High-Density Forms in Contemporary Architecture

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Abstract

The continuous growth of population is stressing out profoundly the global resources, including the physical space that also represents a resource. The population growth needs a physical support in the form of dense urban environments and architecture with similar qualities. Under those circumstances, high-density architectural forms represent the most viable models of the future in general and of housing in particular. The general concern of the study focuses on identifying the most suitable models for the future habitat and on the way in which they can offer the right support for their inhabitants in relation to the crowding factor. The specific objective of the study is the general definition of the concept of density in relation to the built environment, followed by an overview of the typologies and principles in the design of dense architecture. The quality of high-density architectural forms lies in the mix between the spatial configuration and the way in which people live and conduct activities within them.

Rezumat

Creşterea continuă a populaţiei solicită profund resursele globale, inclusiv spaţiul fizic care reprezintă de asemenea o resursă. Această creştere a populaţiei are nevoie de suport fizic reprezentat de medii urbane dense şi de arhitecturi cu calităţi similare. În aceste condiţii, formele arhitecturale cu densitate ridicată reprezintă modelele cele mai viabile ale viitorului în general şi ale locuirii în special. Principala preocupare se concentrează pe identificarea celor mai potrivite modele pentru mediile habitatului viitor, şi pe felul în care acestea pot oferi un suport corect locuitorilor în relaţie cu gradul de aglomerare. Obiectivul specific al studiului este definirea generală a conceptului densităţii în relaţie cu mediul construit, urmată de o privire generală asupra relaţiilor dintre mediile dens populate şi formele arhitecturii dense. Calitatea formelor arhitecturale cu densitate ridicată rezidă în mixajul dintre configuraţia spaţială şi felul în care oamenii locuiesc şi desfăşoară activităţi în interiorul lor.

Keywords: high-density, architecture, population density, building density, dense residential environments, collective housing, high-density density forms

1. Introduction

The continuous growth of population in relation to the constant earth surface and to the limited or hardly renewable resources is one of the global concerns. The year 2006 represented a key moment

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in the evolution of the phenomenon, since from this point on the inhabitants of the cities exceeded half of the world's global population. It is estimated that in the near future the population, and particularly urban population, will continue to grow, at such a rate that two out of three people born in the following thirty years will live in cities [1]. The population growth requires a physical and spatial support and directly attracts the demand for housing. In this context high-density architectural forms and dense urban environments represent the most viable models for the future in general and for housing in particular.

In the present, the implications of high-density architectural models overpass the realm of the urban tissue and that of the architectural object and acquire social, ecological and urban meanings. The connotations of contemporary density and the relation it has with the city are important for understanding the way in which high-density architectural forms draw attention again, after a period in which they have been perceived and discussed as a negative phenomenon [2].

High-density architecture has dual connotations, both positive and negative, and the balance between the two is sensitive, based in part on scientific evidence and partly on subjective perceptions. On the one hand, a design that uses principles of high-density is more compact and manages to conserve important land resources while reducing required distances for transportation and therefore the use of energy, representing therefore a more economically efficient model. There is also the assumption that areas containing high numbers of people are themselves sources of variation, of intensity and diversity, and that densely populated areas provide a communication experience with multiple possibilities and therefore a very rich exchange of ideas [3]. On the other hand there are potential negative implications linked directly to increased noise or lack of intimacy, or more subtle implications, supported by a number of sociological and behavioral studies that identify crowding as a source of stress and as a factor that can cause behavioral changes in people, in conjunction with the architectural environment [4]. Recent researches in neuroscience come to support sociological speculations about the implications of crowding on stress, showing that people born in large cities that are involved in a larger social network have an increased amygdala (a region of the brain associated with memory and emotional intelligence) compared to other people [5].

The study focuses on high-density architectural forms in relation to housing, housing being one of the most inciting themes of architecture, by its universal character and its relation to one of the most basic human needs, that of dwelling. The forms of housing are the result of multiple overlapping contexts, such as political, social, cultural and geographical. High-density collective housing is being reconsidered as a viable design solution in the present context. Still, although life planning, social rituals and economic conditions are constantly changing, it seems that the architectural support remains yet stable. Collective housing is an architecture program in which innovation is not actually perceived, and the principles of spatial and planimetric configuration remain quite traditional. The rooms and the functional relations between them remain those intended for a traditional family in relation to a society in which the classical family tends to disappear, being replaced by other dynamic social structures defined by complex relationships [6]. The reason for that is partly linked to the commercial interests of the construction industry seeking maximal results with minimal risks and investment, and partly to the conservative mentality of the population in relation to housing.

Taking into consideration the implications of the recent economic crisis, most of the major current crises are based on real estate issues. A large number of families recently lost their homes which they bought by credits that they couldn't really afford, aiming for an ideal home and ignoring their real possibilities of purchase. The number of those that can afford an individual home on a plot with a garden is continually decreasing, and the environmental implications of individual houses are largely negative. Individual houses require a high consumption of energy for transportation,

increase in the number of private cars and intense pollution generated by burning fossil fuels. However, the dream of a single family home seems to have been the only available option until now for a family in relation to the available housing typologies [7].

