenet – the layout of infrastructural elements. This layout is to be located and quantified using basic spatial efficiency parameters and indicators. A theoretical matrix has been established for four volumetric typologies, and three dominant program typologies followed by a list of basic spatial efficiency parameters to loosely describe their infrastructural layouts (Fig. 7). The directions of possible transformations

are drawn between programs and volumes with respect to the possibility of similar indications on the spatial efficiency parameters.

Further research will try to address the issue of programmatic transformation, both during the planning, design and development of a building and after its completion. This will be done using multiple case studies chosen according to the scope of two programs within a one-volume typology, with the goal of indicating the infrastructural layout which works in the best possible way for both programs, therefore making the building functionally neutral or ready for mixed use. This kind of strategy can be exemplified by the recent vertical mixed use project Tour Opale (Geneve, 2020) by Lacaton & Vassal (Figure 8), in which the two programs use a floor plate of the same size and structural grid. The large depth suitable for office floors is reduced on housing floors with balconies and winter gardens. Both programs use the same cores for evacuation and installations, while the lower positioned office floors use the provisional independent vertical communications for access. This infrastructural layout enables flexible programming and could be a base for an easy increase/decrease of housing or office portions of the building if that is ever needed since this building is for rent and owned by one corporate owner (Swiss Railway Company).

This paper has tried to establish infrastructure as a driving engine of contemporary architectural composition, oriented towards programmatic transformation (section 1). By following different design models (section 2), it has shown that the role of infrastructure is being customized to evolving economic and spatial constraints, in order to achieve the most from the space available, using evolving plan models: from tight fit to loose fit, typical or functionally neutral (process based) plans (Hypothesis 1). One of the main conclusions that all the transformational strategies analyzed (section 2) are infrastructure based. As they evolve, they do not substitute the previous ones but rather expand and become more precise and typology related. Contemporary architectural composition is based on infrastructural tenets which are typologically determined to fit with its volume type and possible “program range”, and organized with its infrastructural layouts and suitable transformational strategies (Hypothesis 2).

Buildings are built in space, but are exploited in time, a dimension that should be addressed more and more due to unstable market demands and the ever-changing needs and habits of end-users, both businesses and individuals. This segment of the research concludes with an approach towards greater, but pragmatic, program transformability within the prospective envelope (volume) typology defined by the urban parameters. Therefore, it is the role of architects and investors to define together the process and the desired scope of the program transformation of functionally neutral buildings, whose architectural composition will be driven by infrastructural tenets.

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