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ROLE OF BUILT HERITAGE IN 20TH CENTURY PLANNING AND DEVELOPMENT OF EUROCENTRIC URBAN AREAS

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Abstract. *Built heritage preservation and town and regional planning emerged on scientific bases in the process which lasted until the late 20th century. The role of built heritage in town and regional planning has essentially changed in that time. It can be partly explained by developing of scientific methodology of each of the disciplines, and partly by global changes and subsequently emerging challenges.*

Key words: *built heritage, town and regional planning, sustainability, socio-economic development*

1. INTRODUCTION

The urban planning and heritage preservation were founded on the essentially different paradigms, the first one turned to prospects of development, and the later to preservation of historical values. The development of theoretical principles and scientific methodology which are important for both of them and for the process of a harmonization of interdisciplinary collaboration lasted until the end of 20th c. The indications of pro-scientific development appeared in the 18th c, and then the process gradually accelerated towards the second half of the 19th c, and furthermore during the 20th c. The discourse on historical role of immobile cultural heritage in the 20th c planning of urban development requires comprehension of the city planning and preservation of built heritage from their beginnings to modern scientific disciplines, and their gradual approximation to common goals. At the end of the 19th and the beginning of the 20th c, from the viewpoint of urban and regional planning, historical fabric represented the limitation and disturbance of accelerating urbanization. Such attitude was commonly accepted outside of the circle of

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experts and followers and this paradigm has remained long. However, at the end of the 20th c, it has been replaced by the paradigm whereby the architectural heritage is crucial for the identity and distinctiveness of the site, being itself a catalyst for socio-economic development. This paper summarizes the results of the research on how this historical change occurred. The research was motivated by the need for better understanding of transversal impacts from Eurocentric region on the development of a designated local area, which was the topic of a subsequent research.

2. Change of Paradigm of Built Heritage Protection and Town and Regional Planning in 20th c and the Impact of Sustainability Principle

2.1. Planning urban areas in 20th c

Since the beginning of the 20th c, cultural heritage had been more comprehensively considered within the town planning regulation. The focus of cultural heritage preservation has gradually shifted from ancient buildings, individual buildings of architectural and historical value to assemblies of historic buildings with their context, historical sites with main monuments and historical areas of socio-historical significance, as described by Jokilehto [1]. Firstly, in legislative sense, the protection of individual buildings, extended from the building plot itself to the buffer zone, in the first half of the 20th c. In the past, buffer zones have often been allusive, difficult to understand, and a source of many practical problems; despite that, the introduction of protected "buffer zone" was one of crucial moments, because it implied recognition of the importance of the interaction of a structure with the environment in the given context – by experts. It ultimately revealed the necessity of defining and regulating the status of the built environment together with the cultural property itself. In the mid of 20th c this approach was additionally supported by Gestalt psychology. At the beginning of the century, in Italy and France, the discourse about urban preservation increased, revealing prospects of the discipline. The rapid growth of urban areas in the 20th c, following the industrialization of Europe in 19th c. further intensified, and consequently, in many cities the living conditions became poor and urban aesthetics was neglected. Many European cities developed over the historical fabric of earlier settlements, and that process repeated several times, generating (what is nowadays identified as) a complex urban-archeological stratification. According to the theoretician Stubben (Joseph Hermann, 1845-1936), German architect and planner, who published the influential text Der Städtebau in 1890 [2] this kind of development is indispensable in order to take advantage of the existing site amenities. As a consequence of such development, much of the historical fabric typically remains inaccessible under the contemporary city. In Rome, which is used as most common example of a city where the conflict between the past and the present has caused a loss of significant architectural heritage, at the beginning of the 20th c when intensive urbanization took place, such development was opposed by Giovanonni [3]. He emphasized the importance of aesthetic and ethical life in the city and claimed that they are not less important than in the life of an individual, and he proposed theoretical (town planning) principle called "dilution of city tissue" (in Italian Diridamento). Unfortunately, this principle had been only partly applied in Rome under the influence of Giovanonni. Many other Italian cities have emerged similarly over the remains of the ancient cities, and it was necessary to take a stand on their future urban development. By that time, Italy has already implemented several consecutive urban regenerations of many urban areas, among which the most disordering were those carried out under the rule of fascists. The influence of Giovanonni was particularly important regarding his reference to aesthetics of space during urban renewal. The Second World War has exposed the vulnerability of historic cities, and after it ended, a new chapter on the protection of historic cores opened up, a problem which obviously belongs to both domains – of heritage conservation and urban development.

In France, the redefining of old urban centers according to necessities of regional and city planning became the dominant point of view, but not before the late 1950s, and subsequently the Protected Sector Act was adopted in 1962 [4]. In Italian legislation, the competent body proclaimed the principle that a historic city, as a whole, was a monument, in 1928, giving an outline for the future international doctrine [4]. With the adoption of General Plans of Assisi (1955-58) and Urbino (1964), that issue begin to be faced in practice. The opening up of the problems of historic cities, came while working on the planning documents, towards proper space management from the point of view of the protection of the architectural heritage and the future development of the city, which was a very important event without precedent. By that time, the architectural heritage has already had a strong foothold in the Venice Charter, as well as in The Theory of Restoration by Cesare Brandi [5] and his theoretical principle of treatment of (also urban) *lacune*. Brandi's theoretical approach to the treatment of lacuna (meaning gaps, missing parts) applied to urban fabric is, as well as his theory as a whole, fundamentally aesthetical. It refers to the change of the urban context and the treatment of less valuable architectural objects in urban planning.

2.2. Built Heritage as scientific discipline between middle of 20th c and 1990s

International doctrine of heritage preservation started developing at the end of 19th c. However, the first significant international action came with Athens Charter in 1933, and soon after the development was temporarily stopped due to the Second World War. Therefore, the most intensive development came later, in the second half of 20th c. Throughout 20th c the notable theoreticians contributed to the development of theoretical principles, which sometimes preceded international doctrine, and other times came as result of generalization of good practices. The history of the heritage protection international doctrine in the second half of the 20th c can be monitored (in particular) through the work of organizations (e.g. UNESCO, ICROM ICCOMOS, IUCN, the Council of Europe) and through numerous international documents adopted in that period which refer to the problem of interaction between built heritage preservation and planning od urban development. Some of the key steps towards defining the international doctrine have been achieved by adopting the documents in the Table 1.

Table 1 Key documents of the international conservation doctrine regarding built heritage in urban areas

Document	Adoption Year	Comments
Recommendation on International Principles Applicable to Archaeological Excavations	1956	It sets out the rules and principles of archaeological excavations and recommends the national administrative framework and the basis of international cooperation [6]
Recommendation Concerning the safeguarding of the Beauty and Character of Landscapes and Sites	1962	It envisages, within the framework of recommended conservation measures, urban planning and zoning of a wider area including regulation of general aesthetics of space[7]
Venice Charter	1964	The most influential conservation document that established international conservation principles based on authenticity, the importance of preserving the historical and physical context of the site or the building (Article 14); in this document it is emphasized for the first time that the exercise of additional social functions must not distort the appearance or decoration of the monument which implicitly also means that the preservation of cultural heritage is also socially useful, per se [8]. Recently revised.
Recommendation Concerning the Preservation of Cultural Property Endangered by Public or Private Works	1968	An occasion to define "cultural property"[9]
World Heritage Convention (Convention Concerning the Protection of the World Cultural and Natural Heritage)	1972	The document that has the largest number of signatory states, which comprehensively considers protection of natural and cultural heritage, recognizing the value that is created by the interaction of man with nature. This document provides a frequently cited definition of cultural and natural heritage[10]
Recommendation concerning the Protection, at National Level, of the Cultural and Natural Heritage	1972	The UNESCO pointed out the responsibility of each state in preserving the world heritage; this document recommends the provision of financial means for the conservation and protection of natural and cultural heritage as well as legislative, administrative, financial, educational, teaching and technical activities for this purpose [11].
European Charter on architectural heritage	1975 revised 1992	It was adopted by the Council of Europe and defines architectural heritage as a common European heritage. It proclaimed integrated conservation (as protection from urban planning led by economic pressures and traffic requirements), [12]. It is base of Declaration of Amsterdam, adopted under UNESCO in 1976, further emphasizing that the architectural conservation must be integrated into planning [13].
Resolution of the International Symposium on the Conservation of Smaller Historic Towns	1975	It was organized by ICOMOS and it relates to typical risks in smaller historical cities and settlements such as accelerated migration [14]
Recommendation concerning the Safeguarding and Contemporary Role of Historic Areas (Warsaw-Nairobi)	1976	It recognizes the danger to society, in the event of loss of historical areas, beyond the economic loss. And defines historical areas: prehistoric sites, historic towns, old urban quarters, villages and hamlets, as well as homogeneous monumental groups; the natural or man-made setting which influences the static or dynamic way these areas

		are perceived or which is directly linked to them in space or by social, economic or cultural ties; “safeguarding” here means identification, protection, conservation, restoration, renovation, maintenance and revitalization of historical or traditional areas and their environment [15]
Burra Charter	1979	Very important document, inter alia, for comprehending heritage value. It is revised regularly. [16]
Tlaxcala Declaration on the Revitalization on Small Settlements (Tlaxcala)	1982	It deals with the right of small communities to decide on the preservation of their environment in accordance with tradition [17]
Appleton Charter for the Protection and Enhancement of the Built Environment	1983	It sets out the framework principles for the protection of the built environment in terms of protection, value, environment, relocation, enhancement, purpose, extensions and environmental control. [18]
Declaration of Rome	1983	ICOMOS, which is important because it speaks of realistic problems in conservation practices that arise in the gap between internationally agreed goals and principles and their implementation at the national level [19]
Convention for the Protection of the Architectural Heritage of Europe (Granada)	1985	It is a very important document that addresses the conservation of architectural heritage as part of urban planning, adaptation of buildings for new purpose, restriction of public access as protection measures etc. [20]
Charter for the Conservation of Historic Towns and Urban Areas (Washington-Lausanne)	1987	The first international document which comprehensively integrated cultural heritage problem in the policy of economic and social development, as well as of urban planning at all levels [21]
Resolution "Problems of protection and modern use of architectural monuments'	1985	Estonia, USSR, Tallinn [22].

The key 4 conclusions of the ICOMOS Meeting in Budapest, held in 1972, which can be categorized as general principles for the belonging generational period, refer to:

(1) the importance of town planning that must take into account existing fabric, and only then create the possibility of adequate integration of contemporary architecture;

(2) Free use of new techniques and materials with respect to the existing masses, scale, rhythm and suitable choice of final design of new buildings;

(3) Preservation of the authenticity of a historic ambience in which no forgery would compromise its value and,

(4) Revitalization and introduction of a new purpose that cannot destroy the historical structure and wholeness of an ambient, a larger entity or the city. [23].

All the above mentioned documents are important both for development of management and planning of urban areas. However (according to [24]), the most important international documents on the development of historical urban area (towns and cities) in noted period include: *Recommendation Concerning the Preservation of Cultural Property Endangered by Public or Private Works*, adopted in 1968 [10], *Recommendation concerning the Safeguarding and Contemporary Role of Historic Areas, adopted in 1976* [12], *Charter for the Conservation of Historic Towns and Urban Areas*, *adopted in 1987* [15], and *The Vienna Memorandum on World Heritage and Contemporary Architecture – Managing the Historic Urban Landscape*, which was adopted much later in 2005[25].

The first substantial step towards an interdisciplinary cooperation, concerning integration of ideas on protection of architectural heritage and planning, occurred in the period from the 1970s to the 1990s, which is nominally designated as the adoption of the principle of integrative protection. At the international level, this concept is based on the European Charter on Architectural Heritage of the Council of Europe (adopted in 1975), the Amsterdam Declaration by UNESCO (adopted in 1976), and the Recommendation on the Protection of Historical and Traditional Plans and Their Role in Contemporary Life (adopted the same year by ICOMOS). Sector planning showed all its shortcomings in the late 1960s and early 1970s. As a consequence of poor planning of land use, there were many mistakes. Thanks to the international activity on the regulation of the doctrine of the preservation of immovable cultural heritage, which was basically preventive, the architectural heritage has legally become a part of "inherited urban planning obligations" that had to be taken into account in planning process. By introducing integrative protection, the way of land use was improved regarding the spatial conflicts between immobile cultural heritage and other functions, which emerged earlier due to sector planning [22]. Although integrative planning has been widely accepted in practice, it should not be considered as a comprehensive solution to the all problems of integration of cultural heritage protection and planning in practice; it marked one stage of interdisciplinary cooperation, and in many cases it has not been completed yet. The other initiatives, which emerged from the side of town and city planners in that period, included global Agenda 21 [26] and Aalborg Charter [27], to mention a few.

2.3. Interpreting „landscape“- a key for understanding spatial development

In the examples of the historic cities of Urbino and, in particularly, Assisi all the complexity of the problem of interaction between the urban and natural environments was distinguished, in a manner that reveals the significance and comprehensiveness of the interpretation of the meaning of the "landscape". It has proven to be the key to the of urban

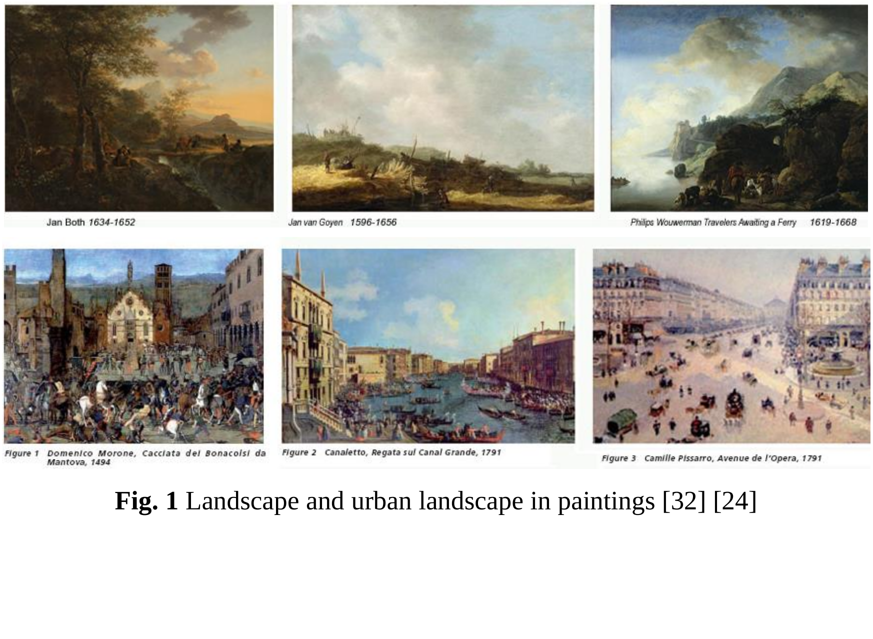


Fig. 1 Landscape and urban landscape in paintings [32] [24]

development through history and even of the interaction between of the two disciplines. The rich connotation of the "landscape" in particularly emerging in the last decades of the 20th and early decades of the 21st century was used in the newly created syntax of international doctrine, which is very important for the protection of architectural heritage and for urban development. Gabrielli [28] described 3 connotative meanings of landscape: (1) “The first regards the landscape as an ‘object of aesthetic experience and subject of aesthetic judgment’, a definition taken from Italian scholar Rosario Assunto in 1973” [29], (2) “The second regards the landscape as a ‘mirror of civilization and research field for the study of the civilization itself’: a synthesis taken from Carl Sauer in 1925” [30]. (3) “The third considers landscape as a material/morphological object of observation, of experienced space, of relationships. According to Corajoud's contemplation from 1981, landscape is “the place of relationships, in which every part is not comprehensible if not in relation to a whole which in turn is part of a wider entity. This third idea of landscape includes an ‘urban’ connotation which the discussion is restricted to.” [31]

According to Jokilehto [33], „modern representation of landscape goes back to Dutch painting in the 16th and 17th centuries (landskip, landschap, landscap, from Dutch), meaning picture representing inland scenery’ (distinguished from seascape’). In the 17th and 18th centuries, the English landscape gardens were designed as a symbolic representation of ancient myths, referring to painted classical landscapes and poetry”. Other authors have also recognized origin of “landscape” in painting and other arts, as it was understood in international doctrine of conservation [34], [35], [36]. Jokilehto pointed out that, according of formulation in Recommendation Concerning the Safeguarding of the Beauty and Character of Landscapes and Sites [7], „landscape was still strongly associated with the idea of identifying it with a ‘picture’. It was a static object, and consequently, it was expected to be treated and restored as if it were a ‘monument’“[33]. After “landscape”, and “urban landscape”, World heritage committee (1992) in 1994 edition of Operational guidelines introduced the notion of “cultural landscape” [11]: … “cultural landscapes are defined as ‘combined works of nature and of man, and they are seen as ‘illustrative of the evolution of human society and settlement over time, under the influence of the physical constraints and/or opportunities presented by their natural environment and of successive social, economic and cultural forces, both external and internal’ (version 2005: art. 47). Cultural landscapes can be designed, organically evolved or associative, and can include urban areas and settlements“. However, „it is noted that a cultural landscape is not only a ‘picture’. It is based on a complex set of criteria, cultural, economic, social, etc. Therefore, the aesthetics are only one dimension, and often not the most important. Instead, it is a territory that has archaeological and historical stratigraphy, and consists of the contributions of the different generations, as well as of the impact of environmental changes (climate, vegetation, etc.) [36]. Cultural landscape was adopted in particularly for the purpose of archaeological heritage, in order to explain complex relation between mankind and landscape which has been changing under human activities. Introducing „cultural heritage“ was step forward towards abstract of „landscape“ whose meaning integrates all those elements of urban space which are necessary for sustainable preservation of heritage site and contributes overall socio-economic development.

2.4. Mitigating of differences between paradigms under the global impacts

The two disciplines both changed under the influence of the global changes that the society was exposed to, primarily demographic changes and sustainability concept(s) towards strengthening of interdisciplinary cooperation through the harmonization of common goals. Industrialization, which originally triggered the rise of urban populations, has undergone significant changes in the 20th c. After the 1980s, many European cities entered the "post-industrial phase", with revenue from services, tourism, cultural industries, etc. replacing revenue from the "traditional" industry. However, migration from village to city continued, and since 2005, for the first time in human history, more residents have been living in urban than rural areas. This circumstance significantly influenced the perception of the role of culture, that is, the architectural heritage, in the overall development of society. At the planetary level, the economy has become a predominantly "urban" economy, and the management of urban resources, which in particular refers to the effective use of land, has become more important than ever. One of the most important global influences in this period has been the adoption of the principle of sustainability.

During the 1980s and the 1990s, international discourse on the economic aspect of preservation of cultural heritage was intensified as a consequence of a significant reduction of available investments to preserve the cultural heritage. Although UNESCO had pointed to the link between cultural policy and economic development in the 1960s and 1970s, the first major initiatives were created not before the 1990s. The economic crisis with which Europe and Western civilization faced in the 1980s can be seen as a moment in which external influence has got a major impact on the development of protection of architectural heritage and town and regional planning. Sustainability of the protection of architectural heritage was originally related to the environment, but soon got economic connotation, which prevailed. In the context of economic sustainability, the impact was reflected in the adoption of the economic value of architectural heritage, the development of conservation and management systems that take into account the overall interests of society. The Discourse on "Sustainable Development" was formally opened in 1972 at the UN World Environment Conference, Stockholm Declaration [37]. This document is the milestone of international environmental law, which establishes the basic principles of natural resource management, human rights, pollution prevention and the relationship between environment and development. In the decades that followed, the understanding of the concept of sustainable development has been improved, and this process can be traced through important international events and the key ideas which were promoted there. In the context of settlement development, an important role played the first UN Habitat Conference in Vancouver [38]. The relationship between the environment and the economy is established by the UN Nairobi Declaration [39], and the entire period was marked by the economic approach to protecting the environment. In many countries, tax reforms have been implemented, involving tax obligations regarding the pollution cost, loss of resources and damage to human health; the economic approach was seen as the most likely concept to successfully control the detrimental impact of the Western production and consumption on environment. In another, environmental approach to land use, as in an early Dutch policy of sustainable development, the pressure on ecosystem was limited according to estimated threshold that can be sustained without irreversible damage. These are just some examples of many methods for introducing the concept of eco-development and economical approach of environment preservation [40]. With Brundtland report, which emerged in the following decade, appeared a strong conviction that economic activities lead to economic growth ("which, according to neoclassical economic theory, lead to the necessary improvement of living conditions in developing countries”) [40]; according to it, current economic activities must not endanger the environment or the needs of future generations. From a time span of three decades, it is evident that the Brundtland report has been well integrated into the internationally accepted concept of sustainable development, and that the definition of sustainable development in this report is the most widely accepted and often quoted. During the first decade after the publication of the Brundtland report, the focus was on understanding and articulating the essential principles of sustainable development and improving planning methods in order to meet the new concepts [40]. New ideas on planning based on partnership and co-operation among stakeholders in planning have been promoted. Among them, in particular, the collaborative planning marked the next decade of planning around the world. Implementation of strategic planning in the urban context has spread. Sustainable development came in the centre of the goals set, and different models have been made in the process of development. During the 1990s, awareness of available resources and energy efficiency increased, as well as the need to create an integrated and consistent policy, as a scenario in which potentially all parties win. At the end of the 1990s, it became apparent that sustainability could still mean a tendency towards different goals, as a result of various paradigms. For example, a difference between the North "which is focused on climate change, biodiversity, conservation of species and habitat" and the South "struggling to provide human health, developing an entrepreneurial base and achieving the necessary economic growth for its development” [40] etc. Agenda 21, UNCED Action plan, held in Rio in 1992 (known as Earth Summit) with the aim of being implemented at the international, national and local levels, encompassing the social and economic dimension, preserving and managing development resources, promoted sustainable land use and encouraged the process of continuous review of the urbanization process with respect to sustainability principles, principles of participation and inclusion, strengthening local institutions and communities, the application of collaborative planning and the cooperation of cities through networking [26]. After the initial conference, others followed: Rio + 5 (1997), Rio + 10 (2002) and Rio + 20 (2012) [26]. The changes of the concept of sustainable development are illustrated as a transition from the Venn diagram to the model of the matryoshka (Russian doll - RDM) (Fig 2). The Venn diagram shows sustainable development as an interaction between economic, environmental and social development, while the matryoshka reflects the principle that all economic activities should be directed towards social progress and that this must be achieved within the framework of ecological restrictions [40].

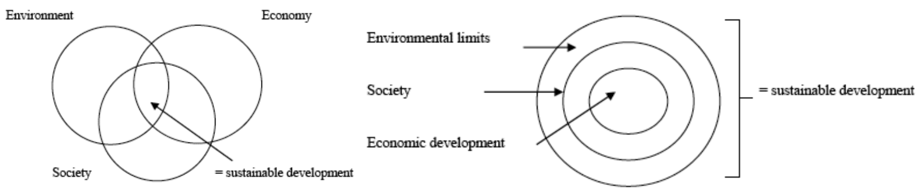


Fig. 2 Model of sustainability by Venn diagram (left) and matryoshka (right) [40] [41]

Models of sustainable development are exposed to on-going critical review from many points: regarding adequate compliance with local, regional or international policies as well as real social potential. Concerning social potential, there was plenty of critic: it has been hypothesized that non-comprehensive, partial paradigms within a sustainable development policy can be successful, but only if the legislative, political and institutional framework is set up to do so[42]; also that progress in the existing organizational framework is impossible, and that every attempt necessarily leads to tokenism [40]; within critical theory, in the framework of ecologically-conscious Marxism, it was debated whether sustainable development is possible within the framework of the capitalist economy, given that economic growth is based on the exploration of natural and social capital, and that capitalist development does not encourage environmental sustainability, cultural diversity and more uniform social development once poverty has been eradicated [42] etc. Being aware of the incompleteness of existing sustainability models, there was a constant effort on improvement. The fourth, institutional dimension of sustainable development, which includes power sharing and enormous rights (environmental management as a form of civil and political rights, involvement in decision making on the environment of the most vulnerable layers excluded from the decision-making process by economic or social basis, etc.) was included (Fig. 3). This four-dimensional model of sustainable development, as well as Brundtland report itself, does not tell of the place and role of culture, which is implicitly included in the social dimension of sustainability. As a reaction to the overstated emphasis of the economy, at the end of the 20th c, the interest in this problem increased [40]. Further, more structured and elaborated the four-dimensional model of sustainable development, in which culture also does not make any of the 4 elementary supports, was proposed by influential World Bank expert on development of urban areas, Pedro Ortiz, in 2016 (Fig. 4) [43].

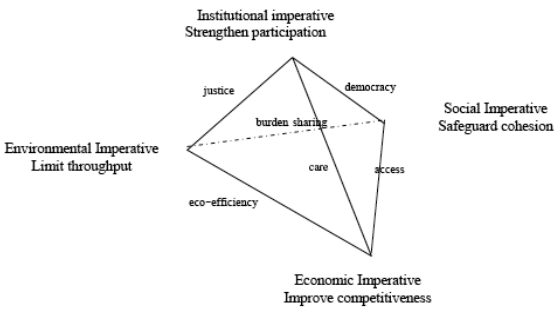


Fig. 3 The 4D model of sustainability model imperatives [40]

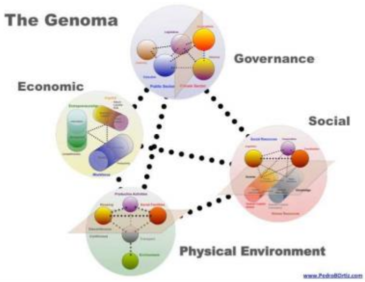


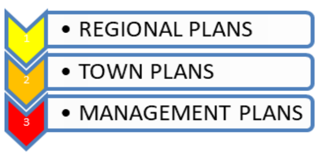
Fig. 4 Genome 2016 by Pedro Ortiz (World Bank) [43]

Sir Alan Peacock is among the first who advocated the application of economic principles as a limitation in engaging funds in cultural heritage projects. In a paper published in 1995, he advocated the consideration of priorities in public expenditures as a prerequisite for deciding on the allocation of funds for cultural heritage projects. The preservation experts reacted harshly to this, stressing that the expert opinion on cultural significance would be replaced by "raw financial criteria and the smallest common denominator of public opinion in decisions on the allocation of funds for cultural heritage" [44] according to [44]. Subsequently, the term "cultural sustainability" was introduced, as a reaction to the fear that economic principles prevail in deciding on cultural values. In the discourse on the relationship of culture and sustainable development, concepts such as "strategy of cultural sustainability" and "sustainable development of nature and culture" have been introduced. These considerations are contained in Agenda 21 for Culture [45] based on the Universal Declaration of Human Rights [46] the International Convention on Economic, Social and Cultural Rights [47] and the UNESCO Universal Declaration on Cultural Diversity [48]. This document is compiled with similar ambitions as Agenda 21 (adopted in 1992), only for culture, with indications of showing culture as the fourth pillar of sustainable development (which is bviously in contrast to the previously mentioned models). To sum up, in the last decades of 20th c the long discourse began on the acceptability of economic analysis of cultural values, which ended by the adoption of the Faro Convention in 2005[49]. In the context of sustainability, it is obvious that there is no consensus on the place of culture, and that it is implicitly positioned in the sphere of "society" in the proposed sustainability models.

2.5. New paradigms and changes after 1990s

The adoption of the World heritage Convention in 1972 was followed by introducing World heritage List, which includes cultural and natural heritage, as well as mixed heritage. Inscription on the World Heritage List has positive effect on preservation (similar as inscription on national and heritage list), among many other benefits, and therefore this convention has received the widest support of UN member states as confirmation of its justification. The Convention is considered to be a turning point in the international practice of protection of cultural and natural heritage, as it provides a legal framework for launching international campaign for the protection of heritage worldwide.