It is obvious that traditional design methods are no longer viable under current conditions, and finding new ways to design high-density built environments is a necessity. The new high-density residential concepts, in an idealized vision, should achieve a balance between the dream of a rural house and the reality and necessity of living in dense urban areas, combined with the actual economic possibilities of their envisioned future residents.

2. Understanding the term density

Population density is a phenomenon related to the way in which people are distributed on the land surface. Population is unevenly distributed across the land, reaching high concentrations in dense urban areas while large areas of land remain uninhabited, because people naturally tend to concentrate in areas with desirable conditions. The differences in population distribution are high both across countries and between regions of the same country [8], and thus the concept of *built environment density* has relative connotations when trying to compare indices of different areas.
Starting from this fact, it becomes clear that the exact definition of the term *high-density architecture* can be difficult. The term *"density"* is itself a complex concept, involving some diversity in terms, and defining it is important before starting to discuss density in relation to architecture.

2.1 The Definition of Density

High density refers either to *physical density*, namely the density of a large number of people or the built density related to the land surface, either to subjectively *perceived density* in relation to the environment and to other participants into a certain space.

Physical density is a numeric measure of the concentration of individuals or physical structures in a certain geographic unit, being a spatial objective indicator, quantitative and neutral. In practice, it only makes sense when linked with a specific reference scale.

Perceived density represents the individual perception of an estimated number of people present in a given area or that of the vacant space and its organization. The character of space itself is important for the perception of density, but the interaction between individuals and environment as a whole is more important. Also the individual cognitive attributes and socio-cultural norms are factors that contribute to this interaction. Perceived density doesn't only refer to the relative relations between individual and space, but also to the relations between individuals located in the same space.

Usually, in architecture and town planning, two categories of measurement are used for physical density: *population density* (Fig. 1) and *building density* (Fig. 2). *Population density* is defined as the number of individuals or households per given area, while *building density* is defined as the ratio of building structures related to plot surface. All those measures are used in urban planning policies.
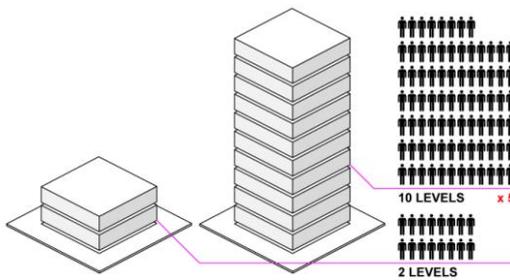
Figure 1. Population density.   Figure 2. Building density.
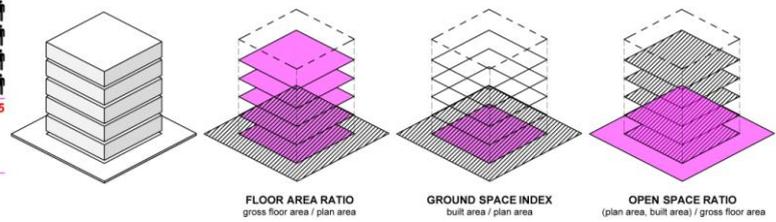
Building density has a complex relation to urban morphology, playing an important role in determining urban form. Different combinations between *plot ratio* and *site coverage* will manifest into a variety of different built forms, and urban development of the same density can have very different urban forms [9].

The differences between the surface distribution of population density and that of building density are visible when comparing data of almost every urban tissue. The following example (Fig. 3) illustrates the differences between the two density types in the case of Timişoara, expressing graphically data of the year 2011.
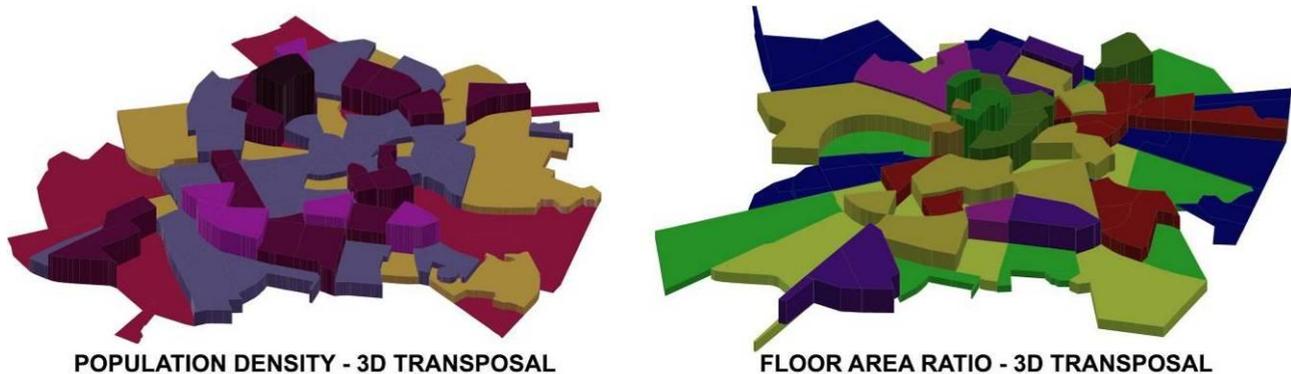

Figure 3. The difference between the distribution of densities of people and buildings in Timişoara.