TARGET: Sustainable preservation of built heritage



Operationalization

Fig. 5 Planning process [50]

That same year, when World heritage Convention was announced, UNESCO adopted Recommendation concerning the Protection, at National Level, of the Cultural and Natural Heritage [11], emphasizing that every heritage site on the List must have adequate management system and management plan. “The purpose of a management system is to ensure the effective protection of nominated property for present and future generations". UNESCO Recommendation refers to the natural and cultural heritage, as well as mixed heritage [11]. In the Recommendations, it is stated that management plans should be harmonized with regional and town plans (Fig. 5.), as well as conservation plans by heritage preservation authority. Any work that might result in changing the existing state of the buildings within protected area should be subject to prior authorization by the town and country planning authorities, relaying on the expertise of the specialized services, responsible for the protection of the cultural and natural heritage. "Management systems may incorporate traditional practices, existing urban and regional planning instruments, and other planning control mechanisms, both formal and informal." [11]. Significance of promotion of heritage management plans comes from experience which has shown that the regional and town plans are effective in preserving land use-providing space for immovable cultural heritage, but not for fostering their development role. The management plans became essential step in the operationalization of the objectives of regional and town planning regarding heritage. "Role of management plans has evolved since 1970s reflecting expectations which significantly increased. The first generation of heritage projects focused on urgent preservation, disregarding costs and community demands. Management plans focused on single heritage site, though being expected to be consistent with regional and town plans. Despite inclusion of immovable heritage studies in the regional and town plans, problem of taking in account demands of different stakeholders remained. In practice, conservation planning reflected the attitude of experts, often not aligned with the values and interests of the local community or interests of economic development. Therefore, the second generation of plans, being influenced by collaborative planning and embracing social significance of the issue, has focused on the urban renewal with respect to cultural monuments preservation and presentation, as its component. Simultaneously, after 1980s, global economic issues raised awareness about the economic feasibility of cultural heritage projects. In time, this disclosed an economic potential of cultural heritage projects, which was originally considered less important. The third generation investment in immovable cultural property considered heritage to be a catalyst of economic development of wider area. Therefore, management plans shares responsibility with regional and town planning in heritage preservation. Number of the third generation cultural preservation projects has increased rapidly in the 21st century. Chinese experience serves as good example of it. From 1993 to 2013, the government of China initiated investment of 1.323 billion US$ in 12 heritage projects. Those projects included all three generations of heritage management plan (3 projects belong to the first generation of projects, with focus on urgent preservation, 3 projects belong to second generation of projects of urban renewal with cultural component, and 6, created after 2004, belong to the third generation of projects). They reflect integrated and broad-based approach which "addresses (1) broader urban and regional environment of historic cities and sites (2) province-wide cultural heritage conservation and tourism development that involve multiple sites, and (3) strengthen links between heritage conservation and local economic development" [51]. Actual challenges of economic development include actions "to: a. Maximize economic benefits of heritage conservation b. Leverage traditional knowledge for smart growth and energy conservation c. Strengthen the integration of cultural heritage conservation and tourism development (and) d. Recognize cultural heritage conservation as an asset for creative industries" [51]. Management plans bridge the gap between regional/town planning and preservation of the architectural heritage projects, in terms of economic development. Need for bridging the gap can be easily explained when taking in account that economic sustainability cannot be achieved at heritage site itself and over 90% of income has to be collected in the surroundings of the heritage site.

Evaluation of built heritage sites, which is regularly conducted since 1990s, is analyzed in economic theory framework, in order to determine the economic potential and investments required for presentation, interpretation and maintenance of the site. The problem belongs to field of culture economics, which takes advantage of numerous methods, originally developed for natural heritage management. The economic evaluation has been fully supported by Faro Convention [49], which framed European policy for cultural heritage, based on positive benefits accumulated from the use of heritage as a cultural capital. This document has given full legitimacy to the economic revitalization of cultural heritage, without degrading other values of importance to the society. Economic evaluation of built heritage in terms of cultural capital continues to occupy an important place in urban development and in international doctrine of cultural heritage. From the aspect of urban development, it seems heritage provides authenticity and distinction of the area, and therefore a solid base for harmonic, consistent, sustainable development, based on a genuine value of designated urban area. The architectural heritage has a cultural and economic value, each of which contributes in its own way to the welfare of the society. The logic of urban planning based on the advantages of the architectural heritage can be explained, and this often happens through the identity of an urban area. Namely, the architectural heritage does not include everything that was originally meant as legacy by those who built the city, but that which its inhabitants over centuries recognized and preserved as valuable, and at the same time those structures that the circumstances were inclined to, which survived in spite of wars, disasters, accidents and aging. Architecture of built heritage is a reflection of the ideas of its inhabitants, value of a site, characteristics of the natural environment, ethical and aesthetic attitude and more, and it is, perhaps, the only comprehensive, credible testimony of a human community in a given period. It always accurately reflects the level of development and organization of a social community and the system of values that result from it. The previous text points to the subtle relation between architectural heritage and the identity of the city, which superimposed on the strong link between identity and city development, explains the natural connection between architectural heritage and urban development.

The new paradigm has affected not only heritage sites of international significance, but those relevant for national and sub-national level and whenever sustainable development is required. Furthermore, heritage management planning of third generation has provided so far the only methodological, institutional and legislative framework for treating built heritage as catalyst for socio - economic development which is internationally accepted.

After 1990s, international doctrine further focused on heritage management issues, which led to adoption of new term “historical urban landscape” at the begging of 21st century, invented to mark an area which is significant for the management, and that is, typically, far beyond borders of designated buffer zone of a heritage site.

3. Discussion – Good/Bad Sides of Interdisciplinary Impact and Lack of it

The mutual influence of the two disciplines was not always constructive, nor mutually beneficial, which should be briefly considered, in order to clarify the reality of the approaching of the two disciplines during the 20^{c}.

Some of the problems that arise in practice are still only partially overcome. For example, the extensive and diverse archaeological heritage of Europe, stratified by the numerous wars and tendencies of European peoples towards building, through the overall existence, objectively represent the limiting factor of the urbanization, because it makes construction process slower and more expensive, in everyday life; this problem has been resolved in some European countries, by abolishing state monopolies over archaeological research, yet presenting newly discovered archaeological findings *in situ* wherever possible, and by incorporating heritage sites into the economic flows of the urban areas.

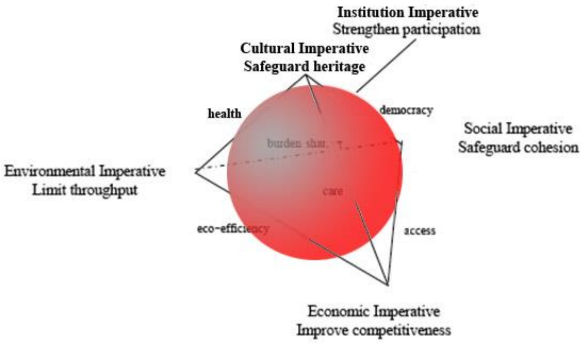


Fig. 6 Sustainability model to which cultural& institutional needs are added as necessity

A basic critique of the planning being applied in conservation refers to it that it does not mean it is a step in the right direction without additional consideration. The experience has shown that too detailed planning is a wrong approach, which exhausts the creative potential of available human resources, leading to the setting of unrealistic goals, regarding given financial capacities, primarily because they are created in isolated conditions and do not perceive the interests of all parties [52]. Furthermore, the application of collaborative planning to the built heritage is still largely considered to be disputable, due to the weaknesses it has shown in town and regional planning. It is wider accepted that public participation is necessary in the process of making decisions about the future of the architectural heritage, but in many countries this has not come to life in practice. In addition, it should be kept in mind that the mistakes that may arise in attempting to democratize the decision-making process can have irreversible consequences for the heritage in subject. Because of this and similar reasons, the harmonization of goals and paradigms of two disciplines should not be understood as a completed process, or as a process that proceeded smoothly from the beginning to current stage.

The place of culture in socio-economic development is evidently unclear. Based on the review of the development of sustainable development for four decades, it can be seen that the change in the relation to culture was essential, from the beginning, when there was no mention of culture, to the recognition of culture as an equal factor, or one of the four key pillars of sustainable development. In the proposed model in Fig. 6, institutions are seen as a sphere that reinforces the link between the environmental, cultural, social and economic imperatives of sustainable development. The most important challenges of national development policies and global impacts are in the proper place of each of these factors. Agenda 2030 [53] abandons the terms “pillars” and “imperatives” but it develops on essentially-the-same model.

Previous analyses confirm that culture can help the sustainable development, but questioning the opposite, if "sustainable development" can contribute to the cultural development, we come to the analogy between culture and nature, which has been extensively argued among scholars. The similarity is based on the uniqueness of natural and cultural values, which, once destroyed, cannot be recovered with the same properties that they previously had. Methods for managing sustainable development of the natural heritage began to develop before those for built heritage, and cultural heritage benefited methodologically from the systematizations of economic values and management methods developed for natural heritage, which were adapted for noted purpose at the beginning of the 21st century. It is a strong argument in favor of the mutual benefit.

4. Concluding Remarks

The paradigms of two scientific disciplines at the beginning of the 20th c were strictly opposed - one was fundamentally orientated towards preserving the past regardless of the price, while the other orientated to novelties, regardless of the effects on society. By the end of the 20th c, it turned out that there was only one goal - sustainable development, which was not only social, not only economic, and achievable if all available resources were smartly used, with the full cooperation of various experts and institutions. The planning of urban development and the protection of architectural heritage, as a science-based discipline, have come close enough to enable further cooperation on common challenges. In practice, this meant that urban planning, from the perspective of the protection of built heritage, was not seen as a threat, despite intensive urbanization, and that cultural heritage was not seen any more as a burden and an obstacle to urban development despite the restrictions on land use, but as a socio-economic development potential. This paper describes how such significant change has occurred.

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ULOGA GRADITELJSKOG NASLEDJA U PLANIRANJU I RAZVOJU EVROCENTRIČNIH URBANIH PODRUČJA U 20. VEKU

Proces definisanja očuvanja baštine i urbanističkog i prostornog planiranja na naučnim osnovama trajao je do kraja 20-og veka. Uloga graditeljske baštine u urbanističkom i prostornom planiranju je suštinski promenjena za to vreme. To se delimično može objasniti razvojem naučne metodologije svake od disciplina, a delimično globalnim promenama i, posledično, novonastalim izazovima.

Ključne reči: *graditeljsko nasleđe, urbanističko planiranje, prostorno planiranje, održivost, društveno-ekonomski razvoj*

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ASSESSING THE CURRENTLY-USED METHODS FOR IMPROVING CONTINUED-EDUCATION SKILLS IN THE ARCHITECTURAL ENGINEERING DEPARTMENTS IN EGYPT

UDC 72:378(620)

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Abstract. *The present study is concerned with assessing the currently used methods for improving the skills of continued education in the architectural engineering departments as well as the architectural market in Egypt. The main hypothesis of this study is that: the concept of continued-education in architecture is absent in Egypt, the current mechanisms of supporting continued-education are neither active nor effective, and the architectural education is not enough alone to build a professional architectural character.*
Survey forms have been distributed for practitioners, and interviews have been conducted with stakeholders for the sake of assessing the role of the universities in Egypt in supporting the graduates' skills development. The study compared the collected data about these universities through three main points: continued-education, graduates' follow-up and environment & community services.
At the end, this study suggests some mechanisms based on the data analysis of the collected information. These mechanisms will help improving the practice of architecture in Egypt. In addition, the study proposed some recommendations regarding practicing architecture in Egypt for architecture's practitioners, Egyptian Engineering Syndicate, and Egyptian executive entities such as ministry of higher education & prime minister office. These recommendations will be delivered as well as a copy of this research to all stakeholders in order to be taken into considerations.

Key words: *Continued Education, Self-Learning, Architectural Education, Skills Development, Architectural Career, Professional Practice*

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INTRODUCTION

The knowledge-based economy indicators in societies are real indicators of building a professional career and making money out of the gained knowledge through the university education; which indeed increases the economy of these societies. The World Bank's report of knowledge-based economy indicators stated that the top countries in order are Sweden, Germany, Norway, Canada, Australia, Denmark, UK, and USA. (5) Egypt in that report came in the 67th place! The Egyptian scientists in these developed societies are well paid and thez achieve high economic status, which does not happen inside Egypt; and this is an important indicator that there is a big gap in Egypt between Knowledge and Economic Return.

Architects play an important role in the well-developed societies, where one can find some professional entities specialized in supporting and sponsoring the development of the architectural career, as well as enhancing the skills of the architects themselves. In order to effectively develop and positively influence the environment around us, we have to activate the role of the continued-education, and also, we have to do periodical tests for the practitioners to assess and evaluate their knowledge about all updated architecture-related issues such as materials, applications, construction techniques, …etc. This will make the practitioners themselves keen to practice the self-learning, the continued-education, and the effective development of their skills; in order to satisfy the local market needs. (4) (11) (12)

For example, the Royal Institute of British Architects (RIBA) -which is one of the oldest organizations in the field of architecture- is concerned for: enhancing the architecture career's environment, encouraging the architects' continued-education, and developing the architects' professional skills; in order to create the suitable prosperous environment for the architecture practice. In USA, the American Institute of Architects (AIA) takes the same role. The AIA has three main objectives, which are: improving the current practitioners of architecture, finding qualified practitioners for the future, and representing the architectural career in front of all organizations or entities. (17) (18)

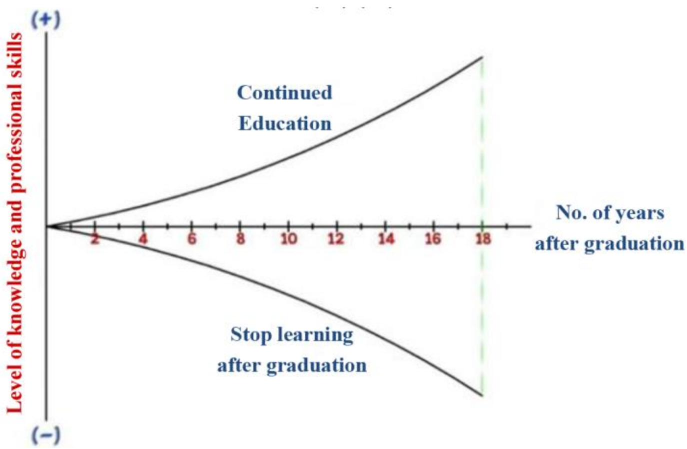

Fig. 1 The Effect of Continued-Education on Architecture Practitioners
(*Source*: Al-Erian, Ahmed, The Continued Education of Engineers)

1. PRACTICING ARCHITECTURE IN EGYPT

There are many organizations in Egypt take the responsibility of taking care of architecture career as well as architects themselves, which are listed in figure (2).

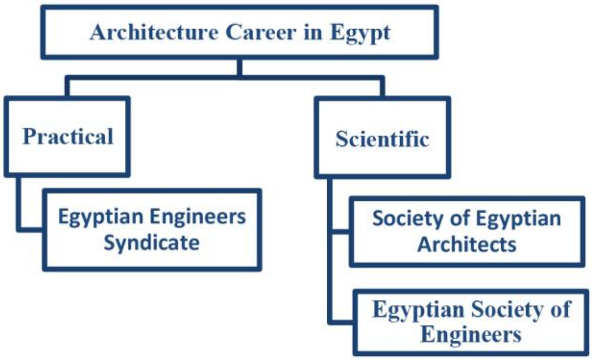

Fig. 2 Classification of practical architectural organizations in Egypt
(*Source*: By Researcher)

The Society of Egyptian Architects and the Egyptian Society of Engineers are responsible for the scientific part (Conferences, publications, competitions, …...etc). On the other hand, the Egyptian Engineers Syndicate is responsible for the professional practices.

1.1. Society of Egyptian Architects (SEA)

The Society of Egyptian Architects has been established in 1917 in Cairo by pioneers of architecture. It is a founder member of the International Union of Architects (UIA), which has been established in 1948 in Paris. (18)

SEA cooperate and participate with international and/or regional organizations to implement international and regional projects and researches in architecture, urban planning and engineering fields. It also organizes conferences and workshops in order to develop the profession of architects and urban planners, through dissemination of technical experience and to preserve the physical environments of human settlements.

1.2. Egyptian Society of Engineers

The Egyptian Society of Engineers has been established on Dec. 1920 when its administrative board gathered for the first meeting. The main purpose of establishing this organization was to work in the scientific and cultural field of engineering by following the engineering studies and researches, in order to achieve the scientific developments in different engineering fields. It encourages the publication of lectures, seminars, researches thesis, …...etc. Not this only, but also making connections with other organizations outside Egypt to create an effective scientific cooperation.

1.3. Egyptian Engineers Syndicate

The Egyptian Engineers Syndicate has been established in 1946. It represents all engineers with their different majors for the sake of achieving the engineering practice targets. It is the responsible organization for taking care of the engineers as well as organizing the professional practice of the engineering career. (14)

2. THE ROLE OF EGYPTIAN ENGINEERS SYNDICATE IN SPONSORING THE ARCHITECTURAL CAREER IN EGYPT

2.1. Evaluation of Practicing the Architecture Career

To evaluate the role of Egyptian Engineers Syndicate in sponsoring the architectural career, the researcher attended one of the meetings of Architecture Division Council in the Egyptian Engineers Syndicate's main branch in Cairo to explain what have been reached so far for the members, and to take their feedback, suggestions, and comments about the current situation of practicing the architectural career in Egypt; in order to complete this research in its most significant way. The head of the council board stated that: "there is neither effective evaluation system for architects nor following-up system for architects' continued-education and skills development, that is why -by time- the gap between architects and the syndicate increases".

On the other hand, the researcher interviewed some of the stakeholders inside the syndicate's head branch in Cairo in order to measure the effectiveness of the rules that control the professional practice of the architectural career in Egypt. The administration responsible for practicing architecture stated that: "the rules are really existing but not activated, and that the syndicate gives any architect the needed practice license ones he/she pays the stated fees".

All these statements are against the syndicate's original regulations, and obviously this happened because of neglecting the activation of these regulations, as well as absence of needed mechanisms to control practicing architecture in Egypt. Table 1 shows how far practicing architecture in Egypt meets the practicing architecture authorization requirements that are set by the Union of International Architects (UIA). (3) (14) (15) (20)

Table 1 International Union of Architects UIA Authorization Requirements

	Item	Egypt	UIA
1.	Studying duration in architecture departments (in years)	4-5	4-5
2.	An effective evaluation system for the curriculums to be approved	√	√
3.	Obligatory practical training duration before getting the license to be an architect (in years)	×	3-2
4.	Existence of evaluation system for graduates to be certified	×	√
5.	Existence of practicing licenses	√	√
6.	Periodical renewal of practicing licenses	×	√
7.	Ethical code for the practice of architecture	√	√
8.	The title of 'Architect' is protected by laws	×	√
9.	Continued education	×	√

(Source: By Researcher)

2.2. Evaluation of Training Systems

As a trial to evaluate the training system of the Egyptian Engineers Syndicate, the researcher coordinated with the head of training committee in the syndicate's head branch in Cairo to attend the training workshop that was held by the committee to discuss the obstacles and challenges that face the engineer's training programs, and also to discuss the needed mechanisms to develop and to improve these training programs.

Regarding the continued-education issue, -in addition to observations and writing minutes- during the interview with the vice president of the Egyptian Engineers Syndicate he stated that: "the syndicate was dealing -for a long time- with the training as income source only" and that: "the certificates given by the training centers reflect only the attendance of the trainees not the gained training skills or knowledge". Also, during another interview with the head of the training committee he said that: "the current training and evaluation mechanisms are neither effective nor applicable; because training is not obligatory for engineers, and that's why they are not keen to pass training and preparation requirements unless they need the certificates to work outside Egypt". (10)

As a conclusion, the problem of the lack of continued-education culture in Egypt is not because the requirements and regulations are not existing, but because they are neither activated nor effective, and because we do not have the needed mechanisms to apply these regulations. (1) (2)

3. THE ROLE OF THE EGYPTIAN UNIVERSITIES IN SPONSORING THE ARCHITECTURAL CAREER IN EGYPT

There are about thirty departments of architecture in the Egyptian public universities, and more than thirty departments of architecture in the Egyptian private universities in additional to about thirty-five departments in institutes in Egypt. From the lists of the Egyptian Engineers Syndicate -all over Egypt- the Egyptian universities -which are connected with the syndicate's committee of training are only four universities (American University in Cairo, Helwan University, Ain Shams University, and Banha University). (7) The rest of universities in Egypt are not collaborating with the syndicate in training and preparing the engineers for the professional practice; which means that there is lack and insufficiency in the role of the Egyptian Universities in sponsoring the architectural career in Egypt.

This study is investigating and analyzing the universities in Egypt which are registered in the Egyptian Engineers Syndicate in order to: figure out their mechanisms for supporting the practitioners of architecture in Egypt, assess their communications with the graduates, point out the mechanisms of serving the surrounding environment and community, and to measure their consideration to improve the skills of both students and graduates.

The factors of choosing these universities were:

- Diversity between public and private universities.
- Different locations all across Egypt.
- Reputation and importance for Egyptian high education.
- Availability of information and data.

The collected data has been analyzed and compared with each other through three main points: continued-education, graduates' following-up, and environment & community services.

Table 2 The role of Egyptian Universities in Supporting the Architectural Practice

	Universities	Community Services	Graduates' Follow up	Continued Education
1	Cairo University	√	√	X
2	American University in Cairo - AUC	√	√	√
3	Mansoura University	√	√	X
4	Banha /university	√	X	√
5	Alexandria University	√	√	X
6	Zagazig University	√	X	X
7	Asyout University	√	√	X
8	Kafr El Sheikh University	√	X	√
9	Suez Canal University	√	X	√
10	Helwan University	√	√	√
11	Ain Shams University	√	X	√
12	Tanta University	√	X	X
13	Monofeya University	√	X	X
14	Arab Academy for Science and Tech. - AAST	X	√	√
15	Fayoum University	√	X	X
16	German University in Cairo - GUC	X	√	√
17	British University in Egypt - BUE	√	√	X
18	Al Azhar University	√	X	X
19	Al Menia University	√	X	X
20	Bani Sweif University	√	X	X
21	Misr International University - MIU	X	√	X
22	Pharous University	√	√	X
23	6 October University	√	√	X
24	Modern Academy	X	√	X
25	Delta University for Science & Tech.	√	√	X
26	Future University in Egypt - FUE	√	√	√
27	Sinai University	X	X	X
28	Al Nahda University	√	X	√
29	Misr Academy for Eng. & Tech. - MET	X	X	X
30	Modern University for Tech. & Info. - MTI	X	X	X

(*Source*: By Researcher)

This study studied in great detail sixteen public universities and fourteen private universities shown in table 2, which have been put in this order according to the "Webometrics Ranking of World Universities". Webometrics is an initiative of the Cybermetrics Lab, a research group belonging to the Consejo Superior de Investigaciones Científicas (CSIC), the largest public research body in Spain. The original aim of the Ranking was to promote Web publication. Supporting Open Access initiatives, electronic access to scientific publications and to other academic material are our primary targets. However, web indicators are very useful for ranking purposes too as they are not based on number of visits or page design but on the global performance and visibility of the universities. (16)

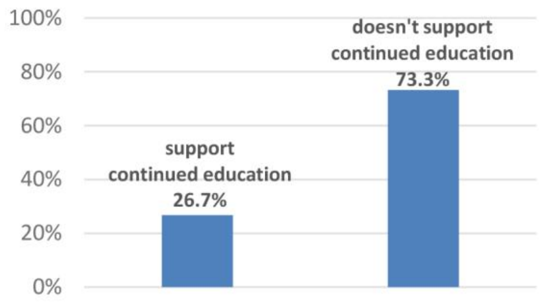

Fig. 3 Percentage of Egyptian Universities Supporting Continued-Education (*Source*: By Researcher)

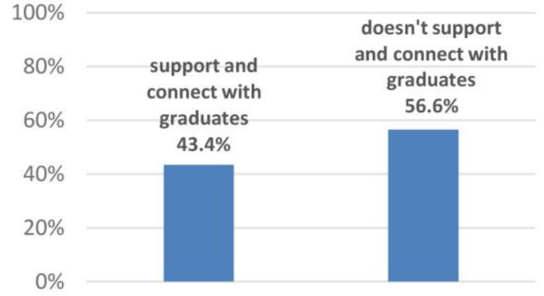

Fig. 4 Percentage of Egyptian Universities Supporting the Graduates' Professional Skills (*Source*: By Researcher)

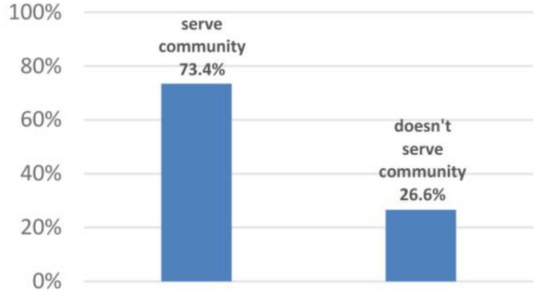

Fig. 5 Percentage of Egyptian Universities Serving the surrounding Community (*Source*: By Researcher)

As a conclusion, by comparing universities with each other this study found out that all universities in Egypt are considering giving their students a high-quality education, but most of these universities unfortunately have no role in communicating with the graduates and following up their career path. Also, most of the universities do not care effectively about graduates' continued-education and skills development. This study also found out that the public universities are more concerned with environment & society services than the private universities. On the other hand, the private universities are more concerned with both graduates' continued-education & following up the graduates than the public universities. In addition, both public and private universities are equal when it comes to the preparation for national and international accreditation, as well as when it comes to improving the quality of education itself.

4. Documentation of the Current Situation of Practicing Architecture in Egypt

Survey forms have been designed and published among the registered practitioners of architecture in Egypt with their different age group and different categories. The questions of these survey forms have been designed based on the already done theoretical study in the preparation of this research in order to reach real results which lead to achieve this study objective.

4.1. Survey Form Design

Two survey forms have been designed for the practitioners of architecture in Egypt. The first survey form is for the employees and the second survey form is for the employers. Both survey forms have common questions with each other, and each of them has a different group of questions addressing the survey targeted community. In the following sections the objective of every question will be explained, and the answer will be analyzed.

4.2. Collecting Data and Analyzing Results

The data of this study have been collected through the delivered hard-copies for the practitioners, and through the electronic data-base that has been created online in order to make the distribution of forms and the collection of data easier and more effective. The online data-base is accessible through the following URL:
https://docs.google.com/forms/d/151Cf1aWuNMZ_o1q1wJzb4Cu1YUSOKH5l3Syj6Mheqc/viewform

Table (3) states the numbers of distributed forms, the numbers of collected-back forms, and the percentages of responses from the architecture practitioners' community.

Table 3 Percentage of Response for Different Age Segments

Age groups (in years)	Count of distributed forms	Count of collected forms	Percentage of response
20 – 30	131	114	87.0%
30 – 40	69	58	84.1%
40 – 50	24	16	66.7%
50 – 60	9	4	44.4%
60 – 70	6	1	16.7%
Total	239	193	80.75%

(*Source*: By Researcher)

4.2.1. The Purpose of Choosing Architecture as a Field of Studying

Objective of question: measuring architects' awareness of the nature of practicing this career before choosing to join this community.

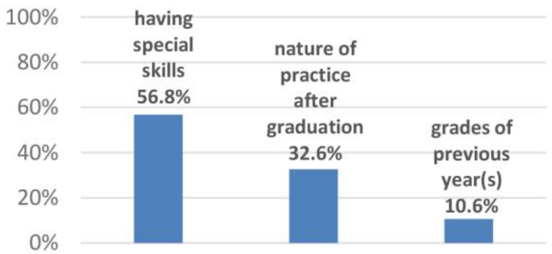

Fig. 6 Percentage of answers about purpose of choosing architecture as study field (*Source*: By Researcher)

Analysis of answers: the percentage of those who choose the department of architecture because of the nature of practicing it after graduation is very low; which indicates that the awareness of the professional practice is minimal.

4.2.2. Perception of Architects' Career

Objective of question: evaluating the conviction of the needed and required skills and techniques for being an architect.

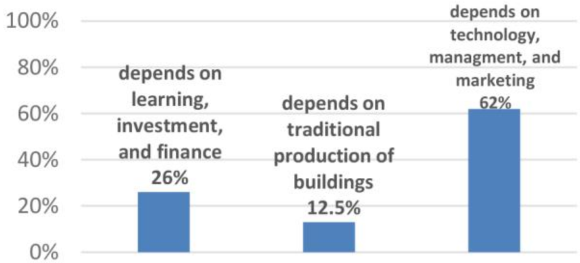

Fig. 7 Percentage of answers about the perception of architects' career (*Source*: By Researcher)

Analysis of answers: large number of the surveyed practitioners believe that the architectural career depends on learning and investment indicates the lack of believing in the importance of both continued-education and skills' improving. Some of the surveyed practitioners believe that architects' career depends on traditional production of buildings, which indicate the deterioration in the general awareness of practicing architecture in Egypt.

4.2.3. Knowledge Level of the Fresh-Graduate Architects

Objective of question: measuring the current situation of the fresh-graduate architects' level of knowledge and the gained skills for both public and private universities' graduates.

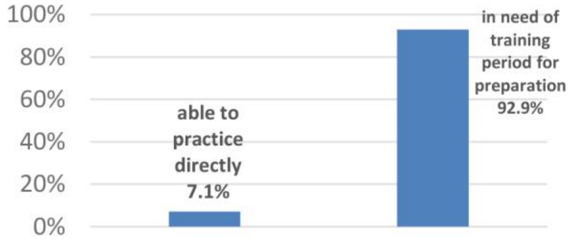

Fig. 8 Percentage of answers about the knowledge level of fresh-graduate architects (*Source*: By Researcher)

Analysis of answers: choosing of the importance of the training period for fresh-graduates to prepare them for the professional practice from almost the majority of the survey community confirms the importance of activating the syndicate's systems of training and evaluation.

4.2.4. Importance of the Training Period Before Giving the Title of an Architect

Objective of question: investigating if the architects in Egypt will or will not accept applying regulations of examining the graduates after an obligatory training period before being certified as architects.

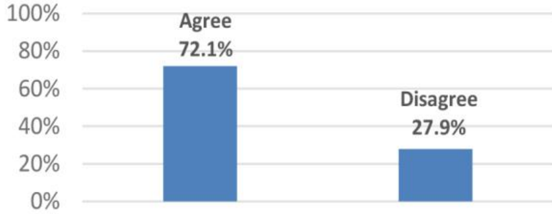

Fig. 9 Percentage of answers about the importance of the training period (*Source*: By Researcher)

Analysis of answers: most of surveyed community admitted the importance of the training period and qualification exams after graduation; which means that if the needed mechanisms have been created to make these systems effective, the architecture community in Egypt will go for it with satisfaction.

4.2.5. The Current Situation of Architectural Education in Egypt

Objective of question: measuring how appropriate architectural education in is Egypt, and figuring out Egypt's position compared with the international developments.

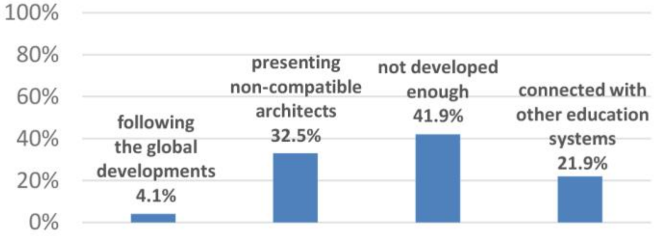

Fig. 10 Percentage of answers about the current situation of architectural education (*Source*: By Researcher)

Analysis of answers: the majority agreed that the Egyptian architectural education currently is not developed enough and produces architects with less-needed-qualifications. And also the survey community gave only 4.1% for the following of global developments and international lead; which indicates that there are real problems regarding practicing architecture in Egypt; which matches this study hypothesis.

4.2.6. Problems of Practicing Architecture in Egypt

Objective of question: investigating the opinions of the architectural community in Egypt about the existence of some problems facing the architectural career; for the sake of testing the hypothesis of the present study.

Analysis of answers: 100% of the survey community agreed that the architectural career in Egypt is actually facing some serious problems.

4.2.7. The Current Mechanisms for Supporting the Continued-Education of Architecture Graduates in Egypt

Objective of question: measuring the effectiveness of currently used mechanisms for supporting the continued-education of fresh-graduate architects and figuring out the common problems if any.

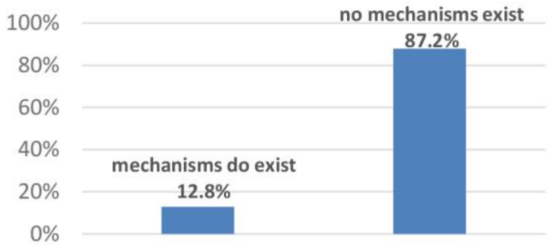

Fig. 11 Percentage of answers about the current mechanisms of supporting continued-education (*Source*: By Researcher)

Analysis of answers: the majority of survey community stated that there is lack of mechanisms supporting the continued-education of fresh-graduate architects in Egypt. Also, the current mechanisms are not effective enough because of existence of some problems. These responses affect directly the recommendations at the end of this study.

4.2.8. The Effectiveness of the Regulations Controlling the Architectural Career in Egypt

Objective of question: measuring the effectiveness of the currently existing mechanisms used for controlling the professional practice of architectural career in Egypt.

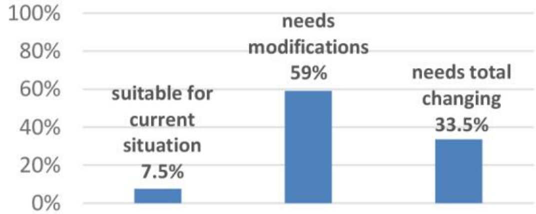

Fig. 12 Percentage of answers about the affectivity of current regulations (*Source*: By Researcher)

Analysis of answers: the survey community is divided about the current organizing regulations between being insufficient and in need of additions & modifications and being in need of total changing. But large percentage goes for the first point -needs modifications-; and this indicates that this study's hypothesis is valid.

4.2.9. The Fresh-Graduate Architects

Objective of Question: measuring how much employers trust the graduates from architecture departments in Egypt.

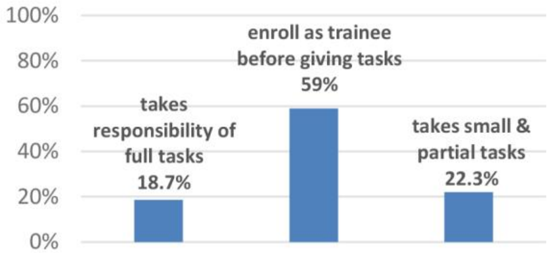

Fig. 13 Percentage of answers about the trust in fresh-graduates (*Source*: By Researcher)

Analysis of answers: the majority of the surveyed community agreed that the fresh-graduates must be trained first, and could take partial responsibility of tasks not full tasks; which indicates that this study's hypothesis about the architectural education -being not enough to build a professional architectural character- is valid for architecture-graduates in Egypt.

5. The Gap in Practicing the Architectural Career in Egypt

During the visit of professors of engineering -with different majors including Architectural Engineering- from University of Cincinnati to Future University in Egypt, some of them had been interviewed to investigate their opinions about the professional practice of engineering in Egypt especially architectural engineering. Architectural engineering prof. Zarka stated that: “applying the system of sub-majors inside architecture departments is one of the most important factors affecting the leading of the American practice of architecture among the whole world”. Prof. Zarka added that: “In USA you will never find one architect doing all the drawings and designs of one project by his own only like what is happening in Egypt”. Prof. Zarka mentioned one of the used mechanisms in architecture schools of USA which is having students choose a specific sub-major of architecture to be applied in their graduation projects, and involving graduation projects’ students in team-work groups to create one complete graduation project for each group. At the end of the interview, prof. Zarka notified that all architecture schools in USA have to be accredited from the National Architectural Accreditation Board (NAAB); which make them follow the NAAB’s stated regulations, such as: (Environment & society services, Practical-training for students & continued-education for graduates, Connecting graduates with new-comer students for the sake of experiences exchange, and Connecting the market & industry with departments in order to produce highly qualified graduates. (6) (8) (9) (13)

This study summed up the problems of practicing architecture in Egypt in the following points:

- Getting the license to practice architecture is a matter of being graduated and paying the fees, and this allows some of those who are not suitable for this career to join it.
- The continued-education is not obligatory, and being only a source of money for the syndicate.
- The classifications of architects in Egypt depends only on years of practice regardless of the qualifications level.
- The cooperation between the Egyptian Engineers Syndicate and (universities, public organizations, training centers) is weak and not effective.
- The syndicate has no control and does not have any rights to withdraw the educational license from any educational institute in Egypt; that is why the syndicate has no control on the graduates of architecture departments.
- Most of universities in Egypt take good care of their students in the undergraduate levels, but have no role with their graduates regarding continued-education and skills developments.

6. Mechanisms of Developing and Improving the Practice of Architecture in Egypt

This study is suggesting some mechanisms based on the data analysis of the collected information. These mechanisms will affect improving the practice of architecture in Egypt. These mechanisms are the following:

- Increase the effective communication between the syndicate, the universities, the public organizations, the ministries, the national entities, …etc.
- Increase the public awareness of community about the importance of architecture and its value in serving the surrounding community and environment.

- Increase the awareness of the nature of practicing architecture in high schools before joining the architectural community.
- Increase the support of continued-education and make it obligatory.
- Activate the training programs' system for fresh-graduates to prepare them for the professional practice as a basic requirement to get the practicing license.
- Improve the curriculums and the mechanisms of architectural education to follow the lead of global developments.
- Make the license renewal a periodical process based on evaluating the improvement of professional skills.
- Modify and activate the regulations of the Egyptian Engineers Syndicate regarding the support of practicing architecture in Egypt.
- Activate the classifications of architects through the years of practice based on evaluation tests of their professional level.
- Support the private offices and companies and encourage them to improve the skills of architects who are working for them.

7. Recommendations

7.1. Recommendations for Architecture's Practitioners

- Consider continued-education as a basic process, and never stop learning after graduation.
- Publish the culture of continued-education among colleagues and connections.
- Participate in the architectural competitions.
- Follow up the architectural scientific magazines and publications.
- Try to attend the meetings of administrative board of architecture division in syndicates in order to effectively develop practice regulations.
- Keep connections with university through training services and experience exchange with students by visiting and communicating with the university after graduation.

7.2. Recommendations for the Egyptian Engineers Syndicate

- Give the practice license only after passing well-designed evaluation tests.
- Make the license renewal a periodical process based on evaluating the improvement of professional skills to ensure practitioners' self-learning and continued-education which will positively affect the architecture itself.
- Make an active and effective link between syndicate and universities to improve quality of the graduates and to match the market needs.
- Dominate the syndicate on practicing architecture in Egypt through activating the current regulations after modifying them.
- Organize the practice of private architectural offices and companies and check them periodically.
- Consider the training and continued education as a basic process not just as a source of money.

7.3. Recommendations for Egyptian Executive Entities (Ministry of higher education, Prime minister office, ... etc)

- Create laws and regulations to guarantee architects' rights (salaries, working environments, career path, …. etc) to encourage them to do their best in improving the quality of built-up environment which we live in.
- Prepare a strategic plan for training and continued education of graduates.
- Encourage the employers to hire only the certified architects by Egyptian Engineers Syndicate which guarantee their qualifications.
- Consider the opinions of syndicate's board regarding giving or withdrawing educational licenses from universities or any other institutes.

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ULOGA GRADITELJSKOG NASLEDJA U PLANIRANJU I RAZVOJU EVROCENTRIČNIH URBANIH PODRUČJA U 20. VEKU

Ova studija se bavi procenom trenutno korišćenih metoda za poboljšanje veština kontinuiranog obrazovanja na odsecima za arhitektonski inženjering, kao i na arhitektonskom tržištu u Egiptu. Glavna hipoteza ove studije je da: koncept kontinuiranog obrazovanja u arhitekturi nije prisutan u Egiptu, trenutni mehanizmi podrške kontinuiranom obrazovanju nisu ni aktivni ni efikasni, a arhitektonsko obrazovanje nije samo dovoljno za izgradnju profesionalnog arhitektonskog karaktera .

Obrasci ankete su distribuirani inženjerima iz prakse, a obavljeni su i intervjui sa zainteresovanim stranama radi procene uloge univerziteta u Egiptu u podršci razvoju veština diplomaca. Studija je uporedila prikupljene podatke o ovim univerzitetima kroz tri glavne tačke: kontinuirano obrazovanje, praćenje diplomaca i usluge zaštite životne sredine i zajednice.

Na kraju, ova studija predlaže neke mehanizme zasnovane na analizi podataka prikupljenih informacija. Ovi mehanizmi će pomoći u poboljšanju prakse arhitekture u Egiptu. Pored toga, studija je predložila neke preporuke u vezi sa praktikovanjem arhitekture u Egiptu inženjera arhitekture, Egipatskog inženjerskog sindikata i egipatske izvršne vlasti kao što su Ministarstvo visokog obrazovanja i kancelarija premijera. Ove preporuke će biti dostavljene kao i kopija ovog istraživanja svim zainteresovanim stranama kako bi se uzele u obzir.

Ključne reči: *Kontinuirano obrazovanje, samoučenje, arhitektonsko obrazovanje, razvoj veština, arhitektonska karijera, profesionalna praksa*

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THE IMPACT OF SHOPPING CENTRES ON THE RESTRUCTURING IN THE POST-SOCIALIST CITIES WITH A PARTICULAR FOCUS ON PODGORICA

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Abstract. *This paper considers transformation of urban form of post-socialistic cities arising from the transition from socialism to capitalism. The structural transformation resulted in creation of polycentric cities, deindustrialization and revitalisation of suburban zones and led to emerging of commercial developments as a manifestation of activity of new urban players. The emergence of shopping centres marks the beginning of consumerism in the consumer society that has formerly been exclusively oriented to industrial production. The effects of this phenomenon on the urban tissue are similar in all cities of Central and East Europe. Likewise, in Podgorica, such effects reflected in restructuring of previously known urban structure, inducing creation of new town districts to the full extent. The purpose of this study is to reassess the existing and introduce new mechanisms of urban policy of the post-socialistic cities, with a particular focus on Podgorica, thus enabling facilitation of legal frameworks and an institutional approach to the further process.*

Key words: *post-socialist city, polycentricism, suburbanisation, shopping centre*

1. INTRODUCTION

From the aspect of changes in state and society, the post-socialist period assumed transition from socialist to capitalist system, where such process was used as a temporary label to be applied until the system had safely achieved some familiar type of society (Pickvance, 2005). The transition also involved some very radical and uncontrolled transformations carried out within a narrow time-frame, often leading to anarchy and ad hoc measures, which in turn produced a negative impact on society. In terms of urban changes, this period entailed a deconstruction of then known urban matrix of a socialist city.

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In literature, a transition is defined as a complex reform process referring to five major macro-problem levels (political, economic, social, cultural and environmental). Here, a spatial level features as a separate problem that is observed for causality, meaning within each of these five circles the space transformation stands out as a cause and/or effect, and most frequently as both (Pušić, 2001).

The post-socialism brought gradual adoption of capitalism postulates and globalisation, which assumed orientation towards the West. An inflow of foreign capital, market internationalization and consumption-based economy are only some of the characteristics of this period.

The overall impact of the completed processes manifested in the chaotic patterns of the post-socialist urban development, with rigid structure of former socialist cities being softened by relatively small yet numerous interferences of private investors.

A combined effect of the post-socialist processes induced deep structural transformations leading from monocentric to polycentric spatial structures, from compact cities to the increasing urban peripheries, from high-density city centres with institutional and residential functions to exclusively commercial-business city districts, from former industrial complexes to Brownfield sites that new urban players find attractive (Stanilov, 2007).

2. From Socialism to Transition

The period of socialism was marked by an order in which the space transformation was intrinsically linked to the state and its influence. It was the state that influenced the development of space morphology at all levels. Transformation of urban form is just one among numerous consequences of restructuring of the social system. Although established in a short, still critical time frame, the spatial development patterns had produced long-term effects on future development of the transition cities.

The period of socialism records development of infrastructure but only such infrastructure that responded to the industrial needs. Given that housing settlements cantered around the factories, a place of residence was only secondary to the place of work.

While absence of commercial developments was typical of periphery, department stores dominated central city zones, without disturbing a traditional commercial function of the old city centre. The department stores occupied an open plan and flexible space, structured by areas and department. Most socialist countries did not allow private businesses or tolerated it to a small extent. In such setting, social goals often prevailed over the logic of profit making.

In early 90s of the last century, a systemic transformation took place, when moving towards capitalism gave rise to the idea of establishing a system similar to the developed western societies.

Nevertheless, the post-socialist transformation did not take the preferred turn as it proved to be a demanding process in every aspect. The changes came at several levels, in particular at political, economic and urban level.

Reorganization of urban space of a post-socialist city involves restructuring of the existing and forming of new urban zones which leads to completely new urban formats.

The inherited socialist principles are often in conflict with the principles of the capitalist social and economic system, thus leading to reshaping of the existing urban structures. The most visible effects are often concentrated at the attractive central areas of the city as well as at the suburban locations. Key transformations in the spatial matrix of former socialist cities included commercialization and expansion of urban tissue, radical transformation of the outer urban zones as well as the conversion of the suburban zone. Indeed, under the deindustrialization process, the suburban zones emerged as zones of new possibilities, with their previous structures undergoing a complete transformation due to the huge interest of the private investors.

At the same time, central zones of the city mainly focus on business as well as on tourist-oriented facilities, while retaining the purposes of central and cultural functions.

Urban changes of the post-socialist city saw their spatial articulation through the emergence of shopping centres. Development of this space takes the shape of primarily economic but also political and social restructuring, the consequences of which can be seen in everyday life of inhabitants of the city and its wider environment.

3. Shopping Center in a Post-Socialist City

The first large shopping centres appeared in Central Europe in the mid-90s. Major retail chains put forth their whole strength first in the capitals of Central Europe, with a three-year delayed emergence of the shopping centres in the "secondary" cities. The investment decisions were made at the moment when the reversal of the existing commercial sector and purchasing power of population were attributed to the economic transformation.

The shopping centres became a place where citizens could feel the changes spawned by the consumerist culture and social stratification, becoming a symbol of transformation. High aspirations to western society and trends thereof give rise to consumerism in the consumer society that was formerly exclusively oriented to the industrial production. The shopping centres create a concept of leisure shopping, placing the consumers into a hyper-real environment which itself nourishes contradictions in the perception of real and imaginary, true and false (Ritzer, 2005).

Notwithstanding their lifetime is as predictably shorter compared to residential and business facilities, the shopping centres represent a key factor in terms of investments in the commercial sector. When concentrated in suburban areas instead in central zones, the shopping centres strongly affect the traffic flows and stimulate residential suburbanisation. Hence, at this time, the dramatic transformations of urban space and physical structure unfolded in the peripheral urban tissue, reflecting the notion that the converted commercial sector relies on the use of vehicles. This because of the fact that shopping centres are accommodated in large buildings and as such are oriented to urban transit zones, fringe areas and suburban areas. These transformations of urban structure bring huge change to the post-socialist cities in Europe, where traditional centre was generally regarded as the centre of commercial activities.

The foregoing led to re-urbanisation of certain parts of the central zone, the crisis of big socialist complexes and emergence of a new low-density residential ring.

According to literature (Dinić, 2015), trends in positioning of large commercial buildings in the period beyond the year of 2000 have important implications for urban tissue:

1. Presence of commercial facilities in the city centre decreases and fades in importance;
2. A significant part of commercial function shifts from the city to the shopping centres on the periphery with no direct links to the traditional city core;
3. Reorientation of consumers to large shopping centres directly affected small retail shops in other city districts as well. A number of small retail shops sees a rapid drop;

4. Large supermarkets and hypermarkets with a dominant road access replace former day-to-day supply stores with easy pedestrian access;
5. After the period of their expansion on the periphery, the shopping centres shift back to the city centre locations.

In addition to high demand for products and services which directed the unprecedented success of the shopping centres in the post-socialist countries (Central and Eastern Europe), there are two distinctive reasons behind this phenomenon.

The first is seen as a pure psychological effect of an unconstrained exposure of the sensory deprived citizens of former socialist countries to the vast assortment of goods, which were then presented in a brand new environment.

The second factor of this phenomenon, which at the same time explains a favourable position of shopping centres in the city matrix, is a very lenient system of urban planning that actually facilitated development of commercial programs. Quite the opposite, city authorities in Western Europe imposed constraints that affected implementation of such projects.

It cannot be said with certainty if the newly formed residential complexes around the shopping centres will be transformed into the edge cities over the time, but without any doubt, they had acted as a dominant factor in the urban changes of the post-socialist cities in the last five to ten years.

3.1. Shopping centres in the Central and Eastern Europe countries

In the countries of Central and Eastern Europe, the transition posed demand for new office space of foreign investors, which needed to comply with the foreign market standards. Accordingly, such new office space occupied the prime locations in the central zones of the cities. Although a small office space suited the requirements at the beginning, the changes came with the expansion of those companies that required larger office space, but now focused on the locations beyond the city core, still well connected to the infrastructure.

In the mid 90-s, the retail market followed the already developed business market, with evident similarities in the patterns of distribution of the foreign investments. Hence, an increasing number of shopping centres can be observed either in the city core or on the urban peripheries, the image of which is thus changing in line with the global consumption trends.

In the last 10 years, most urban areas in the Central and Eastern Europe welcomed several new shopping centres in the central zones. However, the prevailing part of the retail development took place precisely on the urban periphery. The shopping centre buildings often served as nodal points for future residential area growth, as they appeared in the sparsely populated areas, near the main roads, often because of the increased intensity of the individual traffic in cities.

Commercial suburbanisation has left visible traces on the suburban zone, by far more obvious when compared to the effects it had on the residential suburbanisation. This phenomenon can be easily explained given that central zones of the city offer a limited space for construction of a large-size business or shopping centre buildings. For that reason, the investors directed their orientation to two categories of locations. One category comprises the locations that are close to major roads and road intersections. The other category refers to the locations near the subway stations and underground transport terminals. However, the consequences of such development of commercial facilities affect the central zones and traditional city centres where manufacturing shops are closing, as they are unable to compete with the large retail chains. Therefore, traditional centres are becoming less attractive in terms of meeting the needs of a contemporary consumer.

The foregoing considerations served as a basis for determining the key factors of impact of shopping centres on the post-socialist city development, which refer to several elements:

- establishing new principles of urban development, market globalisation and internationalisation;
- intensive migrations from city cores into suburban areas;
- spatial stratification - place of residence depends on economic standing;
- city polycentrism - old urban core and newly formed suburban centre created as a consequence of the emergence of shopping centres;
- shopping centres as a place for socialisation and social activities;
- urban policy of new players, which uses plans to illegally facilitate construction of new shopping centres.

3.1.1. Warsaw

Among the cities of Eastern Europe, Warsaw can certainly serve as an example to illustrate the changes concerned. With reference to the emergence of the shopping centres area, the changes in urban structure of the city are best illustrated by the example of Marszalkowska and Pulawska corridor (Fig. 1), which extends from the city centre to the border with a satellite town Piaseczno. The shopping centres built along this corridor (Europlex, Galeria Mokotow, Geant Ursynow) introduced changes into the city structure in terms of both generation of new facilities in their vicinity and transformation of the existing facilities. This transformation of the central city structure from socialist to market-oriented space may be regarded as a symbol of the changes. Moreover, the shopping centres located on urban periphery symbolically mark the direction of the shift from one system to the other - the transformation from an industrial to post-industrial zone of the post-socialist city, thus contributing to urban dispersion. Remodelling of the Mokotow district centre shows an example of urban transformation from a non-profit, public use open space to the enclosed and privately owned commercial space and as such represents the best illustration of global changes induced by the transition from the socialist to capitalist society (Dinić, 2015).

Nevertheless, the resulting changes have stirred discontent as the so called "rural urbanisation" leads to creation of an urban landscape filled with incompatible buildings constructed with either too small or too large gaps in between.

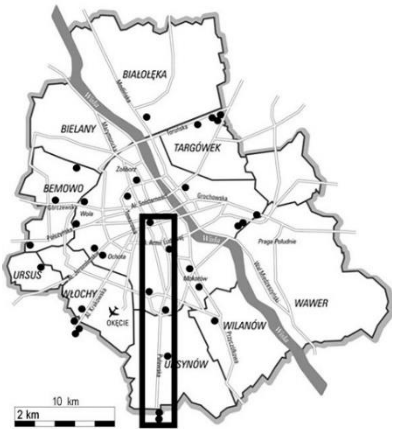

Fig. 1 Modern shopping centres in Warsaw (dots) and commercial corridor Pulawska/ Marszalkowska (square). (Source: Kreja, K.: Spatial imprints of urban consumption: largescale retail development in Warsaw, in: Tsenkova, S.; Nedović-Budić, Z.: The urban mosaic of post-socialist Europe: space, institutions and policy, pp. 259., Physica-Verlag HD, New York, 2006.)

3.1.2. Ljubljana

Another example of the impact of the transition commercial patterns on the spatial changes can be observed in Ljubljana. The increased number of new commercial developments and change in the manner of use of the urban land has risen directly from the transition. Four large shopping centres (BTC, Rudnik, Interspar, Mercator) were built on the city periphery, close to the main roads and major transport routes. One of the first shopping centres appeared on the site of a former warehouse, with each successive shopping centre built on the sites of former factories or on the unused industrial land.

3.1.3. Budapest

Budapest certainly does not fall behind the post-socialist transformation trends and can serve as an example for consideration of the emergence of shopping centres in the city structure.

One of the earliest commercial facilities of this kind, Csavargyári Épület, was established in an old screw factory. Evidently, the deindustrialisation process caused by commercial development follows the well-established pattern.

The first completely new commercial facility of this kind was Duna Plaza, also established near the industrial zone, primarily due to the extremely good transport connections, but also in line with a tendency to convert the overall surroundings into the commercial centre.

Ever since, the number of shopping centres in the area of Budapest has increased, especially on former industrial sites. An important role in the expansion of commercial development is naturally attributed to foreign investments. It is interesting to note that almost 500 000 m^2 of new space allocated to commercial purposes was built only between 1990 and 1999, out of which 75% within the city limits and the rest in the surrounding areas (Tosics, 2005).

3.1.4. Prague

Commercial development had significant impact on the transformation of suburban zone of Prague. While residential developments were scattered throughout the suburban area, commercial developments concentrate in complexes built close to major highways and important transport routes. Location-wise, another important factor was the existence and proximity of metro lines. Two shopping centres - Tesco and Globus, being among first of the kind in the Czech market, one on the western and the other on the eastern edge of the city were both located close to the highway and metro stations. Up to 1989, most commercial developments (nearly 50%) were concentrated in the city centre (Sykora, 1999). However, during and after the transition, large proportion of the commercial function shifted to suburban zone.

The spatial distribution of commercial developments in Prague is likely to be transformed by an ever-increasing decentralisation resulting from the post-socialist city development.

3.1.5. Belgrade

In the transition period, the urban tissue of Belgrade was exposed to intensive transformations due to the vast available space, developed infrastructure and just minor commercial development. The interest of private investors and market pressure to focus on commercial construction led to the emergence of shopping centres and hypermarkets. One such example can be seen in the case of the shopping centre “Ušće” that was built on the unoccupied land within the residential block, near the existing city landmark of Belgrade - office building PC “Ušće”. Consequently, the shopping centre affected the higher frequency of mobility in the direction of Novi Beograd, making this part of the city a more attractive zone in terms of social activity rather than just an inert residential-type tissue.

Notwithstanding an evident functional diversity of the suburban zone of Belgrade, this commercial development failed to establish a suitable spatial framework for a residential centre.

3.2. Shopping centres in Podgorica

In case of Podgorica, being among representatives of cities under the post-socialist regime, an entirely predictable modification of urban matrix is observed. Given the response to the emerging trends of globalisation and consumerism, in addition to the housing construction there is an evident presence of a substantial commercial construction and shopping centres in particular. The constructed shopping centres have led to restructuring of the previously known urban structure or fully encouraged emergence of new city districts.

In 2008, following the period of building boom and privatisation, a completely new facility emerged in the city once familiar with only small businesses in the commercial sector - the first shopping centre “Delta City” (Fig. 2). The shopping centre with a total floor area of 24 000m^2 was built on the land area of 46 000m^2, near the main road to the coast. All world brands targeting middle-class consumers brought together in one place, within the commercial building facility. This completely new shopping environment has suited even the social life of those visitors with no interest in shopping.

This novelty, however, yielded the unpredictable large-scale effects. Although it was expected for certain portion of social life to shift from the old city core to a newly established facility, still it was unlikely to have the city morphology fully transformed. Consequently, a change takes place - the housing and living density decreases in central zones and increases in peripheral zones.

The suburbanisation process induced by construction of the shopping centre “Delta City” in Podgorica, on the site of the old furniture factory “Marko Radović” has also entailed the transformation of a former industrial zone. In that way, the transition-related space renovation and treatment of industrial heritage occur at the same place. Private investment projects are implemented on the site of factories and near the new commercial developments in the form of residential-business programs. In the specific case of Podgorica, a number of districts have been formed in response to the shopping centre construction and concentration of a social class discerned as a primary and consumption-oriented. Therefore, the choice of residence location is affected by economic standing, which leads to socio-spatial stratification (Šarović, 2016).

Since that time, on the site of the same factory one more shopping centre was built in 2016. The shopping centre "City Mall" (Fig. 3) is a two-storey building connected with an eight-storey business tower covering an area of 8000 m^2.

Fig. 2 Shopping centre “Delta City” in Podgorica
(Source:https://waytomonte.com/rs/p-657-delta-city)

Fig. 3 Shopping centre “City Mall” in Podgorica
(Source:http://celebic.com/referenca/city-mall-i-biznis-kula/)

Moreover, construction of commercial facilities has generated new residential-business developments in the adjacent area. "City Kvart" was the first such development (construction period 2006-2016) built on the place of a previous heavy-machine factory "Radoje Dakić". Detailed Urban Plan "Radoje Dakić" from 2012. provided for construction of total gross area of 572 424 m^2. Before this Plan was developed, 110 964 m^2 of mainly residential-business buildings had been constructed at the level of the scope of the Plan. Other developments provided for in the Detailed Urban Plan included areas intended for educational, health and cultural purposes, the construction of which is still pending.

On the site of the tobacco factory "Duvanski kombinat" (Fig. 4), within the same suburban zone of the town, there is an ongoing construction of another residential-business complex "Central Point" of total gross area of 145 000 m^2 and also a mixed-use complex "Master Quart" (Fig. 5) with total planned gross area of 86 272 m^2.

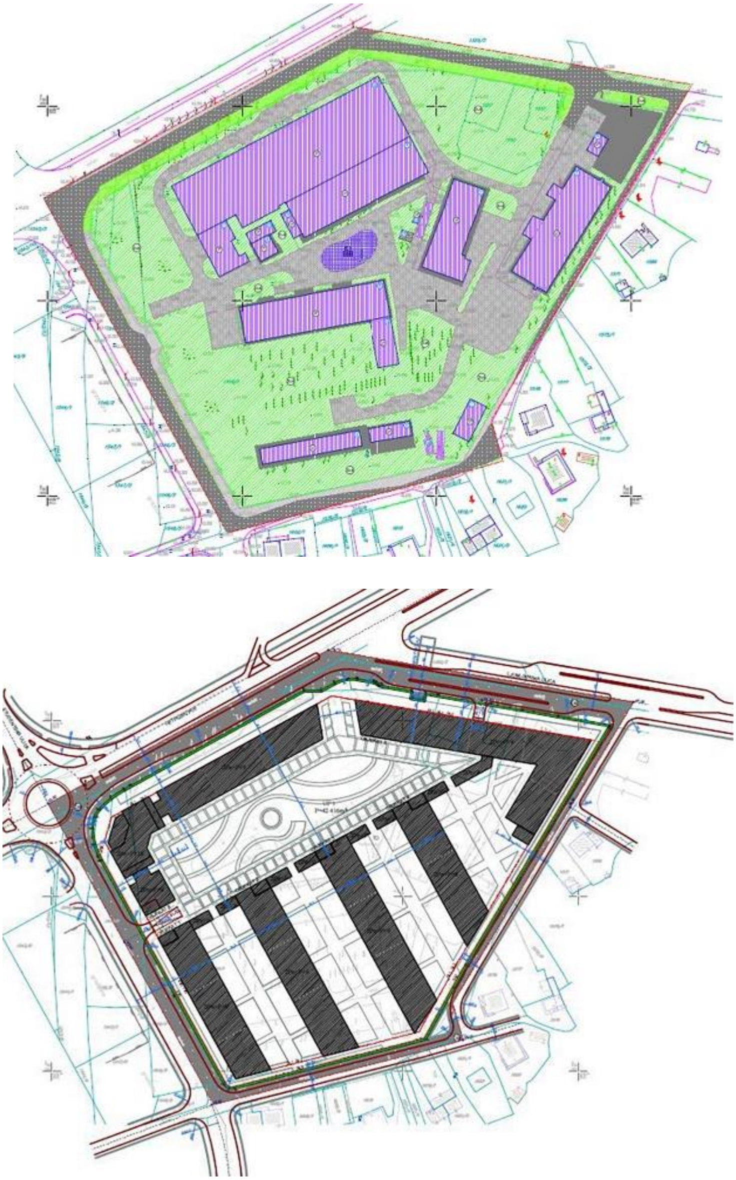

Fig. 4 DUP "Duvanski kombinat" – existing and planned condition (Source:http://podgorica.me/db_files/Urbanizam/PlanskaDokumentacija/2012/IzmjDopUPDuvanski/8.namena-post.sta-model.pdf; http://podgorica.me/db_files/Urbanizam/PlanskaDokumentacija/2012/IzmjDopUPDuvanski/17. plan_parcelacije_regulacije_i_utu-model.pdf)

The phenomenon created by shopping centres in the post-socialist cities arises from an easy way of obtaining the preferred locations due to a large amount of capital owned by retail chains compared to the local government revenues. Furthermore, the leverage of massive commercial facilities over the socialist commercial systems is above all seen in the wide range of choice, i.e. more diversified offer. It is interesting to note that while Western-European retail chains face hard times on their own ground due to their oversaturation, the same commercial facilities see a boom in the changing West-oriented region. The effects of such processes under the pressure of aspirations of private investors and free market in Podgorica (Fig. 4) also affect the traditional city centre that gradually fades in importance. With a large number of business and commercial offices being closed, the city area is becoming associated with epithets of vacant and insufficiently attractive.

Fig. 5 “Central Point” – under construction
(Source: personal collection)

Fig. 6 “Master Quart” – under construction
(Source: https://www.youtube.com/watch?v=Odos3utXmTI)

Construction of the shopping centre in the former industrial zone has facilitated creation of a completely new visual identity and generated new developments, which contribute to formation of a polycentric city (Fig 5 and 6). The market pressure coupled with the endeavours of private stakeholders had it share in neglecting the construction of buildings intended for core functions in this zone. An evident absence of educational and health institutions in the city zone with ever growing population has been recognised as a problem. There is also an issue of insufficient infrastructure, being greatly manifested through the traffic congestions near one of the main roads that connect Podgorica to the coast.

The unbalanced participation of stakeholders in the development process of the post-socialist Podgorica produces negative effects on future development of the town, such as those seen in the uncontrolled construction and insufficiently specified urban policy frameworks.

Fig. 7 Orthophoto of industrial area of Podgorica from 2003.
(Source: google maps/Podgorica)

Fig. 8 Orthophoto of postindustrial area of Podgorica from 2019.
(Source: google maps/Podgorica)

4. Conclusion

The identified patterns of economic and social restructuring during transition period have deeply marked all social and spatial rules and regulations of that period.

The transition has yielded different outcomes - while some countries underwent successful adjustment, others experienced a mix of the old and the new institutional system, cultural norms and physical planning,

The shopping centres are one of the manifestations of such period. More specifically, the shopping centres stand as representatives of modifications in the urban matrix of the post-socialist cities of Central and Eastern Europe.

Based on the previously considered, a conclusion can be drawn that the spatial morphology of cities changes, with transformation from a monocentric to a polycentric city and the emerging conflict with the existing urban fabric manifested in the diminishing importance of a traditional centre.

The research confirmed that the emergence of shopping centres has emphasized the importance of formation of a residential settlement in the suburban formats, at the same time indicating the social stratification of the population as a consequence of these changes.

It is important to mention the challenges of urban policy, which records an evident lag behind the Western-European trends due to the uncompleted transition processes. This led to a high presence of illegal construction and also construction of programs that are not included in the plans, which explains a great number of shopping centres in some post-socialist cities.

Most certainly, the transition process in Podgorica has been marked by the shopping centre construction, which itself has entailed numerous transformations in both spatial and social structures. Urban landscape underwent modification in compliance with the already established patterns of the post-socialist city development. In urban matrix of Podgorica, this manifested through a polycentric city model as well as through commercialisation and revitalisation of the suburban area owing to the shopping centre as a place for socialisation.

Taking into account the experience of other cities that underwent similar socio-political processes, it is reasonable to expect that similar scenario of saturation and shifting of shopping centres into city cores will also unfold in Podgorica.

Further researches should be focused on reassessment of the existing and introduction of new mechanisms of urban policy. New principles and strategies are expected to provide an elaborated response to the future course of still uncompleted transition processes and to create legal frameworks and an institutional approach to the further process.

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UTICAJ TRŽNOG CENTRA NA RESTRUKTURIRANJE POSTSOCIJALISTIČKOG GRADA SA OSVRTOM NA PODGORICU

Rad se bavi transformacijom urbane forme postsocijalističkih gradova nastalom usled tranzicije iz socijalističkog u kapitalističko društveno uređenje. Kao rezultat strukturne transformacije dolazi do generisanja policentričnih gradova, deindustrijalizacije i revitalizacije suburbanih zona, kao i pojave komercijalnih sadržaja usled djelovanja novih urbanih aktera. Pojava tržnih centara označava pojavu konzumerizma u potrošačkom društvu koje je do tada bilo koncentrisano isključivo na industrijsku proizvodnju. Njihov uticaj na urbano tkivo sličan je u svim gradovima Centralne i Istočne Evrope, bez izuzetka Podgorice u kojoj dovodi do restrukturiranja do tada poznate urbane strukture, odnosno u potpunosti podstiče nastanak novih gradskih celina. Cilj rada je preispitivanje postojećih i postavljanje novih mehanizama urbane politike postsocijalističkih gradova, sa posebnim osvrtom na Podgoricu, koji bi olakšali pravne okvire i institucionalni pristup daljem procesu.

Ključne reči: *postsocijalistički grad, policentričnost, suburbanizacija, tržni centar*

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THE NECESSITY OF TRANSVERSE STEEL REINFORCEMENT FOR CONFINEMENT IN STRUCTURAL REINFORCED CONCRETE WALLS USING NONLINEAR STATIC AND DYNAMIC ANALYSIS METHOD

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Abstract. *Reinforced concrete walls are one of the most efficient and earthquake-resistant systems. In order to provide adequate performance against seismic forces, their ductility should be provided by considering some design principles. Since confining the concrete increases the ductility of the reinforced concrete members, design instructions try to increase the ductility of the wall by utilizing transverse rebars in a certain length of wall edges. In this study, the need for the transverse steel bars to apply confinement in concrete is compared with the equations suggested by previous studies for the displacement-based design of structural bearing walls. For this purpose, nonlinear static analysis and time history analysis was utilized. The results of the study indicate that the lateral deformation of the structural bearing walls is less than the final limit specified by the design codes, even without considering the transverse steel bars for concrete confinement.*

Key words: *Reinforced concrete structural wall, Nonlinear dynamic analysis, Pushover, OpenSees*

1. INTRODUCTION

On March 3rd , 1985, an earthquake measuring 7.8 on Richter occurred in an area near the central coast of Chile. The city, affected by the earthquake, was the city of Vienna Delmar, with about 400 modern concrete reinforced buildings designed and built on engineering principles [1]. Most of the buildings had numerous reinforced concrete structures designed to deal with lateral forces. Initial reports indicated that the buildings had shown a very favorable

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performance so that the damage was very low, and in many cases, they were unhurt. Further research [2] showed that although the seismic requirements of the Chilean statute were similar to the U.S. requirements for high-risk areas, the required details by the Chilean regulations were not strict,[1]; also, the Chilean monitoring was less strict comparing to the U.S. Standards. Those buildings in Chile, according to the U.S. classification regulations (such as the Uniform Building Code UBC-88), were in the group of structures with a load-bearing wall. Regarding these regulations, the design forces for this group were greater than the flexural frame system and the dual system. Consequently, due to the high cost of implementation of great details and requirements for increased structural resistance, the performance of the bearing wall system was rarely economically justified in the United States, while the bearing wall system operating in Chile was completely economical.

There are various parameters that can affect the structural behavior of systems. For example, the geometrical variables and materials used in members play a significant role in structures,[3]–[6]. On the other hand, many researchers showed that ductility of the lateral load-carrying structural systems has a significant influence on the performance of the building in earthquakes. For instance, Alimohammadi and Lotfollahi Yaghin (2019) [7] studied the seismic behavior of light steel frame (LSF) structures using two lateral load bracing systems and LSF shear walls. They studied and compared different seismic behavior factors such as ductility, added resistance coefficient, coefficient of hardness, etc., of these two different lateral resistance systems using the nonlinear pushover analysis. They compared their presented coefficient of ductility for various variables in their study, and they showed the accordance of them with the Iranian design regulations for all seismic zones. Their study results revealed that the more deformable lateral resistance building systems could be more building performance efficient in all seismicity zones as well. In another study, Alimohammadi et al. (2019) [8] studied the effects of different shapes of openings on the seismic behavior of the concrete shear walls using nonlinear static analysis (Pushover). They compared the changing of many seismic factors with the opening shapes in the lateral systems, such as the results of the ductility coefficient, energy absorption, hardness, added resistance, and so on. From their simulation results, they concluded that the various shapes of openings affect the resistance and the hardening of shear walls. The effect of a lack of shear walls on the seismic performance and properties of low, medium, and tall buildings is harder than the shear wall with the openings. Also, the closer the openings to the edge of the wall the more decrease in strength and ductility [8]. In lateral resistance systems, it is obvious that the most critical columns are those located at the nearest external frame of the structure, and they should be considered as highly important members in progressive collapse potential reduction as key members [9] and Increasing the stiffness of the column head results in the decreasing of the displacement of the column header as well [10].

According to the description given, as well as the proper functioning of load-bearing wall systems, the researchers concluded that load-bearing walls with limited details could be considered as an effective and economical system against earthquakes [11].

2. Design Method Based on the Displacement of Structural Wall

According to the previous studies, [11] presented the method of displacement-based design of structural walls. In this design method, the need for concrete confinement in the boundary components of the wall is related to the expected response from the structure. They indicated that regulations of the U.S. are very conservative for a wide range of systems used in which structural walls are utilized to deal with the lateral loads. Wallace and Mull also found that the primary variables are influencing wall details such as the ratio of the total area of the walls in one direction to the floor area, the wall aspect ratio (height to length ratio), wall configuration (cross-section), axial force and the ratio of wall longitudinal reinforcement [11]. Displacement - based design method requires a simplified relationship for the displacement range. To achieve this spectrum, the acceleration spectrum is needed, which can be achieved by available codes such as ASCE standards [12]. In this study the Iranian standard for seismic design is utilized [13]. Assuming the region with high seismicity risk (A = 0.3) and type III of the land (T_0 = 0.15 and S = 1.75), and with Eq. (1) it is possible to obtain the elastic displacement range at different times. In figure (1), in addition to the elastic displacement spectrum, the simple displacement range is also illustrated in Eq. (2) As noted, this simplified range, which is linear, is the curve of the elastic displacement spectrum. Consequently, it can be used to compute the maximum displacement at different periods.

$$S_d = \frac{T^2}{4\pi^2} S_a \tag{1}$$

$$S_d = 0.25T \tag{2}$$

The fundamental time period of the structures with R.C. walls can be estimated by analyzing a cantilever beam [14]. On the reinforced concrete structural walls, by considering the effect of stiffness reduction caused by concrete cracks, the variation of fundamental time in the structure can be estimated using Eq. (3) where n is the number of stories, w is the weight of the story level, h_s is the average height of stories, E_c is the modulus of elasticity of concrete, h_w is the wall height, l_w is the length of the wall, p is the ratio of the total area of walls to floor area, and g is the gravitational acceleration of the earth [15].

$$T = 8.8\ \frac{h_w}{l_w} n \sqrt{\frac{w h_s}{g E_c p}} \tag{3}$$

The validity of Eq. (3) has been approved by Wallace and Mull by measuring the time of the main period of reinforced concrete structures. Figure (2) shows the variation of the fundamental time period, according to Eq. (3) assuming w=640 kg/m and E_c=27E+08kg/ m^2.

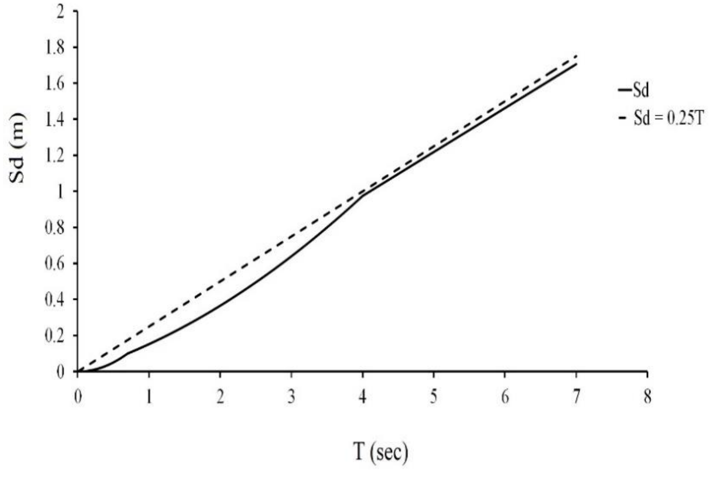


Fig. 1 Diagram of elastic displacement spectra

Considering the difference between a free degree system with a real building that is a few degrees free, the roof displacement can be 1.5 times the spectral displacement. Accordingly, with Eq. (2) and (3) the relative displacement (drift) is achieved at the roof level from Eq. (4), with the help of this relationship, the ultimate curvature value for the wall is calculated from Eq. (6) and (7) [15]. Figure (3) represents the way of changing the relative roof displacement to different proportions of the total area in the wall of one direction (p).

$$\frac{\delta_u}{h_w} = 0.00029\frac{h_w}{l_w}\sqrt{\frac{1}{p}} \qquad (4)$$

$$\varphi_u l_w = 0.0025\left(1-\frac{1}{2}\frac{h_w}{l_w}\right)+2\frac{\delta_u}{h_w} \quad (5)$$

$$\varphi_u l_w = 0.0025+\frac{h_w}{l_w}\left(\frac{1}{1707\sqrt{p}}-0.00125\right) \qquad (6)$$

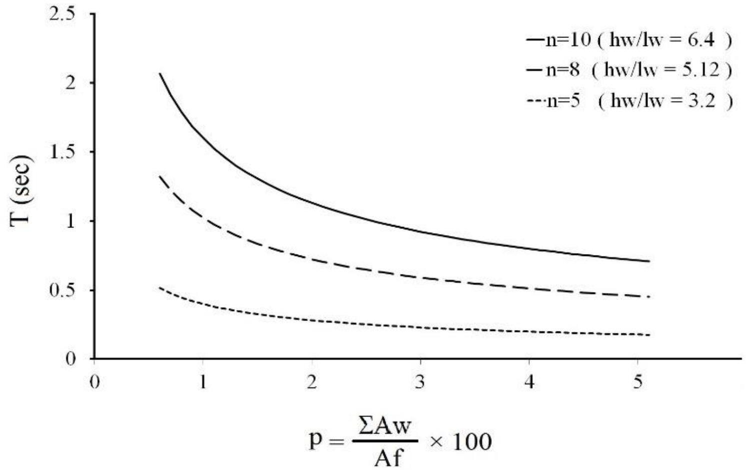


Fig. 2 Structural alternation time for different ratios of wall area to the floor area

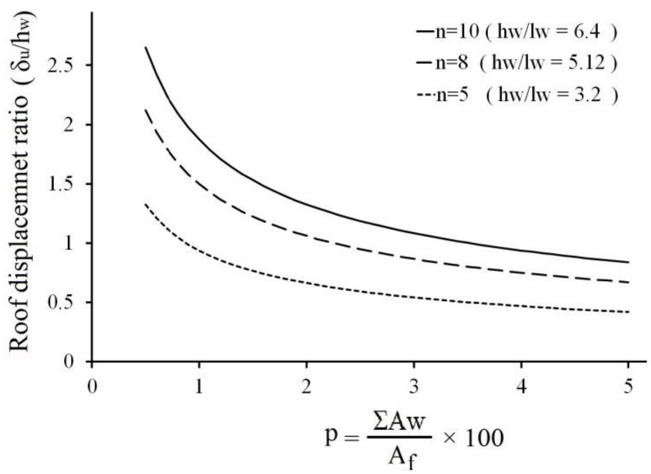


Fig. 3 Relative roof displacement for different ratios of wall area to the floor area

Figure (4) shows a typical cross-section of the reinforced concrete structural wall. For this section, the maximum strain of concrete can be obtained from Eq. (7) [15].

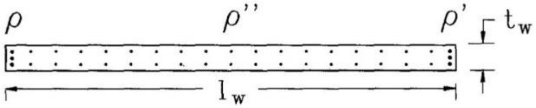


Fig. 4 Typical section of reinforced concrete wall

$$\varepsilon_{cmax} = \left[\frac{\left(\rho+\rho''-\frac{\gamma}{\alpha}\rho'\right)\frac{\alpha f_y}{f'_c}+\frac{P}{l_w t_w f'_c}}{\left(0.85\beta_1+2\rho''\frac{\alpha f_y}{f'_c}\right)}\right]\varphi_u l_w \tag{7}$$

In the above equation ε_{cmax}, the maximum stress of strain in concrete, ρ tensile reinforcement ratio equals to $A_s/t_w l_w$, ρ' the ratio of the compressive reinforcement is $A'_s/t_w l_w$, ρ" the ratio of distributed reinforcement in the wall web is A''_s / t_w l_w, β_1 is a reduction factor for utilizing uniform equivalent stress, f_y is the yield stress of the steel rebars, f_c is the ultimate compressive strength of the concrete, P is the axial force, L_w is the length of the wall, t_w is the wall thickness, α=1.5 and γ=1.25 the coefficient of over strength and strain hardening effect of steel for tensile and pressure, respectively and φ_u is the ultimate curvature. By accessing to the ultimate curvature amount (φ_u) the maximum strain of concrete can be predicted in the wall cross-section.

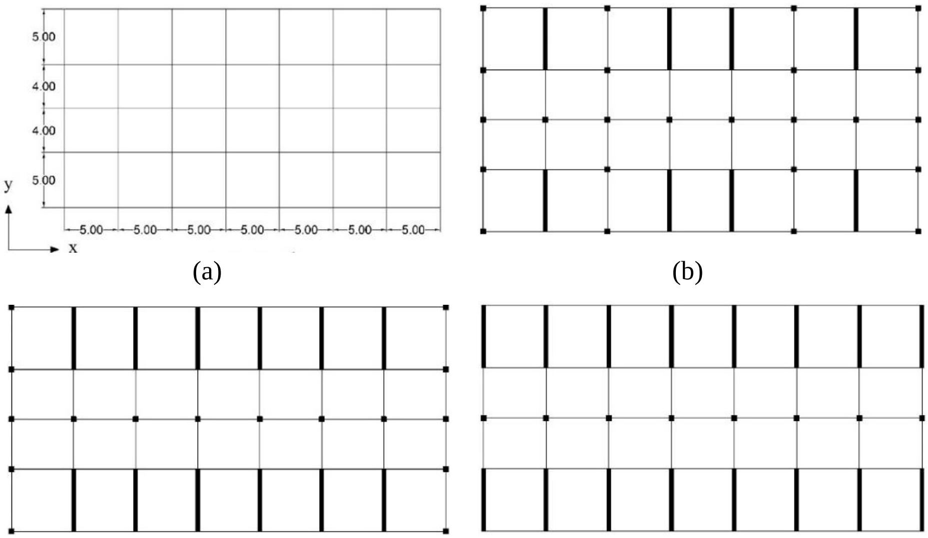
3. Introduction of the Analytical Models and Design of Reinforced Concrete Walls

In this study, in order to investigate the necessity of transverse rebar in the boundary areas of a concrete structural wall, a simple reinforced concrete structure is considered, as shown in figure 5-a. The structure is designed in two heights of five and eight stories in which the height of all stories is considered 3.2 meters. The lateral load resisting system in both directions is R.C. structural walls with a rectangular cross-section. The ratio of the total area of the wall to the area of the floor in the y-direction is constant and equals to 1.9 %. In the first model, eight walls in the y-direction are assumed shown in figure 5-b. In this case, the walls' behavior will be as a shear wall. Due to the low number of walls in the plan, the lateral contribution forces will be higher than the gravity force. In the other two models, shown in figures 5-c and 5-d, by keeping the total area of the existing walls on the floor area resulting in thinner walls, the number of walls has increased. As a result, their portion from lateral forces is reduced, and their performance will be like a bearing wall. In all models, two-way reinforced concrete slabs are considered a floor system. Dead load is 600 kg/m^2 and live load is 200 kg/m^2. The properties of the material used in the design of the models are presented in Table 1. In modeling of structures, the stiffness of the walls has been neglected in the weaker direction as well as the frame and wall interaction, and it is assumed that lateral forces are resisted only by structural walls. The models are designed utilizing ETABS 9.7.4 software [16]. The longitudinal reinforcement is distributed uniformly along the wall cross-section. In this study, the ninth edition of Iran's national building design standard is utilized.

Table 1 Properties of materials used in model design

Concrete		Steel Reinforcement	
f'_c (Mpa)	E_c (Gpa)	f_y (Mpa)	E_s (Gpa)
25	26.52	400	210

In the design of models that have the same number of stories, in order to have the correct comparison of results in the nonlinear analysis, the ratio of demand to the capacity of the wall (D/C) is maintained, unless it is necessary to put the minimum ratio of longitudinal bars (ρ = 0.0025).



(a) (b)

(c) (d)

Fig. 5 Hypothetical model for reinforced concrete structures: (a) dimensions of the building plan, (b) structures with 8 shear walls, Figure (d) structures with 12 bearing walls, Figure (d) structures with 16 bearing walls

The results obtained for the design of the walls with their geometrical specifications are expressed in Table 2. In this table, the models are named SW-m-n, where m represents the number of walls in the y-direction, and n represents the number of stories of structures. Also, in this table r is equal to the apparent wall ratio, $t_w$wall thickness, ρ, ρ' and ρ," as shown in Fig. (4), respectively, as the ratio of the longitudinal bars in the tensile, compressive, and wall areas. The l_c and h_c is the length and height required for trapping of the reinforcing according to the criteria mentioned by the design code regulations. Figure 6 shows, for example, the maximum amount of concrete compressive stress, as well as the length and height needed to create transverse reinforcement ($l_c$and h_c) for the SW-8-8 model. In Table (2) the periodicity obtained from linear analysis (T_a) with the results for the periodicity of relation (3), (T_c), as well as with the periodicity obtained from the proposed standard relation 2800 [13], (T_c), are compared. As can be seen, the results obtained from relation (3) provide a relatively closer evaluation of the main structural alternation time than the proposed standard 2800 relation [13].

With the help of Eq. (6) and (7) referred to in the previous section as well as using the p, p' and p" in Table (2), the ultimate elongation plot of the concrete is obtained for different proportions of the total area of the wall area (p), in Fig. (7) and (8), respectively, for structure 5 and 8.

Table 2 Specifications of designed models

Model	$r = \frac{h_w}{l_w}$	t_w (m)	Story	Longitudinal Reinforcement	ρ = ρ' (%)	ρ" (%)	L_c (m)	h_c (m)	T_3 (sec)	T_c (sec)	T_a (sec)
SW-8 -5	3.2	0.3	all	TO 12 @ 30	0.015	0.28	0.3	3.2	0.290	0.400	0.348
SW-12-5	3.2	0.2	all	TO 12 @ 30	0.022	0.43	0.5	4.0	0.290	0.400	0.348
SW-16-5	3.2	0.15	all	TO 12 @ 30	0.030	0.57	0.8	5.6	0.290	0.400	0.348
			1-2	TO 18 @ 25	0.033	0.64					
SW-8 -8	5.12	0.3	3-4	TO 14 @ 25	-	-	1.6	12.8	0.742	0.569	0.840
			5-8	TO 12 @ 25	-	-					
SW-12 -8	5.12	0.2	all	TO 12 @ 25	0.022	0.43	1.96	13.2	0.742	0.569	0.841
SW-16-8	5.12	0.15	all	TO 12 @ 25	0.03	0.57	2.0	16	0.742	0.569	0.841

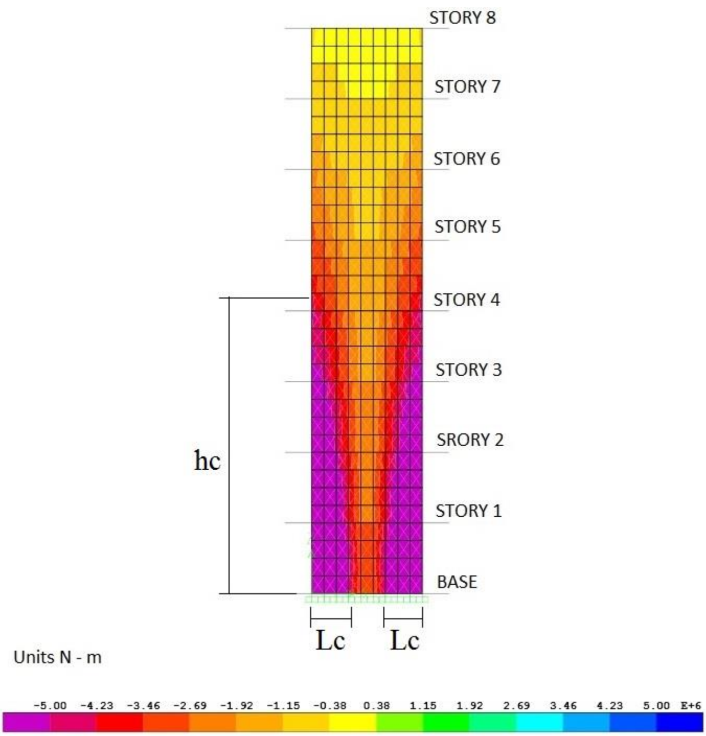


Fig. 6 Length and height required for transverse reinforcement enclosures for SW-8-8

As can be seen, none of the designed models will require transverse reinforcement for concrete confinement since the maximum strain created in concrete will be less than the final strain of non-confined concrete (ε_c= 0.0035). However, according to the criteria of the design code, each model following table (2) requires trapping during different heights.

To investigate this difference, in the following sections, static and dynamic nonlinear analysis, the maximum concrete strain, as well as the relative displacement [8], [9], [17] of the stories for each model without any confinements are evaluated.

4. NONLINEAR STATIC ANALYSIS

4-1. Modeling of reinforced concrete in structural walls

Nonlinear analysis requires proper analytical models for structural members, including reinforced concrete walls. Various methods have been proposed by researchers to simulate the nonlinear behavior of concrete structural walls [6], [8], [18]. These methods are mainly divided into three parts, including small scale methods, medium-scale methods, and large-scale methods. In small scale models such as the finite element model, the wall is divided into the limited number of small elements connected at a finite node.

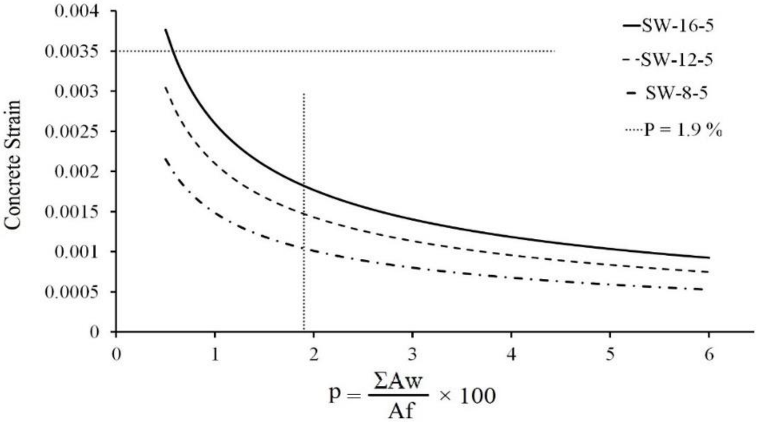


Fig. 7 Diagram of changes in concrete strain versus wall-to-plan ratio changes for 5 story structure

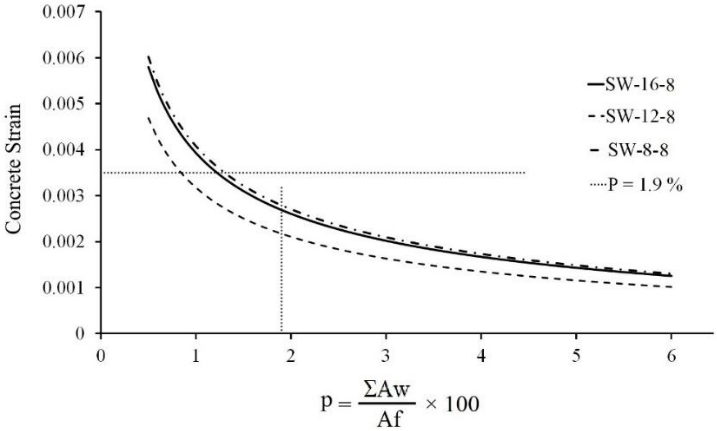


Fig. 8 Diagram of variations of concrete strain against wall-to-area ratio changes for 8 story structure

Although the Finite element method has very high precision and can consider the simultaneous effects of axial force, shear force, and bending anchor well [19], this model requires solving a large volume of complex equations and consequently very long duration. Therefore, it is not possible to apply this method for large structures in practice.

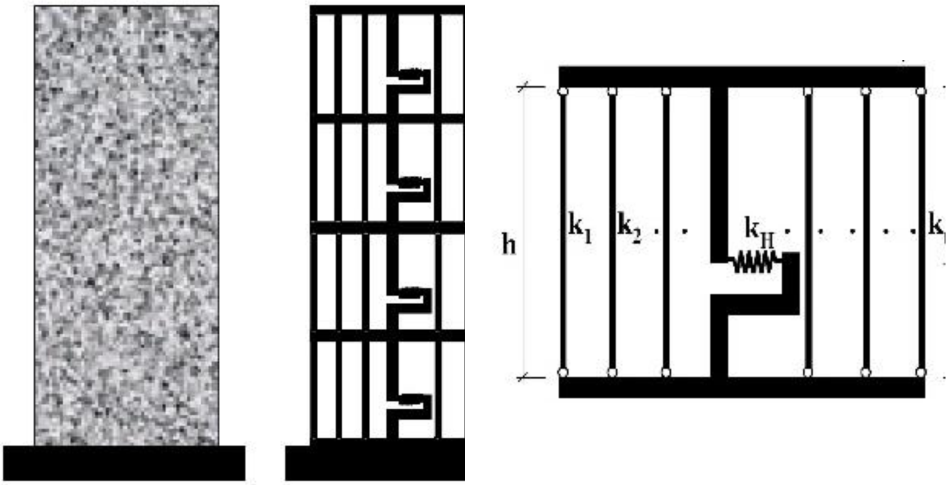
Medium-scale models were based on some structural theories (fiber model of beams). In this method, motion conditions and equilibrium are calculated on the original scale, while stresses and internal variables are calculated on the local scale. The average-scale models, on the one hand, allow the use of a simple hypothesis of the beam's theory (Navier-Bernoulli or Timoshenko) that would significantly reduce the bulk of the equations. On the other hand, integration allows the rapid integration of compliance laws in the context of uniaxial strain stress theory [20].

Large-scale methods generally have different types, such as single-component model, two-component model, multi-axis spring model, truss model, multi-vertical linear model (MVLE), and so on. Large scale methods are based on displaying the overall action of shear walls such as wall deformation, resistance, and energy absorption capacity. In this study, Vertical Multi Linear Method (MVLE) was used to model the walls. The model was first introduced by Volkano and his colleagues in 1988 [21]. In this model, several vertical elements with only axial stiffness are connected in parallel to each other at the top and bottom, as shown in Figure (9a). Two side elements (With an axial hardness of K1 and Kn) represent cross - wall parts in the flexural and axial behavior of the wall. A nonlinear horizontal spring is used to simulate the shear resistance of the wall. The relative rotation of the wall occurs around a point in the central axis of the wall and at the height of "c×h" from the bottom of the element. The parameter selection c is based on the curvature distribution at the height between stories (h), which is a number between 0 and 1. Based on the comparison between the laboratory results and the modeling results, the value of 0.4 for c is suggested by Volkano and his colleagues [21]. As shown in Figure (9b), the MVLE elements overlap the analytical model of the wall.

In this study, OpenSees software [22] is used to perform nonlinear analysis and modeling method MVLE used to simulate the wall. Concrete01 is used for modeling nonlinear concrete behavior, and Reinforcing steel for vertical steel bars is defined based on the proposed Kent, Scott, Park, Change, and Mender relationships, respectively. Figure 10 shows the stress-strain diagram of the defined material.

4.2. Performance of nonlinear static analysis and investigation by acting in structural changes of the target location

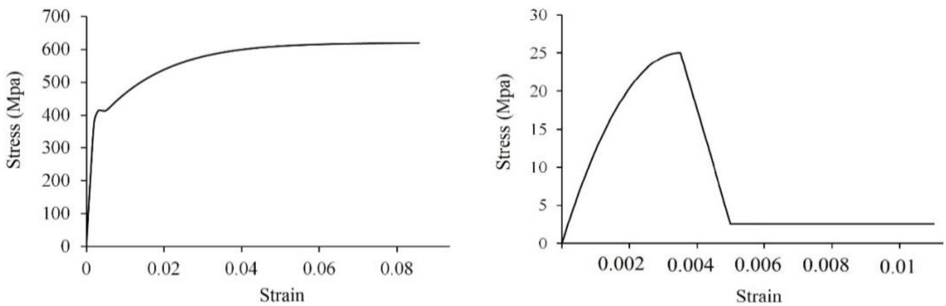
For nonlinear static analysis (Push-up), first, the load is applied as a load-control procedure on the structure. Then, by holding these loads constant, lateral forces are applied as displacement-control over the structure. Since the walls in the y-direction were examined in this study, lateral forces and consequently nonlinear static analysis were performed in this direction. After the capacity curve is obtained, the change of the target site has been calculated with the help of seismic improvement instructions, Journal 360 [23]. In Figure 11, the structural capacity curve of up to 1.5 times the target displacement and its ideal two-line curve are shown along with the target displacement values.



(a) (b)

Fig. 9 Modeling of reinforced concrete wall structure using MVLE method Figure: (a) MVLE element, (b) Positioning of MVLE elements and forming an analytical wall model

Figure (12) shows the drift of the stories in the target displacement. According to Standard 2800, this ratio should not exceed 0.025 for structures less than 5 floors and 0.020 for other structures. Fig. 13 shows the maximum deflection of the concrete along the wall length and in changing the target location for different models. As observed, the maximum strain generated at the foot of the wall is less than the confining stress of the concrete (ε_c = 0.0035) in the design code.



(a) (b)

Fig. 10 Nonlinear stress- strain diagram of materials: (a) concrete, (b) steel rebar

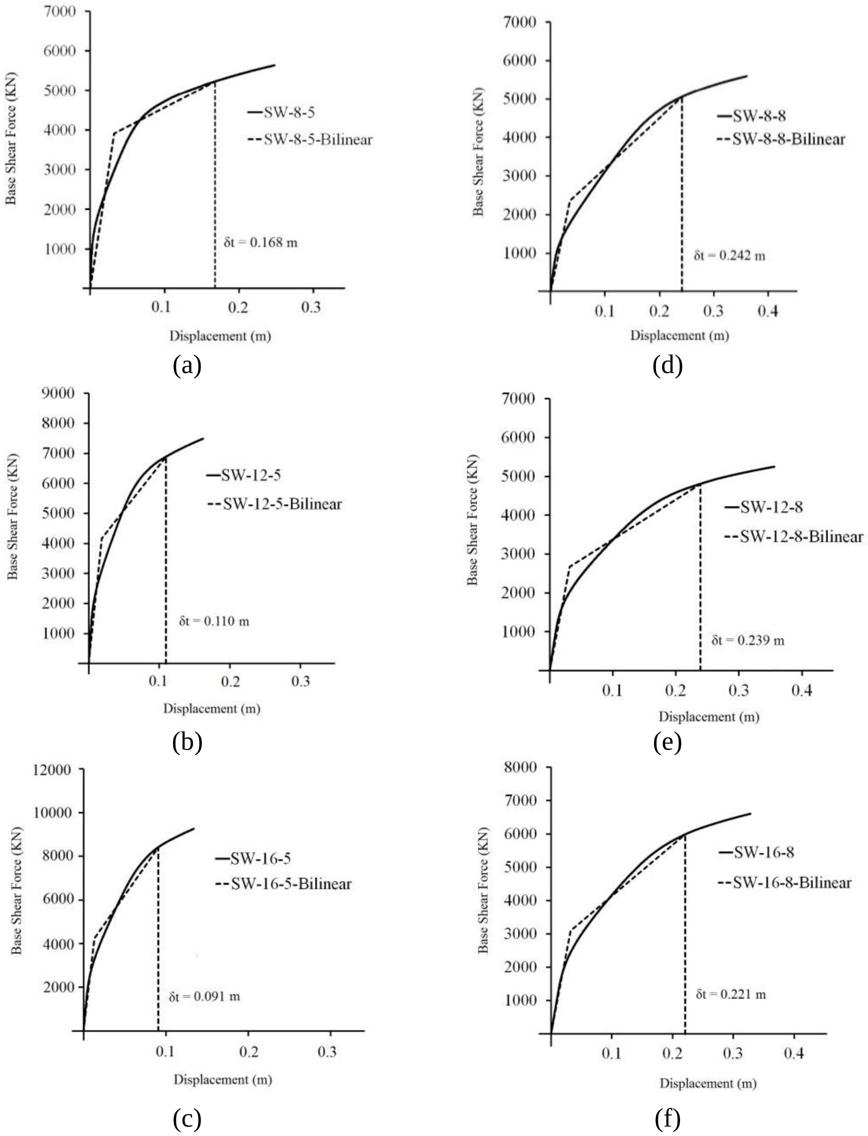
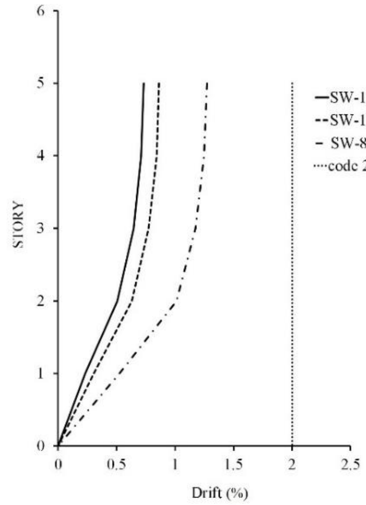
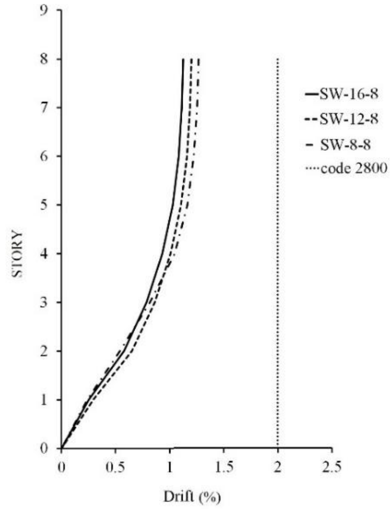


Fig. 11 Capacity curves of designed structures and ideal diagrams at target displacement (a) 5-story building with 8 structural walls, (b) 5-story building with 12 structural walls, (c) 5-story building with 16 structural walls, (d) 8-story building with 8 structural walls, (e) 8-story building with 12 structural walls, (a) 8-story building with 16 structural walls



(a)

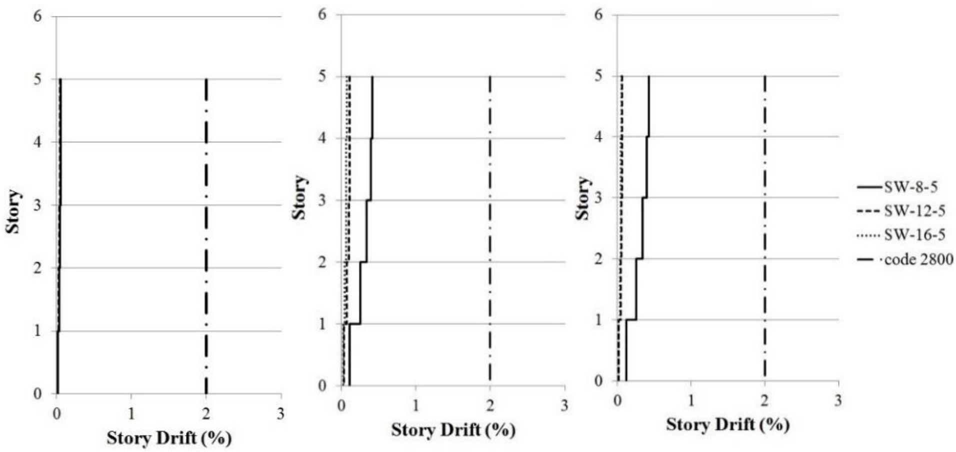


(b)

Fig. 12 Story drift ratio in target displacement: (a) 5-story buildings (b) 8-story building

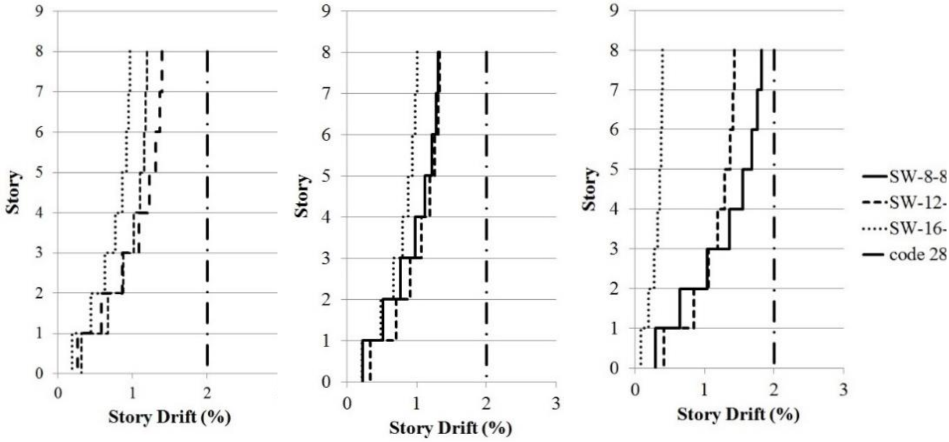
5. Dynamic Analysis of Nonlinear Time History

In this study, in addition to nonlinear static analysis, a nonlinear time history analysis method has been used to evaluate the designed models. For this purpose, three accelerations related to earthquakes in Loma Prieta, North Ridge, and Taiwan Smart were selected according to the conditions of the supposed region of the models. After scaling up with a standard range of regulation of 2800, they were used to evaluate the models. To the drift chart, the figures (13) and (14) show the maximum relative lateral displacement of stories for 5-story and 8-story models. It is observed that the relative displacement of the stories is lower than specified in the code.



(a) (b) (c)

Fig. 13 Relative lateral displacement of floors in 5-story models: (a) LomaPrieta, (b) Northridge, (c) Tiwan Smart, earthquakes



(a) (b) (c)

Fig. 14 Relative lateral displacement of floors in 8-story models: (a) Loma Prieta, (b) Northridge, (c) Tiwan Smart, earthquakes

CONCLUSION

The necessity of using transverse rebars to apply confinement at the edges of the framed wall was investigated in this study. For this reason, theoretical models had framed walls (shearing and bearing) with a simple plan, in which the total summation of the walls' area was kept constant on the floor area. In these models, the required length to create confinement were estimated according to the criteria of the design code instruction and also based on the displacement-based design method. The results of nonlinear static and dynamic analysis demonstrate that the rules in the design code are very conservative in applying transverse rebar to make confinement in concrete when the axial stress is more than 0.31 f_{cd}. Because, the transverse rebars can apply confinement and consequently increase the ductility of the wall when the strain value in the concrete reaches the corresponding strain of maximum stress (usually 0.003). It is also concluded that, based on the proper performance of structures, the simplified correlation of the displacement spectrum (Eq. (2) has sufficient validity to estimate the needed length for confinement in walls boundary areas. So, the other result from this study is that for a constant wall to floor area ratio, considering architectural aspects, the use of more walls with less thickness is more efficient than the smaller number of thick walls. This issue can distribute the bearing walls in the building plan causing reduction of target displacement, story drift ratio, and in result, lower seismic demand of the building.

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POTREBA ZA POPREČNOM ČELIČNOM ARMATUROM U CILJU UČVRŠĆAVANJA NOSEĆIH ZIDOVA OD ARMIRANOG BETONA IZRAČUNATA NELINARNOM STATIČKOM I DINAMIČKOM ANALIZOM

Armirani betonski zidovi jedan su od najefikasnijih sistema otpornih na zemljotres. Da bi se pružile odgovarajuće performanse protiv seizmičkih sila, treba osigurati njihovu duktilnost uzimajući u obzir neke principe dizajna. Budući da učvršavanje betona povećava duktilnost armiranobetonskih elemenata, projektna uputstva nastoje da povećaju duktilnost zida korištenjem poprečnih armatura u određenoj dužini ivica zida. U ovom istraživanju potreba za poprečnim čeličnim šipkama u cilju primenu učvršćavanja betona upoređuje se s jednačinama predloženim u prethodnim studijama projektovanja konstruktivnih nosećih zidova zasnovanih na pomeranju. U tu svrhu korištena je nelinearna statička analiza i vremenska analiza. Rezultati studije pokazuju da je bočna deformacija nosivih zidova konstrukcije manja od konačne granice određene projektnim pravilinicima, čak i bez poprečnih čeličnih šipki za učvršćenje betona.

Ključne reči: *Noseći zidovi od armiranog betona, nelinearna dinamička analiza, Pushover, OpenSees.*

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DESIGN AND FUNCTIONAL CHARACTERISTICS OF THE MULTI-FAMILY HOUSING ARCHITECTURE IN THE PERIOD OF MATURE AND LATE MODERN ARCHITECTURE OF NIŠ - CASE STUDIES

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Abstract. *The topic of this paper is the functional and design characteristics of multifamily (formerly collective) residential buildings created in the post-war period of Modern architecture of Niš. For the post-war period of intensive and mass construction of residential buildings, a time classification of constructed buildings was performed, and they are classified into two categories. The first category includes buildings built in the 1950s, in the period of the „mature" Modern architecture, which is a continuation of modern architecture of Niš between the two world wars. The second category consists of residential buildings created in the late 1960s and 1970s, in the period of the late (industrial) Modern architecture of Niš. In this paper, two representative examples of residential and commercial buildings from the mentioned periods were selected, both built on the 14. Oktobar square, in the central core of the city of Niš. As typological representatives of the mentioned periodizations of construction, the buildings will be analyzed in the form of two case studies.*

Key words: *Modern architecture in Niš, functionality, design, building, form*

1. INTRODUCTION

The term "housing" can, in the context of this research, be defined as the elementary and existential need of human action in architecture and the living space in general. This was especially the task of modernizing the cities of former Yugoslavia after the Second World War, which was primarily researched as a topic of optimizing "invested and obtained", all with the aim of designing buildings for „the masses", that is a large number of inhabitants. The processes that were carried out within the socio-political context of socialism by the previous state apparatus and profession, took place as complete initiatives

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with the general ambition of common improvement of the living conditions of citizens. The residential multifamily architecture of Niš in the period between 1945 and 1980 was based on social and humane ideas within the framework of construction, which were guided through the principles of the methodology of design and realization of buildings of that time. The aspiration towards rational, economical and humane housing was materialized through the optimal functionality of the apartments and the reduced architectural form of the buildings with emphasized primary-secondary plasticity of the facade planes. In addition to the above periodization and grouping of buildings in the previous chapter, the buildings of "mature" and "late" Modern architecture of Niš can be put into a certain spatial framework where residential and residential-commercial buildings within the central city core can be generally typologically grouped, in relation to buildings formed on the spacious boulevards, the former outskirts of the city of Niš. A characteristic example of representatives of authentic Niš architecture from the two mentioned periods in one place, on the 14. Oktobar Square, is a residential and business low-rise building from the period of the so-called „mature“ Modern architecture of Niš, built in the mid 1950s, and a high-rise building built twenty years later in the period of the late-industrial Modern architecture, opposite this low-rise building. The mentioned buildings will be analyzed as typological representatives of residential architecture from the mentioned periodizations of construction, in the form of two case studies. In addition to the selected buildings, the systematization of their parts and elements will be performed, all with the aim of objectifying the topic under research.

2. 14. OKTOBAR SQUARE - CITY-PLANNING LAYOUT AND SPATIAL ORGANIZATION OF BUILDINGS

One of the characteristic micro-urban city units - squares in Niš is certainly 14. Oktobar square. With its city-planning setting, it leans on one of the mentioned street backbones of the city from the time of "Winter's plan". The formed square represents the beginning of Obrenović Street (formerly Pobeda street) on the south side, which develops from there to the north through the main central part of the city all the way to the Oslobođenje Square, that is to the Fortress.

Fig. 1 14. Oktobar square - Schematic representation of the selected buildings (Source: author - based on part of the graphic documentation of PGR Mediana - first phase in Niš)

The city-planning layout of the square is an adopted model of the central park area - "islands" with high greenery that simultaneously form a roundabout. The island is mostly "framed" by residential buildings of different heights with commercial premises on the ground floor. On the north side of the square on both sides of Obrenović Street, there are residential buildings from G+3+A to G+5 in the original design, built in the 1960s. The residential buildings have a rectangular base and a double orientation, towards the street and the inner courtyard (Figure 1).

As a counterpoint to the longitudinal residential buildings, on the south side of the square there is a complex of residential tall buildings-towers also with business facilities on the ground floor. In this relatively small area, a high population density was achieved because in this case it was the height that was primary in the design process. (Figure 1.) The positioning of residential towers in that place proved to be a good solution, because in addition to a large number of inhabitants, other city-planning parameters were also met. Despite the great height, a sufficient distance from other buildings is provided, respecting the min. H/2 of a taller building, so there is enough insolation, especially on higher floors. Open views were achieved on all four sides, especially towards the central park, as well as towards the complex of the Orthodox Cathedral, which is located near the east side of the square. The only possibly disputable urban parameter is the number of parking spaces, especially from this perspective, but the standards from the period of construction which was in the early 1970s, should be taken into account. At that time, it was also not a practice to build underground garage levels near residential collective buildings, as it is today, almost half a century later.

3. Case Studies

3.1. Case study 1 "Marger" residential and business building on the 14. Oktobar square in Niš

The residential and business building "Marger", B1+G+3+A, was designed in the architecture bureau "PROJEKTBIRO" from Belgrade, the author was the architect Mihajlo Mitrović. The design and construction period was 1955/1956. The building in question was designed as a building in a staggered row consisting of four bays.

3.1.1. Architectural-urbanistic structure and form of the building - volumes and facade surfaces

The structure of the set volumes at the given location primarily represents a corner single tract on the corner of Obrenović Street and 14. Oktobar Square. By moving the part of the facade plane, that is shifting the part of the west facade towards the interior of the block, seen from the direction of Obrenović Street, four connected residential and residential-business bays with open views in all directions were obtained (Figure 2).

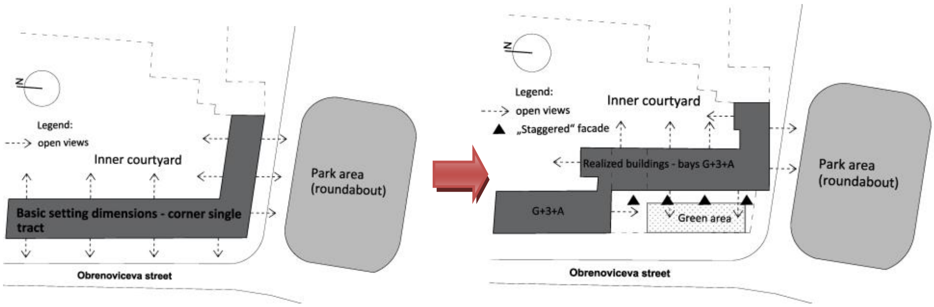

Fig. 2 Analysis of displacement- "staggering" of the part of the facade plane
(Source: author)

In addition to the disunity of the volume and the movement of the masses, the architectural form-facade composition represents a human-dimensional and discreet play of primary and secondary plasticity, primarily materialized in two levels. At the level of volume-mass and at the level of facade planes. The volume-mass level means the ratio of the basic volumes of the above-ground floors and the volume of the retracted attic in relation to the main western facade plane, as well as the mutual ratio of bay windows - balconies oriented towards the central park and the basic cube of the southern facade. The first level of "plasticity" of buildings includes subtractive openings in parts of the ground floor for the formation of passages to the inner courtyard-atrium, as well as subtraction of basic volumes at the ground level at the corners where accentuated uneven entrances to residential buildings are formed.

The next level in the installation of primary-secondary plasticity is the level of facade planes. "Plastic displacements" at this level are primarily characterized by the "full-empty" principle which is presented in the form of the main volumes ratio and openings in them, or walls, given in the form of windows or retracted balconies-loggias. At this level, there is a sub-level of tertiary plasticity that is formed in relation to the primary plane of the facade in the form of protruding frames or retracted parts of the facade around window openings, as well as slight "movements" of certain architectural elements in parts of balcony fences (Figures 3 and 4).

Fig. 3 Main street front - west facade of residential-business buildings
(Source: author - based on part of the graphic documentation of the final design from the Historical Archive of Niš)

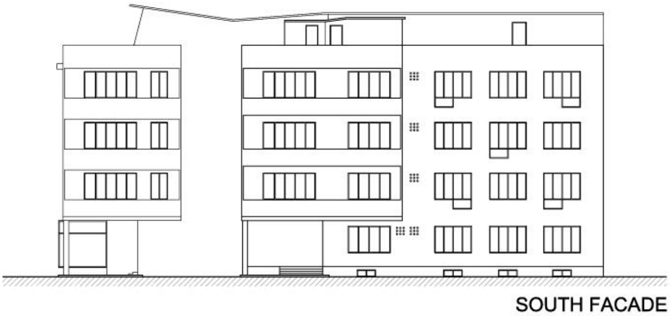

Fig. 4 South facade of residential-business buildings - facing the park
(Source: author - based on part of the graphic documentation of the final design from the Historical Archive of Niš)

Unlike the "moving" and dynamic facades of the buildings observed from the street front, the inner courtyard facades are characterized by a certain simplicity, "calmness" and uniformity of window openings without decorative plasticity. One-dimensionality is emphasized in the setting of the basic planes of the facade tracts, except in the part of the common vertical communications - staircases which are partially protruding in relation to the basic plane. Slightly protruding inner balconies - loggias, which are "supported" on both sides by the mentioned staircase, represent elements of "interruption" of monotonous facades. The manner of treating the facades of the street front "richer" than the interior-courtyard facades is a continuation of the matrix taken from the early Modern architecture of Niš, residential architecture that was created between the two world wars (Keković A., 2008).

3.1.2. Detail

In the case of the observed buildings, we can recognize two established levels of architectural details:

- design-plasticity (architectonics) and
- spatial-design detail (volumetry).

The protruding accentuated frames around the window openings on the west facades of the main street front are primarily design-plasticity shaped. In the immediate vicinity of the accentuated frames, a contrast was made by gently pulling in certain parts of the facade around the windows of the adjacent rooms. In that way, the frames in the "negative" were obtained, and the parts of the horizontal ring beams on the buildings were additionally highlighted. In the extension, a kind of "architectural play" of fence elements on the retracted balconies-loggias was used. By vertically shifting the "wavy" parts of the concrete fences covered with "salonit" slabs due to the visual effect, the perception of dynamic movement of the facade elements was created. It can be stated that all three types of the mentioned "details" form a unique facade unit and the main motif of the western (street) appearance of the buildings (Figure 5).

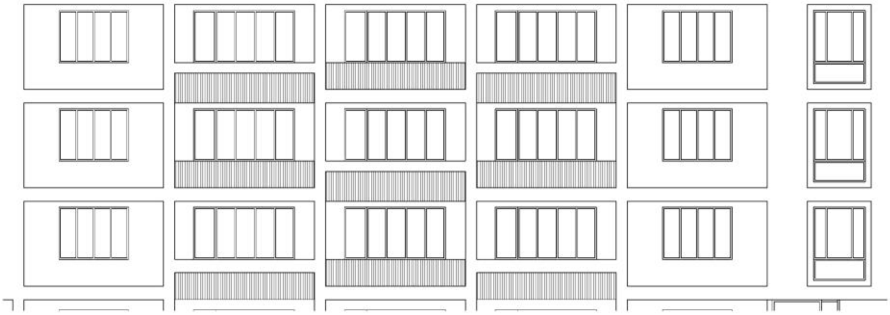

Fig. 5 Part of the western facade - "movement" of the facade elements and their mutual relationship
(Source: author - based on part of the graphic documentation of the final design from the Historical Archive of Niš)

On the concrete example of the presented buildings we can recognize all the mentioned cases and spatial-design details.

In addition to the passages and retracted attics, the dominant spatial-design architectural detail are the open living areas, balconies-loggias in the form of bay windows, designed so that they are oriented towards the central park (Figure 6).

Fig. 6 Balconies-loggias oriented towards the central Square - park
(Source: author)

The entrances to the residential parts of the buildings are especially emphasized, and they certainly belong to the group of spatial-design details. Although the entrances to the residential part of the buildings are "sidelined" in the corners of the bays, their visual experience is a reminiscence of the entrance covered porches of traditional Serbian houses, which in addition to their basic purpose also have the function of the viewpoint, resting and socializing. Also, within these entrance parts, the emphasized spatial element consists of dominant pillars, which also reminds of mostly wooden constructive elements of old houses from traditional Serbian architecture. In this segment, the contextual design approach in shaping and creating post-war modern architecture of Niš is clearly seen.

3.1.3. Typical storey assembly

According to its structure, the assembly of the typical storey of the subject buildings can be considered as a single-tract, angular and double-sided built-in assembly. It can also be characterized as an asymmetrical set of dispersed form, and generally two-sided orientation (G. Jovanović, 2007) (Figure 7).

The assembly of the standard storey has an optimal and favorable two-sided orientation of all bays individually, that is all apartments. Especially in terms of maximally used views towards the near and far outside environment, that is the inner courtyard, an optimal solution was achieved primarily through good structuring and quality layout of the buildings in the manner described in the previous presentation. Due to the two-sided orientation of the apartments of all buildings, this assembly belongs to the typology of shallow tract assemblies.

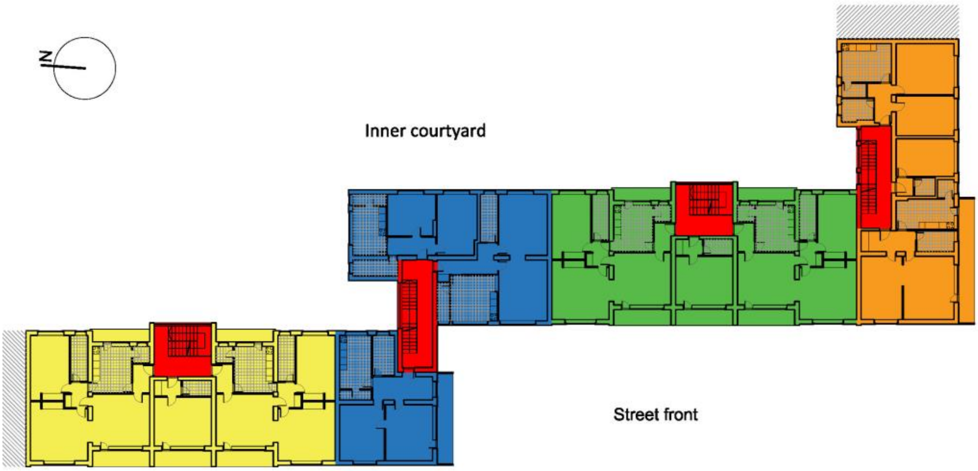

Fig. 7 Typical storey assembly
(Source: author - based on part of the graphic documentation of the final design from the Historical Archive of Niš)

A characteristic element that generates each assembly around itself are common vertical communications - stairs and elevators, as well as common horizontal communications - corridors, passages, galleries. (Jovanović G., 2007) On the subject example, there are two types of common communications in the form of U-shaped and straight stairs with corridor extensions. The two bays with U-shaped stairs are completely identical in their structure of the assembly, that is the structure of the apartments within them. They contain three apartments "on the staircase", two of which are symmetrically placed "as in a mirror" in relation to the staircase, while one studio is "inserted" between them. The other two buildings are equal according to a straight staircase with a corridor area and the number of apartments, three apartments in each bay. The structures of these apartments are all different and have different views (Figure 7).

3.1.4. Functional organization of characteristic apartments on a typical storey

Taking into account the fact that the investor of these residential and business buildings was the former JNA (Yugoslav People's Army), it already says about the "fulfillment" of quality not only in terms of design and material, but primarily in the functional sense of the designed apartments. As already mentioned in the previous chapter, the assembly of the standard storey consists of four bays with three apartments on the staircase, of different structures and areas. The representation of apartments by area ranges from a studio to two-room and three-room apartments.

The two bays within the assembly (bays A and C according to Figure 8) are completely identical, with the identical structure of the repeating apartments, and where the larger apartments have a two-sided orientation. For that reason, these characteristic apartments will be analyzed in more detail. The apartments within bays B and D are mostly two-room apartments, except for one studio apartment, while they differ in the structure of functional organization and state of equipment (Figure 8).

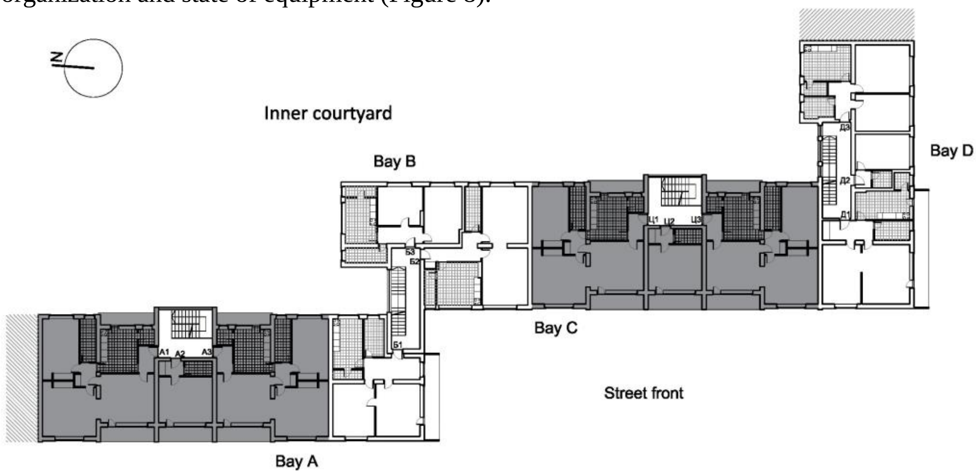

Fig. 8 Structure of apartments within the bays
(Source: author - based on part of the graphic documentation of the final design from the Historical Archive of Niš)

The three-room apartments of identical bays A and C are also completely identical in terms of their functional layout and areas, and face each other according to the "mirror" system in relation to the corresponding staircase, that is the middle, centrally positioned studio. Thanks to the small depth of the tract, the apartments have an open two-sided east-west orientation, while they are also two-sided "built" in the north-south direction. One of the basic characteristics is the "non-existence" of hallways, except for the entrance party, which is the result of striving for greater rationalization and maximum use of space. This results in the concept of a "passage room" in the west part of the apartment, which is also multifunctional: it has the function of a living room, common gathering (gathering center), drawing room for guests, dining room, communication with another room or other parts of the apartment. This design concept is partly taken from the Early Modern architecture between the two wars and the so-called "Belgrade" drawing room apartment, with clearly separated zones for residential and household area (Keković A., 2008).

In the specific case of the observed apartments, the zone for household, that is food preparation (a kitchen with a pantry) is physically separated in the east part of the apartment, but it also has a direct connection with the hallway to access the rooms and the bathroom. It can be stated that in that way a double "circular connection" was achieved in the communication within the apartment (Figure 9).

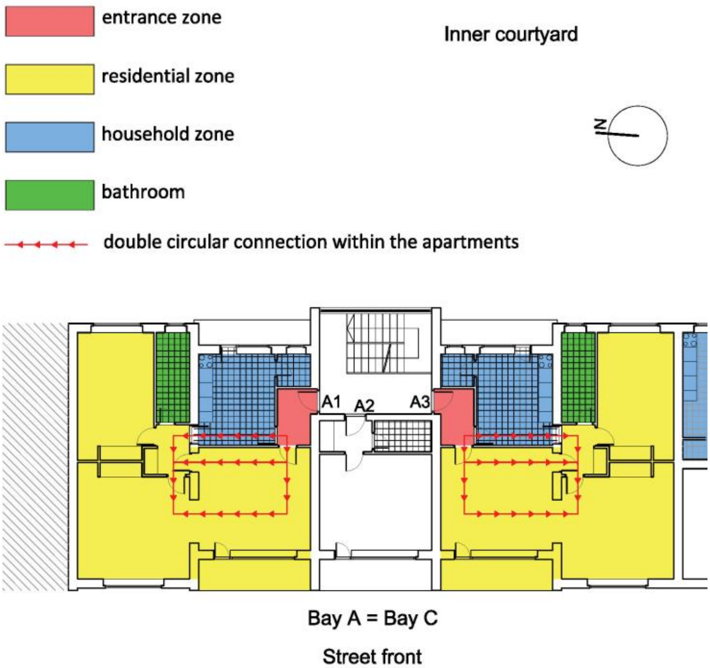

Fig. 9 Apartments in a "mirror" with a double circular connection
(Source: author - based on part of the graphic documentation of the final design from the Historical Archive of Niš)

In addition to the two balconies-loggias on the west side and in the part of the east kitchen block, the apartments also have built-in closets in the children's room - study and the bedroom, which further increases the quality of these apartments since other apartments on that floor do not have them.

3.2. Case study 2
Residential and business complex on the 14. Oktobar square in Niš

The residential and business complex with the number of storeys from B1+G+3+A to B1+G+2M+16 was designed in the architecture bureau "GRAĐEVINAR" from Niš, the author was the architect Predrag Janić. The design and construction period was 1974/1976. The building complex in question was designed as a free-standing system of staggered bays.

3.2.1. Architectural city-planning structure and form of the building - volumes and facade surfaces

The structure of the set volumes of the residential and business complex primarily represents a free-standing building of disparate form, positioned in the northern part of the residential block. The unique architectural whole has been decomposed into several smaller bay units in order to enable optimal natural lighting and ventilation of as many residential and auxiliary rooms as possible. This is usually achieved by subtraction and incision of the basic volumes, as well as partial discharges of certain spatial elements in relation to the main facade plane. In addition to the movement of the masses at the plan level, the shearing was also performed vertically by designing bays with different number of storeys. The result is a unique architectural composition of the entire organic form, which is composed of several smaller parts, subunits-modules, with open views in all directions (Figure 10).

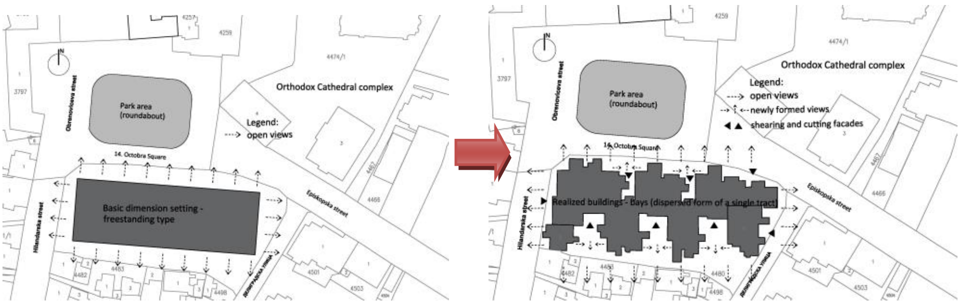

Fig. 10 Analysis of the formation of dispersed volumes of the residential-business complex (Source: author - based on part of the graphic documentation of the final design from the Historical Archive of Niš)

"Organic treatment of the architecture of the complex is reflected in the strong connection of the blocks with the terrain without pulling masses and discharges in the form of bay windows or overhangs. The movement of masses is emphasized by clearly expressed elements of concrete bearing walls, vertical articulation with horizontal elements of parapets and loggia railings. "(Janić P., 1974)

In addition to the disunity of the volume and the movement of masses on the horizontal and vertical level, the architectural design-facade composition represents a discreet play of primary and secondary plasticity at the level of the facade planes. The plasticity of the dispersed form is additionally emphasized according to the "full-empty" principle, which is realized in the part of the indented balconies-loggias in relation to the full walls. The dominant motif of prefabricated concrete elements in the form of window frames with sloped corners and edges, is a recognizable visual detail of the entire spatial structure. Slight slopes on the final parts of the semi-prefabricated and prefabricated facade elements also contribute to the complete impression of "softened" orthogonality.

At the level of the facade design and art treatment, there are also vertical flutes on the horizontal division of the facade prefabricated panels, reinforcing the impression of gradation of the entire architectural complex (Figures 11 and 12).

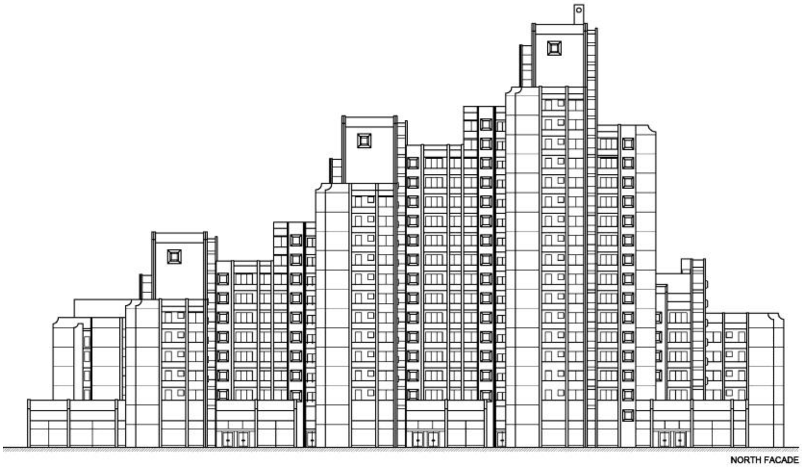

Fig. 11 Main street front - United north facade of all bays of the complex
(Source: author - based on part of the graphic documentation of the final design from the Historical Archive of Niš)

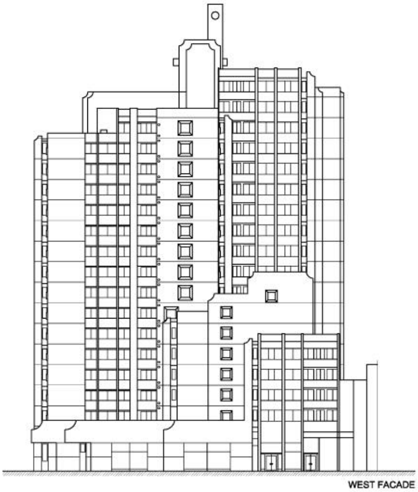

Fig. 12 Side west facade of residential and commercial bays - street view
(Source: author - based on part of the graphic documentation of the final design from the Historical Archive of Niš)

3.2.2. Detail

As in the previous case, in this example of the observed buildings we can recognize two established levels of architectural details:

- design-plasticity (architectonics) and
- spatial-design detail (volumetry).

The first group primarily includes protruding and accentuated frames around window openings on prefabricated facade panels, while the panels themselves are a detail of secondary plasticity on facade planes due to their accentuated horizontal division (setting) and vertical structure of cut-in flutes. A special detail are the side openings in the wall panels of the balconies-loggias with vaulted (bent) edges. The arched ends of the facade panels are also a kind of dominant detail in the space, which gives a special feature to the overall size, that is the silhouette of the entire structure (Figure 13).

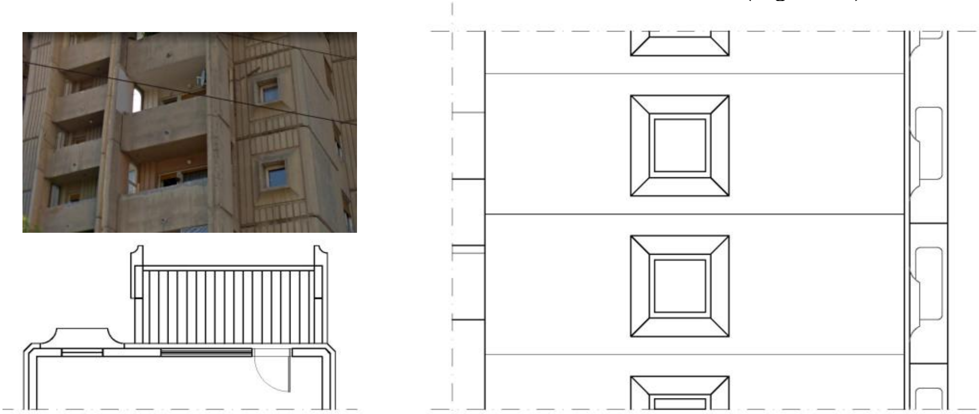

Fig. 13 Details of facade elements and their mutual relationship
(Source: author - based on part of the graphic documentation of the final design from the Historical Archive of Niš)

In addition to the playful form of dispersed "organic modules" of housing units treated as parts of a larger "house-organism", the dominant spatial-design architectural details are cantilevered overhangs in the form of entrances to business premises on the ground floor, designed so that they are all oriented to the central park (Figure 14).

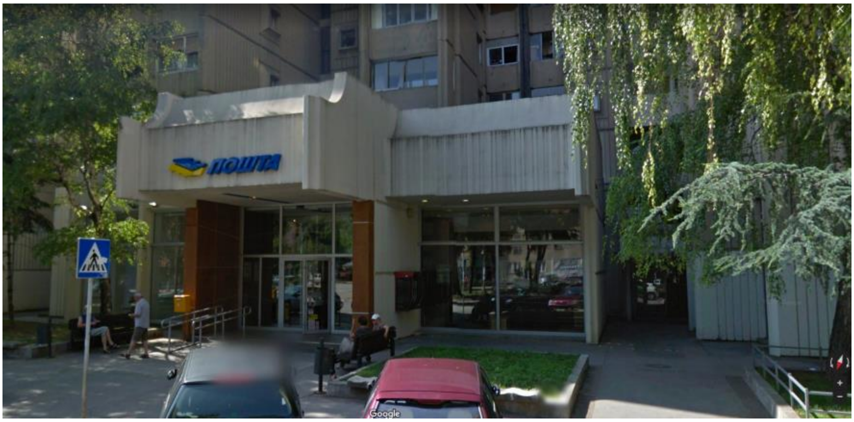

Fig. 14 Overhangs at the entrances to business premises oriented towards the central Square - park
(Source: author)

3.2.3. Typical floor assembly

According to its structure, the assembly of the typical floor of the buildings of the residential-business complex can be considered a free-standing assembly, of asymmetrical and dispersed form (Figure 15).

The type of floor assembly has an optimal and favorable multilateral orientation of all bays individually, that is all residential units. In terms of used views towards the near and far exterior to a maximum degree, the optimal solution was achieved primarily by good structuring and diversification of the elementary form of the deep tract. In that way, an excellent multilateral orientation was achieved, especially in the interior of the apartment block on the south side, despite the fact that the basic layout of the assembly has a great depth of the tract.

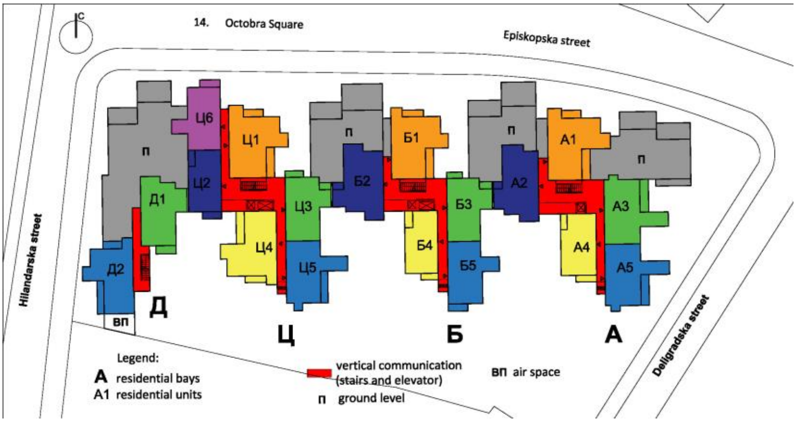

Fig. 15 Typical floor assembly
(Source: author - based on part of the graphic documentation of the final design from the Historical Archive of Niš)

In the presented example, all four bays have common communications in the form of a straight staircase with corridor extensions. Depending on the number of storeys of the bays, the required number of elevators is planned within the framework of joint communications. According to the structure of represented housing units within the assembly of the standard floor, A and B bays have five apartments on the staircase of different structures and apartment areas, C bay has 6 apartments, while D bay has only two apartments on each floor. The first three bays generally have a very similar structural organization of apartments and vertical communications, while the alternate solution of apartments of the D bay is somewhat more significant compared to the others (Figure 15).

3.2.4. Functional organization of characteristic apartments on a typical floor

The investor of this residential and business complex was also JNA (Yugoslav People's Army), with its strict requirements and conditions especially related to the respect of the former standards and regulations, the organization of space within the housing units, as well as the quality of installations and equipment. Within the technical description, that is, the design brief signed by the investor, it is stated, among other things:

"*In each apartment, there should be a direct connection from the hallway and corridor – a hallway with a living room – a kitchen, a bedroom, a bathroom and a* *separate toilet. The walk-through room is not generally accepted. The dining area can be placed in a suitable place depending on the organization of the apartment, so that it is connected to other rooms in the apartment, and with a small increase of area, a secondary living room can be created. In order to organize apartments more rationally and elastically, it is allowed to let the bathrooms, toilets, food and household pantries be without daylight, or with indirect daylight, provided that proper air exchange is supplied by ventilation. Halls and connection corridors do not have to have direct sunlight and special ventilation. It is enough to provide indirect lighting for them from the adjacent rooms that are directly lit.*" (Janić P., 1974).

All of the above speaks a lot about the required quality, not only in terms of design, but primarily in terms of the functional sense of designing apartments. The assembly of a typical floor generally consists of four bays with a different number of apartments on the staircase, different structures and areas. Representation and structure of apartments by area ranges from two-room and two-and-a-half-room apartments to three-room and three-and-a-half-room apartments.

The two bays within the assembly (bays A and B) have the same number of designed apartments per bay (five apartments each), a very similar structure and area of the represented apartments. The difference is in the alternate solutions of the housing units of the corner bay A in relation to the apartments of the bay B which is positioned between two bays (A and C). The number of planned apartments within bay C is six, with one apartment more in the northern part compared to bay B, while the functional organization and area of the other five apartments is very similar to apartments of bays A and B. Within the bay D, which is also a corner bay on the west side, there are two apartments on the floor of different structures, which also represent alternate solutions in relation to similarly positioned apartments within the first three bays. The figure below shows the basis with the functional organization of the characteristic apartments of bays A and B, while the apartments within bays C and D are only alternate solutions of fundamentally identically structured apartments as well as apartments within the first two bays (Figure 16).

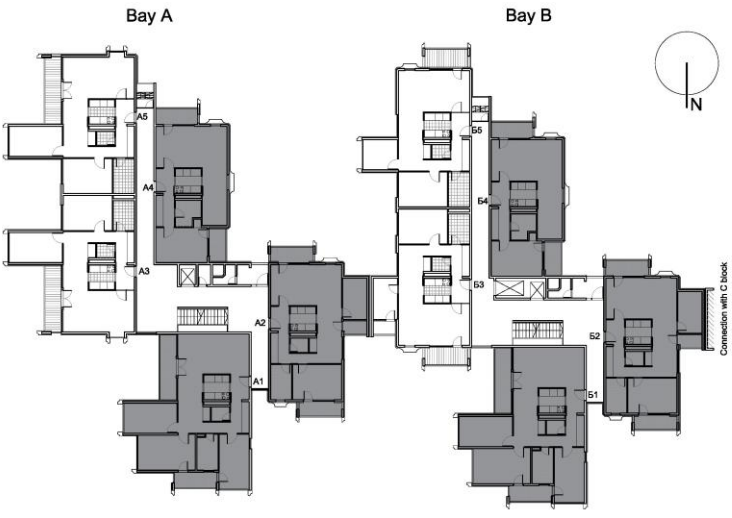

Fig. 16 Structure and functional organization of apartments within bays A and B.
(Source: author - based on part of the graphic documentation of the final design from the Historical Archive of Niš)

As can be seen in the figure, the three-and-a-half-room apartments A1 and B1 of bays A and B are completely identical in terms of their functional layout and areas, as well as the two-and-a-half-room apartments A2 and B2, and the two-room apartments A4 and B4. For apartments A3 and A5 it can also be stated that they are identically structured according to the principle of "mirrors" within the same bay, while apartments B3 and B5 are basically with the same functional organization but with certain variations in relation to each other and in relation to equally positioned apartments within the bay A. The main characteristic and the main motif of the structural and functional organization of all apartments, generally on the typical floor, is the positioning of the sanitary block (kitchen and toilet) in the central part of the apartment, around which there is circular communication, that is "circular connection" in the apartment. A certain degree of polarization into day and night zones was achieved in this way, between which expanded communication with the dining room and additional space for children to play or work was intended, so instead of a rigid "demarcation" between the two zones, a spatial connection that was more elastic, direct and flexible was created. The shortest direct access to the living room and central sanitary block from the entrance was also provided, as well as the dining area directly through the kitchen, without violating the elementary level of privacy and comfort in the area intended for resting and dining. Extended circulation and communication from the entrance provides access to the night zone (bedroom and children's room), which can also be accessed through extended communication, that is the mentioned circular connection (Figure 17).

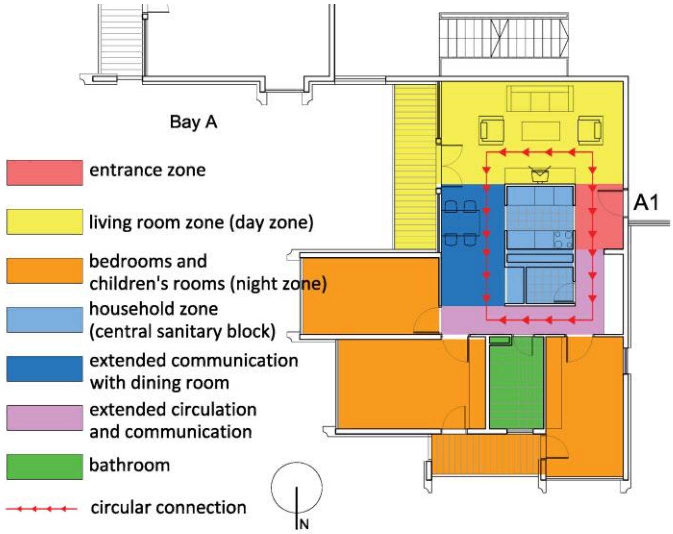

Fig. 17 Apartment A1 in a with a circular connection within bay A
(Source: author - based on part of the graphic documentation of the final design from the Historical Archive of Niš)

It should be noted that the circular connection contributes to:„ *a) raising the general quality of the apartment, b) reducing useless communications, c) better usability of the apartment area, e) better social integration of family members, etc.* (Alfirević Đ. i Simonović Alfirević S., 2018), *which is why it was often applied in residential architecture throughout*

Yugoslavia. In relation to the first post-war examples in which the circular connection is present in a reduced form, later examples created during the 1970s indicate the ability of designers to achieve complex circular schemes by functional structuring of space, which in some examples border on the concept of "liquid" space.“ (Alfirević Đ. i Simonović Alfirević S., 2016)

In addition, as Jovanović-Nenadović points out, locating the technical block in the central part of the apartment so that it represents a kind of constitutive motif of the apartment - the command bridge - the central point of household management control, has become recognized as a characteristic approach to apartment organization. (Ristić Trajković J., Stojiljković D., Međo V., 2015)

The analyzed example of a three-and-a-half-room apartment A1 within the bay A clearly shows the application of the already mentioned and established design principles of the 1960s and 1970s, which appeared as concepts of habitological efforts in housing in the form of an apartment with extended communication, with central sanitary core, apartments with circular connection, etc. In the specific case of the presented apartments, it is a combination of these principles, which raised the achieved quality of housing to a higher level.

4. CONCLUSION

Based on selected and analyzed representative examples of buildings in Niš, created in two periods of one epoch that we call Socialist Yugoslavia, several conclusions can be drawn. First of all, that the presented buildings, as well as many others built in those time periods, were the result of a huge effort and aspiration at the level of the state to achieve, in addition to a large built-up fund of housing construction, a certain quality in the realization of buildings, primarily in the structuring of the functional organization of apartments. Then, that there is an obvious technological progress in the second period of the so-called "Late" Modern architecture, which enabled an even greater increase in standards, the use of new structural systems, prefabricated construction and prefabrication of elements, as well as more storeys. That the influence of the Army, that is JNA as an investor, greatly contributed to the mentioned quality, primarily in the functional, and certainly in the formal sense, reaching the required level. The period of post-war intensive housing construction, both in Belgrade and other larger and smaller cities of former Yugoslavia and in Niš, must be viewed through the prism of self-governing socialism, which according to (Ristić Trajković J., Stojiljković D., Međo V., 2015) „*is primarily connected with the achieved quality of housing in terms of humanization of the environment and functional organization of housing units. Modern residential architecture and city planning were viewed as a representation of social, political, economic, demographic and cultural changes in the period of socialism.*“ Also, supporting the facts about the special characteristics of the residential architecture of the post-war Yugoslav Modern architecture in general, as well as in Niš, there is a consideration which (Alfirević Đ. And Simonović Alfirević S., 2018) in their scientific research work state that among other things: „*Establishing the boundaries of the subsistence in collective housing, maximum spatial "packaging" and optimal functionality of apartments were the basic imperatives within which over time there was a tendency to experiment with new housing patterns in order to find more pragmatic and humane solutions in mass housing construction of high densities. ... it can be characterized by a large number of different examples of* *apartment organization, between 1945 and 1991 in Yugoslavia, which were based on at least one of the presented habitological concepts - expanded communication, circular connection, central sanitary core or extended views in the form of enfilades.“*

Undoubtedly, such a global movement as Modern architecture is, brings with it many objective shortcomings at all levels of construction. However, if architecture should reflect the state of mind of a certain period, political and economic conditions, and represent a cultural and social phenomenon that sublimates the diversity of a particular environment in which it is built, then certainly the Modern architecture of Niš in the postwar period deserves attention in the form of research and more detailed analyses, because it is an indisputable fact that at that time it was designed and built paying full attention both to the community and the individual, both to the city and the apartment.

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OBLIKOVNE I FUNKCIONALNE KARAKTERISTIKE ARHITEKTURE VIŠEPORODIČNOG STANOVANJA U PERIODU ZRELE I KASNE MODERNE NIŠA – STUDIJE SLUČAJA

Tema ovog rada su funkcionalne i oblikovne karakteristike višeporodičnih (ranije kolektivnih) stambenih objekata nastalih u posleratnom periodu niške Moderne. Za posleratni period intenzivne i masovne izgradnje objekata za stanovanje izvršena je vremenska klasifikacija izgrađenih objekata koji su svrstani u dve kategorije. U prvu kategoriju spadaju objekti izgrađeni pedesetih godina 20.tog veka, u periodu „Zrele“ Moderne koji predstavlja nastavak niške moderne arhitekture podignute između dva rata. Drugu kategoriju čine stambeni objekti nastali kasnih šezdesetih i sedamdesetih godina, u periodu „Kasne“ (industrijske)Moderne Niša. U ovom radu su odabrana dva reprezentativna primera stambeno-poslovnih objekata iz pomenutih perioda, oba izgrađena u okviru trga 14.tog Oktobra u centralnom jezgru grada Niša. Kao tipološki predstavnici pomenutih periodizacija izgradnje, objekti će biti analizirani u vidu dve studije slučaja.

Ključne reči: *Moderna Niša, funkcionalnost, oblikovnost, objekat, forma*

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APPLICATION OF DICHROIC GLASS IN THE ARCHITECTURAL DESIGN OF BUILDINGS

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691.629

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Abstract. *The application of coloured and optical glass in architecture is of great importance in terms of creating spatial dynamics and uniqueness of space. Dichroic glass is a type of glass coated with a thin layer of metal, which causes the glass surface to change in colour depending on the viewing angle. The colour of the glass depends on the incidence of different wavelengths of light passing through or bouncing off the glass surface, thus creating different effects of colour refraction. Created effects provide different possibilities in the design of buildings and improvements in the aesthetic quality of the interior space. This paper deals with the analysis and application of coloured dichroic glass in architecture and interior design.*

Key words: *Dichroic glass, coloured glass, colour refraction, optical glass*

1. Introduction

The transparency and translucency of glass has historically given an aesthetic quality to architecture like no other material. It gives a building the ability to change, to move, and to create certain environments. The way in which light passes through a piece of glass in a building can be a powerful design tool for an architect. The glass can reflect, bend, transmit, and absorb light, all with great accuracy (1). Combined with modern technologies and materials such as steel, concrete, aluminum and other materials, this ancient building material has become one of the most important materials in architecture (2). The material properties of glass and its ongoing technological development offer particular opportunities. Modern types of glass, because of their ability to change their characteristics and the ability to adapt to different space, replace other types of materials, thus creating a new kind of aesthetics (3). Dichroic glass, which, in addition to all

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standard features, has the ability to change colour depending on the angle of observation, is one of the new, modern types of glass. The constant change of colour, as well as the three-dimensional structure, gives many possibilities for architects to create very dynamic, colour effects in the object when designing buildings using Dichroic glass. This paper deals with the characteristics and types of Dichroic glass as well as case studies of its application in facade design and interior design.

2. Dichroic Glass

Dichroic glass is modern, composite, opaque glass composed of a layer of glass and micro layers of metal or oxide that show a change in colour depending on the lighting conditions, time of the day or season. Although it is commercially known as "Dichroic", this glass can have a coating or overlay in three - "trichroic" or more colours - "pleochroic". Dichroitic filters applied to glazing are of particular interest to architects. These filters consist of perhaps 10 to 20 alternately low and high refractive layers of various thickness. The typical thickness of these layers is between 45nm and 110nm. The layers are applied by using the SOL-Gel process. Therefore, they are suitable for application on surfaces curved in two dimensions, but on surfaces and bodies with three-dimensional curvature it is usually not possible to achieve an adequately even coating (4).

Dichroic glass first appeared in the 4thcentury AD, as a piece of Roman glass, a transparent glass structure containing colloidal gold and silver particles arranged on a matrix of glass in certain proportions, so that the glass had the ability to transmit certain wavelengths of light that were passing through the glass, and thus the projections and refractions of different light colours (5). In the 20th century, in 1950s and 1960s, NASA began to develop dichroic glass, a technology in which extremely thin metal films were vacuum deposited on the glass surface. The aim of developing such glass was to protect the aircraft from the harmful effects of cosmic radiation, as well as to protect people from the flash of sunlight (5). Further development of dichroic glass has led to commercial applications in art and architecture, in which the process of coating glass with thin layers of metal allows some wavelengths of light to bounce off the surface while other wavelengths pass through the surface of the glass, resulting in discoloration depending on the light being absorbed or reflected, thus producing different visual effects of (5).

In architecture, dichroic glass was first used in 1985 on the Sweeney Church design in Indianapolis, USA by the architectural bureau of James Carpenter Design Associates (15). The glass was mounted on the largest window (dimensions 9.35 x 3.06 m), which is divided into five parts by vertical elements made of ordinary glass, fixed by horizontal stiffeneres made of dichroic glass. The light across these glass bands falls in different colours, influenced by the reciprocal effect of the transmitted and reflected rays along the wall. Depending on the time of the day or year, with the change in the position of the sun and the angle of the incident rays, different light changes occur. As a result, there are four qualities of light occupying the space: 1) the original light which has not been manipulated by any instrument, 2) the reflected light which is reflected by the mirrored panels, 3) the non-light (shadows) which is blocked by the mirrored panels, 4) the transmitted light which passes through the clear glass boards. The four qualities of light interact with one another, except 1) and 3) for they are parallel in space and generate five effects: 1) +2), 1) +4), 2) +3), 2) +4), 3) +4), projecting different sizes of parallelograms with various brightness on the back wall and floor, which are opaque smooth passive screens. Thus, the properties and geometry of the light and the intervening grid are seen on the screens of the wall and floor. With the use of dichroic glass, the simple, white space of the chapel has been completely transformed by the play of light and colour (7).

Fig. 1 Sweeney church Indianapolis, USA, James Carpenter Design Associates

3. Characteristics and Types of Dichroic Glass

There are different types of dichroic films that can be used in architecture. Their division is based on the colours and the three-dimensional effects that are reflected on a smooth, flat texture and a relief, wavy structure.

1. Dichroic glass of a smooth, flat texture is called "red or green" because of the different colours that refract into two colours and the final colour that is reflected; it is composed of layered glass, which also has the effect of a mirror which is reflected in its flat surface (8).

- Transmission colour for “Red” at the right angle viewing will be aqua blue/green, shifting through deep blue, then magenta at the skew angle viewing, while reflection colour will be copper / red shifting through yellow / gold and into green at skew angles (9).

Fig. 2 “Red” Dichroic glass of a flat texture

Fig. 3 Cohen, Children's Medical Center, Thomas Morris

- Transmission colour for “Green” at the right angle viewing will be magenta / purple, shifting through orange, then yellow at the skew angle viewing, while reflection colour will be green shifting into deep blue at skew angles.
- Colours for the Black Sea do not need colour spectrum as the dichroic films used are always “Blue”, unless specifying special runs of “Green” or “Red” (10).

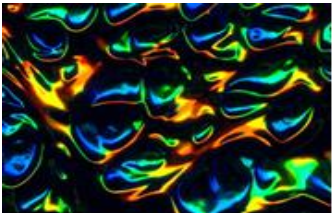

Fig. 7 Black Sea texture of Dichroic Glass by John Blazy Designs

Fig. 8 Black Sea Conference Table

- Burl textures are textures with a unique effect of filtration and refraction of wavelengths of light, achieved by a technology where the glass surface is laminated with more than nine separate polymer layers in three separate lamination processes. The ultimate effect of such a lamination process is the glass which creates the optical effect of the colour change in an instant and at the slightest change in the angle (10).

Fig. 9 Red Burl texture of Dichroic Glass

Fig. 10 Red Burl texture

4. Application of Dichroic Glass in Architecture and Interior

Dichroic glass is widely used in architecture and interior design. Its greatest application is for glazing of facades, as well as in areas where the effect of visual dynamism is required through colour change or three-dimensional texture. The use of glass in the interior can be with glass partitions, tiles, different surfaces in commercial and business interiors or it can occur through different details in the space.

One example of the design of facades by Dichroic Glass is the Prairie Museum, designed by Verner Johnson. The building was built in the prairies of Midwest USA, measuring 3800m^2, and the idea was to fit the shape of the building completely into the topography of the terrain, evoking the flames of fire spreading through the prairie. This effect required the use of non-traditional materials to evoke the movement of fire. The dichroic glass fulfilled the architect's requirements, evoking the movement of fire in the prairie, while introducing dynamics into the museum's white exhibition space from the inside (11).

Fig. 11 The facade of the museum

Fig. 12 Museum Interior

Apartment H is an interior design of a Romanian group of architects Re-Act Now, designed for a 230m^2 apartment in the town of Constance on the Black Sea coast in Romania. The design used dichroic glass as a transparent partition to separate the bedroom from the living room of the apartment. The marine environment defined by the white colour which the walls, floors and furniture are treated with, while the dynamics are created by a mounted glass partition made of dichroic glass, which is in a way a "living" element in space and breaks its entire length, thus defining the function, creating dynamics with a continuous change of colour and reflection and creating a completely different experience of moving through the flat (12).

Fig. 13 Dichroic glass as a partition in the apartment

Spatial structures made of dichroic glass provide new visual identities. An example of a dichroic structure is the design of the Migliore + Servetto architectural studio, which represents an installation in the space designed for the Intesa Sanpaolo skyscraper in Turin. This sculpture is a dynamic work in which light and reflections expand, turning it into a pulsating organism. 16m high panels, alpha-symbol-like, dichroic-coated panels create a sense of monumentality in space, optimizing light diffusion and transforming transparent panels into dynamic light planes (14).

 

Fig. 14 and **Fig. 15** Installation, α-cromactive, Intesa, Sanpaolo, Turin, Migliore+Servetto architects

An example of the use of Dichroic glass through various interior details is the Copenhagen Opera House. In this building, the central foyer holds three spherical chandeliers created by the Icelandic artist Olafur Eliasson. Each chandelier has a 2.9 m diameter made of 1480 triangles of laminated safety glass, fitted with dichroic filters that are semipermeable, allowing some light to pass, and some to reflect. The patterns change when viewed from different angles (4).

 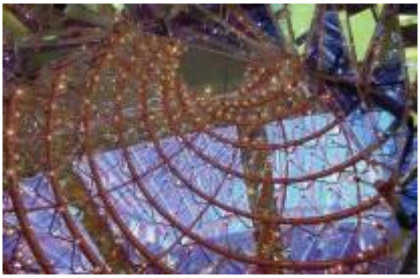

Fig. 16 and **Fig. 17** Copenhagen Opera house, Denmark, Olafur Eliasson, Designer of chandelier

CONCLUSION

Based on the above characteristics and analysis of dichroic glass, it can be concluded that in modern architecture and design this glass can have really wide application. The effects of refracting different coatings with changing viewing angles, different from lighting or sunlight can create different perceptions of the living space, but also give a new unique look to the building.

Different textures of the glass, which are presented in the work, achieve different effects that are applicable in the architectural design of the building but also in different interiors such as commercial, residential, public and sacral, creating a unique spatial experience. The constant development of glass laminating technology, with coatings of different materials, leads to the creation of new effects on dichroic glass, giving architects a huge number of possibilities in realization of their buildings.

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PRIMENA DIHROIČKOG STAKLA U ARHITEKTONSKOM OBLIKOVANJU OBJEKATA

Primena bojenih i optičkih stakala u arhitekturi ima veliki značaj u pogledu stvaranja prostorne dinamike i jedinstvenosti prostora. Dihroičko staklo predstavlja vrstu stakla koja je premazana tankim slojem metala, zahvaljujući kojem dolazi do promene boje staklene površine u zavisnosti od ugla posmatranja. Boja stakla zavisi od upada različitih talasnih dužina svetla koje prolazi kroz staklenu površinu ili se odbija od nje, stvarajući na taj način različite efekte prelamanja boja. Stvoreni efekti pružaju različite mogućnosti u dizajnu objekata i poboljšanja estetskog kvaliteta unutrašnjeg prostora. Ovaj rad se bavi analizom i primenom bojenih dihroičkih stakala u arhitekturi i dizajnu enterijera.

Ključne reči: *Dihroičko staklo, obojeno staklo, prelamanje boja, optičko staklo*

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SEISMIC ANALYSIS OF FRAMES WITH SEMI-RIGID CONNECTIONS IN ACCORDANCE WITH EC8

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624.042.7

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Abstract. *Up to date research has pointed out that most of the structural connections of reinforced concrete (RC) frames, particularly precast ones, behave as semi-rigid. Therefore, it is of great importance to develop an analysis method which takes into account the connection rigidity. For that purpose matrix formulation of the deformation method is used in this paper, and the effect of rigidity of connections on the structure response is included by stiffness matrix for semi-rigidly connected member. The elements of this matrix are functions of the fixity factors at the ends of members. The proposed method is applied in seismic analysis of the precast RC frame structure of the existing industrial hall according to Eurocode 8 (EC8).*

Key words: *semi-rigid connection, stiffness matrix, seismic analysis, precast reinforced concrete system.*

1. INTRODUCTION

Connections form the vital part of precast concrete construction [1]. Up to date research has pointed out that structural connections in existing buildings, particularly in precast ones, behave neither as absolutely rigid nor perfectly pinned but as semi-rigid, which significantly influences the distribution of stresses and strains in the structure. Hence, there is a need to carry out the structural analysis and design taking into account the rigidity of connections. This is especially significant in earthquake engineering because seismic forces cause weakening of connections, i.e. even rigid ones become semi-rigid. This fact has not yet been adequately taken into account in structural analysis of RC structures. In practice the designers mostly tend to simplify dynamic actions of earthquake loads which directly results in structural systems with limited or poor seismic performances.

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In such a case, their seismic vulnerability and cumulative seismic risk appear very high. For example, due to the 1976 Friuli, Italy, earthquake most of the precast RC industrial buildings located in the affected area suffered extensive damage, or total collapse, particularly in the zone of connections [2].

Research on semi-rigid connections of structures has been carried out worldwide for about ninety years. The slope deflection and moment distribution methods were both applied to frames with semi-rigid connections in the 1930's by John F. Baker in England and J. Charles Rathbrun in the United States, [3]. Among other contemporary studies [4], [5], [6], the European project COST C1, Control of the Semi-Rigid Behavior of Civil Engineering Structural Connections [7], has significantly contributed in this field, but mainly in the field of steel structures, while there is less research on connections of precast RC structures.

Theoretical and experimental research on systems with semi-rigid connections has been going on at the Faculty of Civil Engineering and Architecture in Nis, Serbia, since 1980's [8]-[15]. Experimental tests have been performed on precast RC industrial hall structures and the obtained results related to connections have been a basis for the authors' theoretical work. A new simple design procedure for structures with semi-rigid connections has been developed using the matrix formulation of the deformation method, which is briefly presented in this paper. It is also shown how this procedure can be applied in seismic design according to Eurocode 8 (EC8) by use of an example of the existing precast RC industrial hall structure. The conclusions drawn about the influence of connection rigidity on seismic performances of the structure are significant for practical applications.

2 Matrix Analyses of Planar Frames with Semi-Rigid Connections Using the Deformation Method

2.1. Assumptions relating to semi-rigid connections introduced in classical formulation of the deformation method

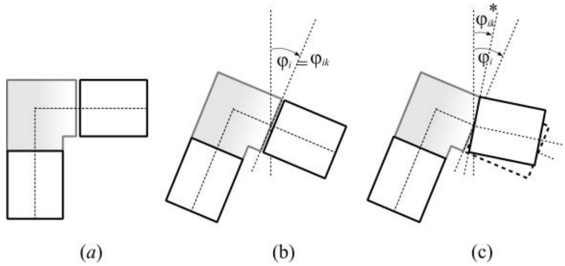

Fig. 1 a) Connection in the node ***i*** before deformation; b) Rotation φ_i of the node ***i*** in the case of rigid connection after deformation; c) Rotation φ_i of the node ***i*** and rotation φ_{ik}^* of the member end at ***i*** in the case of semi-rigid connection after deformation.

In this paper it is assumed that in the case of structures with semi-rigid (elastic) connections the node rotation is φ_i, i.e. φ_k, while rotation of the member end cross-section is φ_{ik}^*, i.e. φ_{ki}^* (Fig.1), so that the fixity factor in node ***i*** is designated as μ_{ik}, and in node ***k*** as μ_{ki}, [14], and they are defined as:

$$\mu_{ik} = \frac{\varphi_{ik}^*}{\varphi_i}, \quad \mu_{ki} = \frac{\varphi_{ki}^*}{\varphi_k} \tag{1}$$

In the classical formulation of the deformation method [16], the expressions for the bending moments at the ends of rigidly connected members are:

$$M_{ik} = a_{ik}\varphi_i + b_{ik}\varphi_k - c_{ik}\psi_{ik} + m_{ik}^{(o)} + m_{ik}^{(\Delta t)}, \tag{2}$$

$$M_{ki} = a_{ki}\varphi_k + b_{ik}\varphi_i - c_{ki}\psi_{ik} + m_{ki}^{(o)} + m_{ki}^{(\Delta\Delta t}, \tag{3}$$

and for semi-rigidly connected members, in terms of the angles of rotation φ_{ik}^* and φ_{ki}^* of the end cross-sections, [14], they are:

$$M_{ik}^* = a_{ik}\varphi_{ik}^* + b_{ik}\varphi_{ki}^* - c_{ik}\psi_{ik} + m_{ik}^{(o)} + m_{ik}^{(\Delta t)}, \tag{4}$$

$$M_{ki}^* = b_{ik}\varphi_{ik}^* + a_{ki}\varphi_{ki}^* - c_{ki}\psi_{ik} + m_{ki}^{(o)} + m_{ki}^{(\Delta t)}, \tag{5}$$

or in terms of node rotations φ_i and φ_k:

$$M_{ik}^* = a_{ik}^*\varphi_i + b_{ik}^*\varphi_k - c_{ik}^*\psi_{ik} + m_{ik}^{(o)*} + m_{ik}^{(\Delta t)*} \tag{6}$$

$$M_{ki}^* = b_{ik}^*\varphi_i + a_{ki}^*\varphi_k - c_{ki}^*\psi_{ik} + m_{ki}^{(o)*} + m_{ki}^{(\Delta t)*} \tag{7}$$

For a member with rigid connections in nodes, introduced constants physically represent bending moments, so a_{ik} is the moment in node ***i*** due to unit rotation of node ***i***, b_{ik} in node ***i*** due to unit rotation of node ***k***, a_{ki} in node ***k*** due to unit rotation of node ***k***, while c_{ik} is the moment in node ***i*** due to unit rotation of a member ***ik***, Fig. 2a. Analogously, physical meaning of the corresponding constants for semi-rigidly connected members, which are marked by *, is the same, Fig. 2b [14].

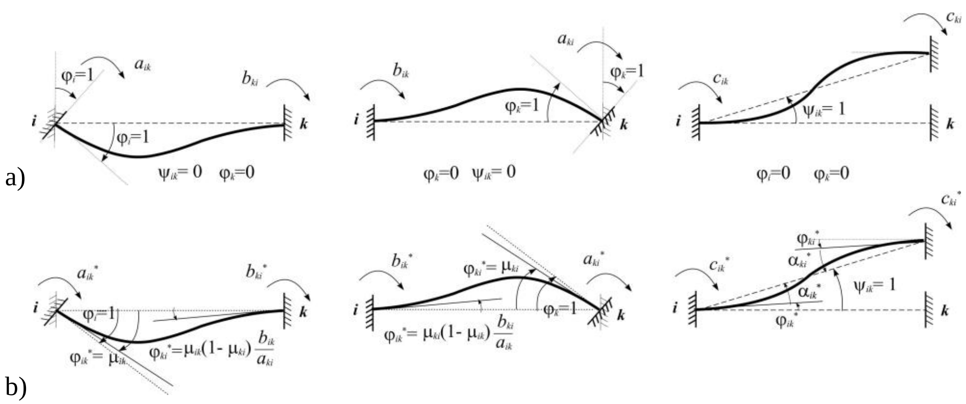

Fig. 2 Physical meaning of constants a_{ik}, b_{ik}, a_{ki}, b_{ki}, c_{ik} and c_{ki} in classical deformation method for a member: a) with rigid connections in nodes; b) semi-rigid connections in nodes

It follows from (1) that rotation of the left end is $\varphi_{ik}^{*}=\mu_{ik}$ due to rotation of the node ***i*** amounting to $\varphi_i=1$. With that in mind, and knowing the physical meaning of the member constants a_{ik} and b_{ik}, the rotation of the right member end φ_{ki}^{*} can be assumed according to the principle of superposition in the following form:

$$\varphi_{ki}^{*} = \mu_{ik}(1-\mu_{ki})\frac{b_{ik}}{a_{ki}}. \tag{8}$$

Similarly, in the case of rotation $\varphi_k=1$of the node ***k***, the rotation of the right member end is $\varphi_{ki}*=\mu_{ki}$, and the angle $\varphi_{ik}*$ is:

$$\varphi_{ik}^{*} = \mu_{ki}(1-\mu_{ik})\frac{b_{ik}}{a_{ik}}, \tag{9}$$

while in the case of the member axis rotation $\psi_{ik}=1$, the angles between chord of the member and tangents to the elastic line at the end cross sections are:

$$\alpha_{ik}^{*} = 1-\varphi_{ik}^{*} = 1-\mu_{ki}(1-\mu_{ik})\frac{b_{ik}}{a_{ik}}, \qquad \alpha_{ki}^{*} = 1-\varphi_{ki}^{*} = 1-\mu_{ik}(1-\mu_{ki})\frac{b_{ik}}{a_{ki}} \tag{10}$$

2.2. Matrix formulation of the deformation method

In matrix analysis the model of a structure is discrete, composed of members (beams and columns) which are connected at discrete points - nodes [17].

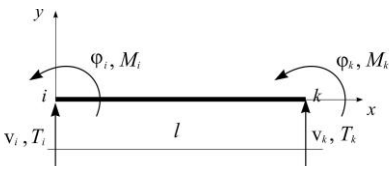

Fig. 3 Generalized displacements and forces at member ends

In structural analysis of line systems, which are composed only of beams and columns, the simplest member model is applied, that is a straight prismatic member at whose ends are the nodes of the structure, shown in Fig.3. Let the member be of length *l*, with a constant cross section, exposed to bending in the *x*O*y* plane of the local coordinate system Its moment of inertia is I and the material modulus of elasticity is E. If the influence of axial forces on deformation of the member is neglected, the generalized displacements in nodes ***i*** and ***k*** (displacement parameters) are transversal displacements (v_i,v_k) and rotations (φ_i, φ_k) of the member ends, thus the element has four degrees of freedom, two at each end. Generalized forces are shear forces (T_i,T_k) and bending moments (M_i,M_k) at the ends ***i*** and ***k***. Convention of positive directions of displacements and forces is shown in Fig 3.

The relation between the vector of generalized forces and the vector of generalized displacements is:

$$R = kq \tag{11}$$

where:

$$\mathbf{R}^T = \begin{bmatrix} R_1 & R_2 & R_3 & R_4 \end{bmatrix} = \begin{bmatrix} T_i & M_i & T_k & M_k \end{bmatrix}, \tag{12}$$

$$\mathbf{q}^T = \begin{bmatrix} q_1 & q_2 & q_3 & q_4 \end{bmatrix} = \begin{bmatrix} v_i & \varphi_i & v_k & \varphi_k \end{bmatrix}, \tag{13}$$

$$\mathbf{k} = \begin{bmatrix} k_{11} & k_{12} & k_{13} & k_{14} \\ k_{21} & k_{22} & k_{23} & k_{24} \\ k_{31} & k_{32} & k_{33} & k_{34} \\ k_{41} & k_{42} & k_{43} & k_{44} \end{bmatrix} \tag{14}$$

are generalized force vector, generalized displacement vector and member stiffness matrix, respectively.

Relation (11) applies to a member with both ideal (rigid and pinned) and semi-rigid connections if the elements of the stiffness matrix (14) are derived taking into account the fixity factor of connections, which is defined above. Herein the stiffness matrix for semi-rigidly connected member, and all of its elements, are marked by *, [14].

$$\mathbf{k}^* = \begin{bmatrix} k_{11}^* & k_{12}^* & k_{13}^* & k_{14}^* \\ k_{21}^* & k_{22}^* & k_{23}^* & k_{24}^* \\ k_{31}^* & k_{32}^* & k_{33}^* & k_{34}^* \\ k_{41}^* & k_{42}^* & k_{43}^* & k_{44}^* \end{bmatrix} \tag{15}$$

The stiffness matrix of the system is formed from stiffness matrices of all members, so determination of a member stiffness matrix is the most important for the solution of the considered problem.

When the axial forces effect on deformation is taken into account, the stiffness matrix of a semi-rigidly connected member can be written as follows:

$$\mathbf{k}^* = \begin{bmatrix} \frac{EA}{l} & 0 & 0 & \frac{EA}{l} & 0 & 0 \\ & k_{11}^* & k_{12}^* & 0 & k_{13}^* & k_{14}^* \\ & & k_{22}^* & 0 & k_{23}^* & k_{24}^* \\ & & & \frac{EA}{l} & 0 & 0 \\ & & & & k_{33}^* & k_{34}^* \\ simetrically & & & & & k_{44}^* \end{bmatrix} \tag{16}$$

2.3. Stiffness matrix of a semi-rigidly connected member

It is known from literature that the elements of the stiffness matrix (14) of a rigidly connected member, based on the variation formulation of the problem of planar beam bending, can be represented in the form:

$$k_{mn} = EI\int_0^l N_m{}''(x)N_n{}''(x)dx \tag{17}$$

where $N_m(x)$ and $N_n(x)$ are interpolation functions defined in [17].

Analogously, the stiffness matrix elements k_{mn}^* for a member with semi-rigid connections at the ends can be determined using the expression:

$$k_{mn}^* = EI\int_0^l N_m^{*''}(x)N_n^{*''}{}_n(x)dx\ , \tag{18}$$

where $N_m^*(x)''$, i. e. $N_n^*(x)''$ are the second derivatives of the interpolation functions $N_m^*(x)$ and $N_n^*(x)$ for a semi-rigidly connected member [14]. The vector of interpolation functions can be shown in the form:

$$\mathbf{N}^* = \left[N_1^*(x) \quad N_2^*(x) \quad N_3^*(x) \quad N_4^*(x)\right], \tag{19}$$

where each interpolation function represents the elastic line of the semi-rigidly connected member at both ends due to the corresponding displacement parameter (generalized displacement) $q_m=1$, (m=1,2,3,4), while all other displacement parameters are $q_n=0$, $n\neq m$, Fig. 4.

When analyzing semi-rigid connections, in the case of applied unit translation $q_1=1$ at the end ***i*** of a member or unit translation $q_3=1$ at the end ***k*** of a member, while all other generalized displacements are equal to zero, the angles between chord of the member and tangents on the end cross sections after deformation, Fig.4, can be expressed according to (10) and the fact that they are small angles (for which it is tgα~α), as follows:

$$\alpha_{ik}^* = \left[1-\mu_{ki}(1-\mu_{ik})\frac{b_{ik}}{a_{ik}}\right]\frac{1}{l}, \qquad \alpha_{ki}^* = \left[1-\mu_{ik}(1-\mu_{ki})\frac{b_{ik}}{a_{ki}}\right]\frac{1}{l} \tag{20}$$

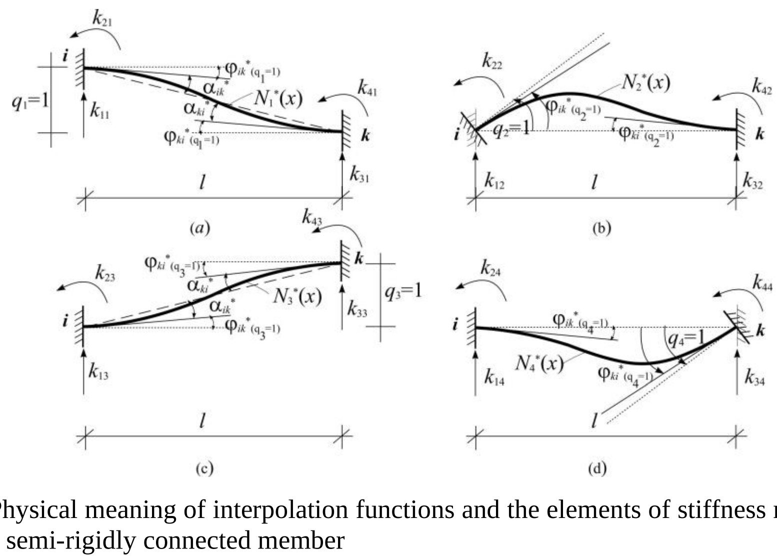

Fig. 4 Physical meaning of interpolation functions and the elements of stiffness matrix of a semi-rigidly connected member

Derivation of the expressions for interpolation functions (19) is presented in [15]. The elements of stiffness matrix are obtained in the following form:

$$
\begin{aligned}
k_{11}^{*} &= \frac{4EI}{\ell}[\alpha_{ik}^{*2} + \alpha_{ik}^{*}\alpha_{ki}^{*} + \alpha_{ki}^{*2}][\quad] \\
k_{12}^{*} &= \frac{2EI}{\ell}\left[2(\alpha_{ik}^{*}\mu_{ik} + \alpha_{ki}^{*\,2}\ell - \alpha_{ki}^{*}\mu_{ki}) - \alpha_{ik}^{*}\mu_{ki} + \alpha_{ik}^{*}\alpha_{ki}^{*}\ell + \alpha_{ki}^{*}\mu_{ik}\right] = k_{21}^{*} \\
k_{13}^{*} &= -\frac{4EI}{\ell}\left[\alpha_{ik}^{*\,2} + \alpha_{ik}^{*}\alpha_{ki}^{*} + \alpha_{ki}^{*\,2}\right] = k_{31}^{*} \\
k_{14}^{*} &= \frac{2EI}{\ell}\left[2(\alpha_{ik}^{*}\mu_{ik} - \alpha_{ki}^{*\,2}\ell + \alpha_{ki}^{*}\mu_{ki}) + \alpha_{ik}^{*}\mu_{ki} - \alpha_{ik}^{*}\alpha_{ki}^{*}\ell + \alpha_{ki}^{*}\mu_{ik}\right] = k_{41}^{*} \\
k_{22}^{*} &= \frac{4EI}{\ell}\left[\mu_{ik}^{2} - \mu_{ik}\mu_{ki} + \mu_{ki}^{2} + \alpha_{ki}^{*}\mu_{ik}\ell - 2\alpha_{ki}^{*}\mu_{ki}\ell + \alpha_{ki}^{*\,2}\ell^{2}\right] \\
k_{23}^{*} &= -\frac{2EI}{\ell}\left[2(\alpha_{ik}^{*}\mu_{ik} + \alpha_{ki}^{*\,2}\ell - \alpha_{ki}^{*}\mu_{ki}) - \alpha_{ik}^{*}\mu_{ki} + \alpha_{ik}^{*}\alpha_{ki}^{*}\ell + \alpha_{ki}^{*}\mu_{ik}\right] = k_{32}^{*} \\
k_{24}^{*} &= \frac{2EI}{\ell}\left[2(\mu_{ik}^{2} - \alpha_{ik}^{*}\mu_{ik}\ell - \mu_{ki}^{2} + \alpha_{ki}^{*}\mu_{ki}\ell) + \alpha_{ik}^{*}\mu_{ki}\ell + \alpha_{ki}^{*}\mu_{ik}\ell - \alpha_{ik}^{*}\alpha_{ki}^{*}\ell^{2}\right] = k_{42}^{*} \\
k_{33}^{*} &= \frac{4EI}{\ell}\left[\alpha_{ik}^{*\,2} + \alpha_{ik}^{*}\alpha_{ki}^{*} + \alpha_{ki}^{*\,2}\right] \\
k_{34}^{*} &= -\frac{2EI}{\ell}\left[2(\alpha_{ik}^{*}\mu_{ik} - \alpha_{ki_2}^{*}\ell + \alpha_{ki}^{*}\mu_{ki}) + \alpha_{ik}^{*}\mu_{ki} - \alpha_{ik}^{*}\alpha_{ki}^{*}\ell + \alpha_{ki}^{*}\mu_{ik}\right] = k_{43}^{*} \\
k_{44}^{*} &= \frac{4EI}{\ell}\left[\mu_{ik}^{2} + \mu_{ik}\mu_{ki} + \mu_{ki}^{2} - 2\alpha_{ik}^{*}\mu_{ik}\ell - \alpha_{ik}^{*}\mu_{ki}\ell + \alpha_{ik}^{*\,2}\ell^{2}\right]
\end{aligned}
\tag{21}
$$

3. Seismic Design According to the Eurocode 8

According to the European standard Eurocode 8 (EN 1998-1:2004) [18], when it comes to the design of buildings in seismic regions, depending on the structural characteristics of the building, one of two types of linear-elastic analysis can be used: *lateral force method* or *modal response spectrum analysis*. As an alternative to the linear approach, non-linear methods can be used, such as *non-linear static (pushover) analysis* and *non-linear time history (dynamic) analysis*. For buildings conforming to the criteria for regularity in plan, or with the conditions presented in provisions (4.2.3.2) and 4.3.3.1(8) of Eurocode 8, the analysis may be performed using two planar models, one for each main direction. In seismic design of such buildings, the above presented proposed method, which includes the influence of the connection rigidity on the response of the structure by stiffness matrix in the form (15) or (16), can be applied.

Lateral force method of analysis may be applied to buildings which can be analyzed by the use of two planar models, and hence it is suitable for the implementation of the proposed procedure. The condition that structure response is not significantly affected by contributions from modes of vibration higher than the fundamental mode in each principal direction has to be met. It is fulfilled if a building has fundamental periods of vibration T_1 in the two main directions which are smaller than the following values:

$$
T_1 \le \begin{cases} 4\,T_c \\ 2{,}0\ \mathrm{s} \end{cases} \tag{22}
$$

where T_c is defined depending on earthquake action, and meet appropriate criteria for regularity in elevation.

For the calculation of the fundamental period T_1 of free vibration of the building well known methods of structural dynamics can be applied [19].

The seismic base shear force F_b for each horizontal direction in which the building is analyzed, is determined using the following expression:

$$F_b = S_d(T_1)\, m\lambda \tag{23}$$

where:

- $S_d(T_1)$ – is the ordinate of the design spectrum (see 3.2.2.5, [18]) at period T_1;
- T_1 – is the fundamental period of vibration of the building for lateral motion in the direction considered;
- λ is the correction factor, the value of which is equal to: λ=0,85 if $T_1 \le 2Tc$ and the building has more than two stories, or λ=1,0 otherwise;
- m - is the total mass of the building, above the foundation or above the top of a rigid basement, computed in accordance with 3.2.4(2), [18]:

$$m = \sum G_{k,i} \text{"+"} \sum \psi_{E,i}\, Q_{k,i} \tag{24}$$

where:

- Σ means „combination of effects of";
- $G_{k,i}$ is characteristic value of permanent action *i*;
- "+" denotes „ in combination with";
- $Q_{k,i}$ is characteristic value of variable action *i*;
- $\psi_{E,i}$ - is the combination coefficient for variable action *i*.

For the horizontal components of seismic action the design spectrum $S_d(T)$ is defined by the following expressions:

$$0 \le T \le T_B: \quad S_d(T) = a_g \cdot S \left[\frac{2}{3} + \frac{T}{T_B}\left(\frac{2.5}{q} - \frac{2}{3} \right) \right] \tag{25}$$

$$T_B < T \le T_C: \quad S_d(T) = a_g \cdot S \cdot \frac{2.5}{q} \tag{26}$$

$$T_C < T \le T_D: \quad S_d(T) \begin{cases} = a_g \cdot S \cdot \dfrac{2.5}{q} \cdot \left[\dfrac{T_C}{T} \right] \\ \ge \beta \cdot a_g \end{cases} \tag{27}$$

$$T_D < T: \quad S_d(T) \begin{cases} a_g \cdot S \cdot \dfrac{2.5}{q} \cdot \left[\dfrac{T_C \cdot T_D}{T^2} \right] \\ \ge \beta \cdot a_g \end{cases} \tag{28}$$

where:

- a_g, S, T_B, T_C, T_D – are values for the elastic response spectrum (Table 3.2 and Table 3.3 EN 1998-1:2004);
- $S_d(t)$ the value of the design spectrum;
- q is the behavior factor, depending on material and structure type;
- β is the lower bound factor for the horizontal design spectrum; the recommended value for β is 0,2.

The seismic action effects are to be determined by applying, to the two planar models, horizontal forces F_i to all stories:

$$F_i = F_b \frac{s_i m_i}{\sum s_j m_j} \tag{29}$$

where:
- F_i is the horizontal force acting on the store *i*;
- F_b is the seismic base shear in accordance with the expression (23);
- s_i and s_j are the displacements of masses m_i and m_j in the fundamental mode;
- m_i and m_j are the stories masses computed in accordance with 3.2.4(2) of EN 1998-1:2004.

The displacements induced by the design seismic action are to be calculated on the basis of the elastic deformations of the structural system by means of the following simplified expression:

$$d_s = q_d d_e\ , \tag{30}$$

where:
- d_s is the displacement of a point of the structural system induced by the design seismic action;
- q_d is the displacement behavior factor, assumed equal to q unless otherwise specified;
- d_e is the displacement of the same point of the structural system, as determined by a linear analysis based on the design response spectrum in accordance with 3.2.2.5 EN 1998-1:2004.

4. Numerical Example

The structure of the existing industrial hall constructed in precast RC structural system AMONT, developed in Serbia, is chosen for the illustration of proposed design method which takes into account the rigidity of connections.

This building meets criteria for regularity in plan and therefore can be analyzed by two planar frames, according to the statement 4.3. 1(5) of standard EN 1998-1:2004.

Laboratory investigation of bearing capacity and deformability of full scale models of chosen characteristic connections of the precast RC industrial hall, shown in Fig.5, has been carried out in the Institute for Earthquake Engineering and Engineering Seismology (IZIIS), Skopje, Macedonia, [22]. Connections have been tested under simulated adequate load to the failure, and both linear and nonlinear analyses of the connections behavior have been carried out.

Based on the results of the tests it is observed that the most of the connections behave as semi-rigid. Frames which are analyzed in two orthogonal directions are both symmetrical, therefore elements in one half of the structure are marked in the Fig.6. Based on the test results connection column-to-foundation pocket can be considered as almost absolutely rigid (fixed) and because of that in longitudinal direction the fixity factor μ_{ik} in nodes 1, 2, 3, 4, 5, as well as in nodes 5 and 6 in transversal direction, is adopted as $\mu_{1\text{-}6}=\mu_{2\text{-}9}=\mu_{3\text{-}12}=\mu_{4\text{-}15}=\mu_{5\text{-}18}=1$. Beam-to-column connections at the roof level behave as pinned, and therefore nodes 19, 22, 25 are modeled as pinned. Columns denoted as S_1 and S_2 are precast as one-piece, so in nodes 6, 12, 18 on these columns of longitudinal frame, as well as in node 7 of transversal frame, connection is rigid with μ_{ik}=1. The fixity factor of the remainder of the connections was varied from μ_{ik}=0 to μ_{ik}=1 for the purpose of computing dynamic characteristics, seismic forces and internal forces due to them, as well as displacements of the structure, depending on the connections rigidity.

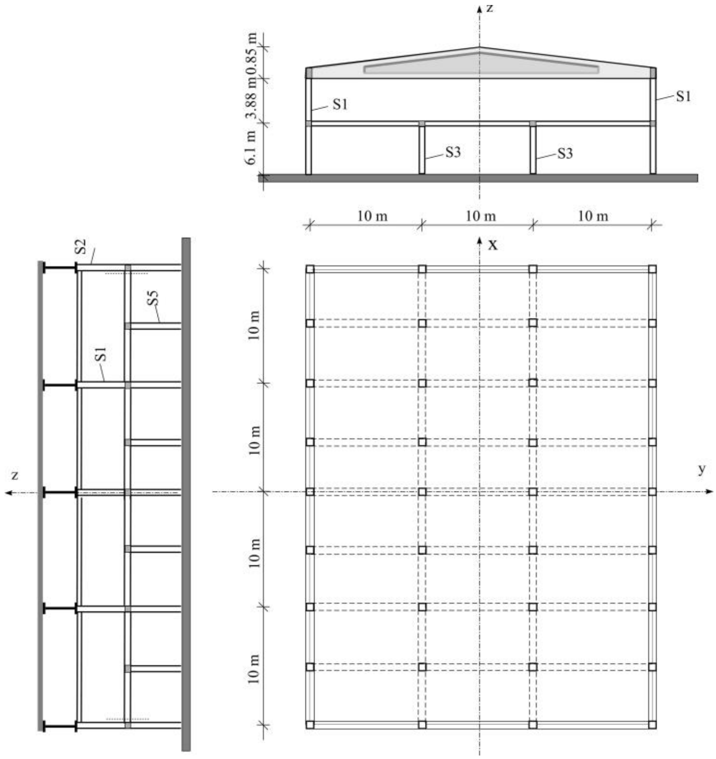

Fig. 5 Ground floor layout, longitudinal and transversal section of the industrial hall

At the Faculty of Civil Engineering and Architecture in Nis, Serbia, software has been developed**,** which is intended for seismic analysis of frame structures and which facilitates the calculation of basic dynamical characteristics and seismic forces and influences due to these forces [21]. It can be applied for structures with both classical connections and semi-rigid connections. Seismic design of considered structure is carried out by use of this software in accordance with provisions of Eurocode 8. Having in mind that above proposed and described method can be applied only for a planar frame, the structure is modeled by two orthogonal planar frames.

Seismic base shear forces F_b are calculated using equation (23). The values S_d are calculated according to the formula (27). The design ground acceleration is taken a_g=0.1 g for seismic zone VII, g= 0.2 g for zone VIII and a_g = 0.4 g for IX zone. In our case, for Type 2 elastic response spectrum and ground type B, S is 1.35 and T_c is 0.25. Total mass of the transversal middle frame is 361.39kNs^{2}m^{-1}, the longitudinal end frame 517.606 kNs^{2}m^{-1}, while the correction factor is λ=1.0. The behavior factor is adopted as q=3.9 according to EN 1998-1: 2004, 5.2.2.2, for multistory and multi-bay frame and middle ductility (DCM) [18].

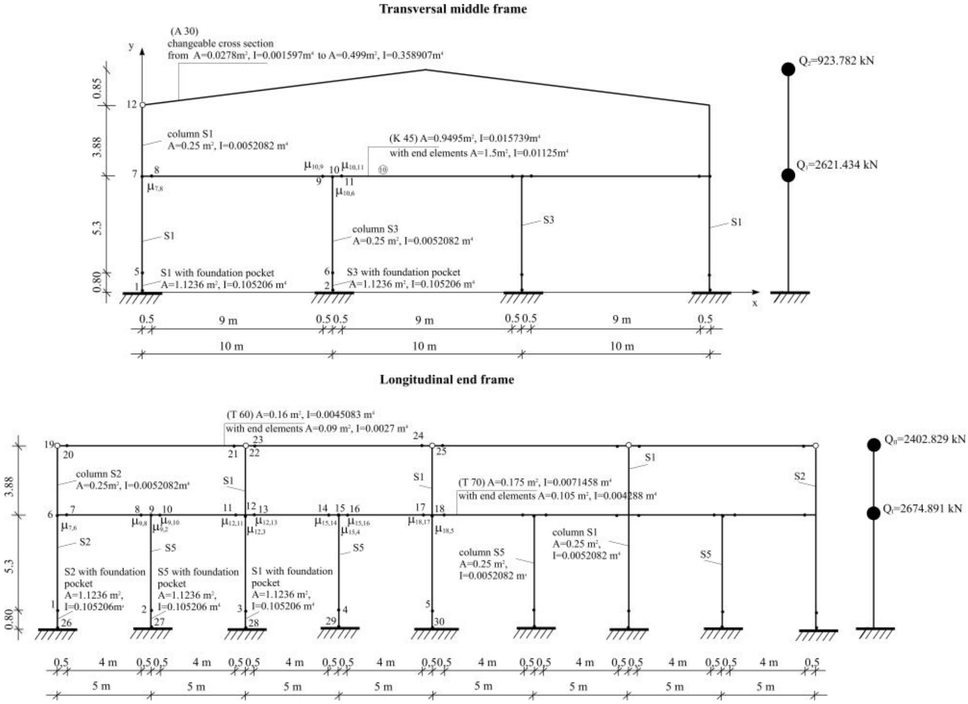

Fig. 6 Mathematical models for linear-elastic analysis taking into account the connection rigidity of the tested RC precast structure

Some of the results of the performed seismic analysis using proposed method are shown in the diagrams (Fig. 7), Table 1. and Table 2.

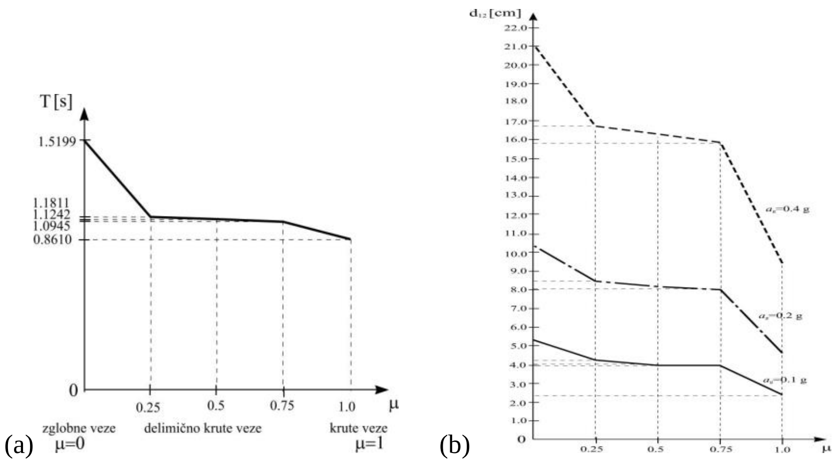

Fig. 7 Dependence on the fixity factors μ_{ik}: (a) Frame fundamental vibration period T_1- transversal direction; (b) horizontal displacement d_s of the frame top due to design seismic action calculated according to EN 1998-1:2004- transversal direction.

4.1. Discussion of obtained results

Based on the results obtained from the *lateral force method* and taking into account the rigidity of connections, it can be concluded that fixity factor significantly affects the redistribution of influences, what is shown in Table 1 and Table 2, where values of displacements of the characteristic points in the first floor level and the top of the building are given for the longitudinal and transversal direction, depending on the assumed connection rigidity for different intensity of seismic action.

Table 1 Displacements d_e[m] according to linear analysis and displacements d_s[m] due to design seismic action calculated according EC8 for transversal direction

		pinned connections		semi-rigid connections						rigid connections	
		μ=0		μ=0.25		μ=0.5		μ=0.75		μ=1	
		T_1=1.5119 s		T_1= 1.1811 s		T_1= 1.1242 s		T_1= 1.0945 s		T_1=0.8610 s	
VII zone a_g=0.1g	d_7 (m)	F_b=22.51 kN S_d=0.0127 g	$d_{e,7}$=0.0052 $d_{s,7}$=0.0203	F_b=28.86 kN S_d=0.0162 g	$d_{e,7}$=0.0040 $d_{s,7}$=0.0156	F_b=30.31 kN S_d=0.0171 g	$d_{e,7}$=0.0038 $d_{s,7}$=0.0148	F_b=31.14 kN S_d=0.0176g	$d_{e,7}$=0.0036 $d_{s,7}$=0.0140	F_b=39.53 kN S_d=0.0223 g	$d_{e,7}$=0.0035 $d_{s,7}$=0.0136
	d_{12} (m)		$d_{e,12}$=0.0135 $d_{s,12}$=0.0527		$d_{e,12}$=0.0107 $d_{s,12}$=0.0417		$d_{e,12}$=0.0104 $d_{s,12}$=0.0406		$d_{e,12}$=0.0102 $d_{s,12}$=0.0398		$d_{e,12}$=0.0060 $d_{s,12}$=0.0234
VIII zone a_g=0.2g	d_7 (m)	F_b=45.02kN S_d=0.0127 g	$d_{e,7}$=0.0104 $d_{s,7}$=0.0406	F_b=57.72kN S_d=0.0162 g	$d_{e,7}$=0.0080 $d_{s,7}$=0.0312	F_b=60.62 kN S_d=0.0171 g	$d_{e,7}$=0.0076 $d_{s,7}$=0.0296	F_b=62.28 kN S_d=0.0176g	$d_{e,7}$=0.0072 $d_{s,7}$=0.0281	F_b=79.06 kN S_d=0.0223 g	$d_{e,7}$=0.0070 $d_{s,7}$=0.0272
	d_{12} (m)		$d_{e,12}$=0.027 $d_{s,12}$=0.1053		$d_{e,12}$=0.0214 $d_{s,12}$=0.0835		$d_{e,12}$=0.0208 $d_{s,12}$=0.0811		$d_{e,12}$=0.0204 $d_{s,12}$=0.0796		$d_{e,12}$=0.0120 $d_{s,12}$=0.0468
IX zone a_g=0.4g	d_7 (m)	F_b=90.04kN S_d=0.0127 g	$d_{e,7}$=0.0208 $d_{s,7}$=0.08011	F_b=115.44N S_d=0.0162 g	$d_{e,7}$=0.0160 $d_{s,7}$=0.0624	F_b=121.24 kN S_d=0.0171 g	$d_{e,7}$=0.0152 $d_{s,7}$=0.0593	F_b=124.56 kN S_d=0.0176g	$d_{e,7}$=0.0144 $d_{s,7}$=0.0562	F_b=158.12 kN S_d=0.0223 g	$d_{e,7}$=0.0140 $d_{s,7}$=0.0544
	d_{12} (m)		$d_{e,12}$=0.0540 $d_{s,12}$=0.2106		$d_{e,12}$=0.0428 $d_{s,12}$=0.1669		$d_{e,12}$=0.0416 $d_{s,12}$=0.1622		$d_{e,12}$=0.0408 $d_{s,12}$=0.1591		$d_{e,12}$=0.0240 $d_{s,12}$=0.0936

Table 2 Displacements d_e[m] according to linear analysis and displacements d_s[m] due to design seismic action calculated according EC8 for longitudinal direction

		pinned connections		semi-rigid connections						rigid connections	
		μ=0		μ=0.25		μ=0.5		μ=0.75		μ=1	
		T_1=1.4646 s		T_1=0.8629 s		T_1=0.798 s		T_1=0.7633 s		T_1=0.697 s	
VII zone a_g=0.1g	d_6 (m)	F_b=33.356 kN S_d=0.0130 g	$d_{e,6}$=0.0040 $d_{s,6}$=0.0156	F_b=56.62 kN S_d=0.0223 g	$d_{e,6}$=0.0023 $d_{s,6}$=0.0090	F_b=61.18 kN S_d=0.0171 g	$d_{e,6}$=0.0021 $d_{s,6}$=0.0082	F_b=63.97 kN S_d=0.0252g	$d_{e,6}$=0.0019 $d_{s,6}$=0.0074	F_b=82.513 kN S_d=0.0325 g	$d_{e,6}$=0.0020 $d_{s,6}$=0.0078
	d_{19} (m)		$d_{e,19}$=0.0106 $d_{s,19}$=0.0413		$d_{e,19}$=0.0063 $d_{s,19}$=0.0246		$d_{e,19}$=0.0059 $d_{s,19}$=0.0230		$d_{e,19}$=0.0058 $d_{s,19}$=0.0226		$d_{e,19}$=0.0039 $d_{s,19}$=0.0152
VIII zone a_g=0.2g	d_6 (m)	F_b=66.712 kN S_d=0.0260 g	$d_{e,6}$=0.0080 $d_{s,6}$=0.0312	F_b=113.24 kN S_d=0.0446 g	$d_{e,6}$=0.0046 $d_{s,6}$=0.0179	F_b=122.36 kN S_d=0.0171 g	$d_{e,6}$=0.0042 $d_{s,6}$=0.0164	F_b=127.94 kN S_d=0.0504g	$d_{e,6}$=0.0038 $d_{s,6}$=0.0148	F_b=165.026 kN S_d=0.0650 g	$d_{e,6}$=0.0040 $d_{s,6}$=0.0156
	d_{19} (m)		$d_{e,19}$=0.0212 $d_{s,19}$=0.0827		$d_{e,19}$=0.0126 $d_{s,19}$=0.0491		$d_{e,19}$=0.0116 $d_{s,19}$=0.0460		$d_{e,19}$=0.0452 $d_{s,19}$=0.0796		$d_{e,19}$=0.0078 $d_{s,19}$=0.0304
IX zone a_g=0.4g	d_6 (m)	F_b=133.424 kN S_d=0.0520 g	$d_{e,6}$=0.0160 $d_{s,6}$=0.0624	F_b=226.48 kN S_d=0.0892 g	$d_{e,6}$=0.0092 $d_{s,6}$=0.0359	F_b=244.72 kN S_d=0.0171 g	$d_{e,6}$=0.0084 $d_{s,6}$=0.0328	F_b=255.88 kN S_d=0.1008g	$d_{e,6}$=0.0076 $d_{s,6}$=0.0296	F_b=330.052 kN S_d=0.1300 g	$d_{e,6}$=0.0080 $d_{s,6}$=0.00312
	d_{19} (m)		$d_{e,19}$=0.0424 $d_{s,19}$=0.1654		$d_{e,19}$=0.0252 $d_{s,19}$=0.0983		$d_{e,19}$=0.0236 $d_{s,19}$=0.0920		$d_{e,19}$=0.0232 $d_{s,19}$=0.0905		$d_{e,19}$=0.0156 $d_{s,19}$=0.0608

Even a small change in rigidity of connection significantly affects the displacements, which is especially noticeable when one compares pinned with connections with small rigidity. For example, displacement δ_{19} of the top of the longitudinal frame with pinned connections (μ =0) is 67 % greater than in the case of the frame with the fixity factor μ=0.25 . (Table 2).

Fundamental periods also depend on connections rigidity, as can be seen from the tables. For example, the fundamental period of the longitudinal frame is T_1=1.4646s for μ=0, and it is 69 % greater than in the case of μ=0.25, when it is T_1=0.8629s, (Table 2). Hence, it can be concluded that even small rigidity of connection effects favorably on redistribution of influences in the structure, as well as on the basic dynamic characteristics.

5. CONCLUSIONS

A method which takes into account the rigidity of connections, based on matrix formulation of the deformation method, for calculation of dynamic properties of a frame structure, as well as influences due to design seismic forces according EC8 is proposed in this paper. The elements of stiffness matrix of semi-rigidly connected members are functions of the fixity factors which are introduced for the purpose of simulating the real connection behavior in the structural design. Fixity factors can be determined either experimentally or assumed, and ranges from 0 (pinned connection) to 1 (rigid connection). The frame structure of the existing precast RC industrial hall, as an example of a frame with semi-rigid connections is chosen for illustration of the proposed method.

The following conclusions are drawn:

- Up to date research has shown that absolutely rigid connection is difficult to achieve in RC precast structures, but at the other hand there is always some rigidity in each connection.
- Significant difference regarding the influences in a structure is observed comparing pinned and connection with a small rigidity. Even small rigidity of connection effects favorably on redistribution of influences in the structure, as well as on the basic dynamic characteristics.
- If the real rigidity is ignored and pinned connections are assumed, as per normal practice for RC precast structures, the structure dimensions would be over designed, i.e. the solution would be uneconomical. On the other hand, if assumed full restraint is not realized, negative consequences regarding the distribution of stresses in structure would arise. It is therefore of utmost importance in optimal dimensioning of the structure to take into account the real fixity factor of connections, particularly in the case of seismic design of precast RC structures.

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SEIZMIČKA ANALIZA RAMOVA SA POLUKRUTIM VEZAMA U SKLADU SA EC8

Dosadašnja istraživanja su pokazala da se većina konstruktivnih veza armiranobetonskih (AB) ramova, posebno montažnih, ponaša kao delimično krute. Zbog toga je od velike važnosti razviti metod analize koji uzima u obzir krutost veze. U ovom radu je za to korišćena matrična formulacija metode deformacije, a uticaj krutosti veza na odziv konstrukcije obuhvaćen je matricom krutosti za delimično kruto vezani štap. Elementi ove matrice su funkcije stepena uklještenja na krajevima štapova. Predložena metoda je primenjena u seizmičkoj analizi prefabrikovane AB ramovske konstrukcije postojeće industrijske hale u skladu sa Evrokodom 8 (EC8).

Ključne reči: *delimično-krute veze, matrica krutosti, seizmički proračun, montažni armirano-betonski sistem.*

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