Source: illustration from the board *Development Analysis I 13_Densities*, General Urban Plan (PUG) of Timişoara [10] (Planwerk and Vitamin Architects).

In reality, especially when the geographic reference unit is one at large scale, the distribution pattern of people or buildings can vary significantly. To solve the spatial variation of density, different measures have been introduced, such as *density gradient* or *density profile*. The *density gradient* is a composite measure of density and is defined as the rate in which density varies in relation to the distance towards a reference location, usually a city center or node. It is calculated usually according to concentric circles that map a certain given area (Fig. 4). By comparing the patterns of density over a period of time, the process of spatial evolution of the city can be depicted, showing either decentralization with a drop of population density in the center and increased density towards the outskirts, either centralization with a growth in population density in both center and outskirts, and the expansion of the borders (Fig. 5) [9]. It manages to depict a dynamic image of density, compared to the static data offered by population density or built density, by including the time variable in its calculation.
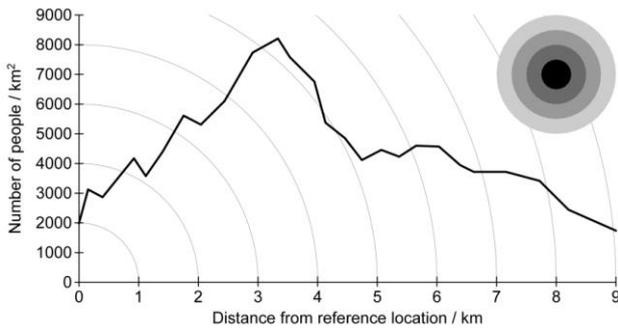
Figure 4. Population density gradient for an abstract case.
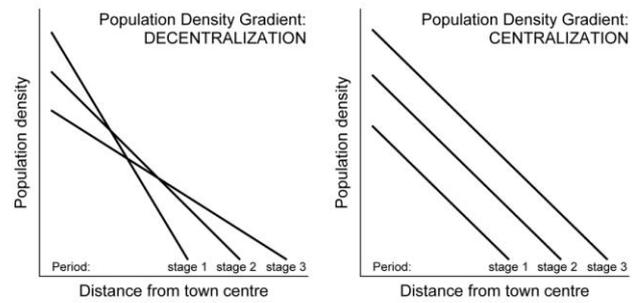
Figure 5. Density gradients over time:
(a) progressive decentralization;
(b) centralization.

From the perspective of rapid urbanization, the relationship between urban density and built form has always been an important focus of research, determining massive mathematical and geometrical investigation upon the spatial benefits of buildings with multiple levels.

The presented definitions and measurements of density are the most relevant ones in relation with the subject of density from an architectural point of view, but they are not the only ones. The definition of density in relation to built environment can have different meanings or different quantifications according to the method of analysis and spatial indices taken into account. There is no universal standard formula, only some formulas are being used more as opposed to others.

2.2 The Qualities of Density

Dense environments have always been considered as carrying both positive and negative connotations. On one side they are considered positive due to the sustainable use of resources and the intense social links they generate, but on the other side they are recognized to generate negative effects on humans, such as stress. Starting with the industrial revolution, a strong debate arose regarding the benefits and downsides of density, especially regarding the relation between existing crowded urban environments and the programmatic development of new and healthy environments. The debate remained unsolved for a long time, until recent studies have determined an important element of the equation that actually shifts the balance between good or bad density, namely the *quality of the built environment*.

According to Uytenhaak R., who has comprehensively studied density from the perspective of architecture and urban development, the built density is the source of a loss of (natural) quality, and the role of urban and architectural design is to neutralize this effect by eliminating oppressive spatial configurations and by generating diversity through the design of "intelligent puzzles". The *quality of density* is the most significant feature of the urban built context and as Uytehnhaak R. points out "without sufficient quality, density does not work – it even becomes dangerous". Spatial quality, as he states, should be sought for in the architectural design of new buildings as a way of compensating for density and its potential negative effects [11].

The *quality of density* balances the previous interdisciplinary discussions about the justifications underlying positive or negative high-density architecture models of the architectural culture, determining the defining criterion for models that function correctly.

3. Formal Typologies of Dense Residential Architecture

In relation to dense residential environments, defining the *typologies of collective housing* is important. *Collective* or *mass housing* is defined primarily by quantity and it acquires its spatial

quality through grouping. This type of dwelling houses large numbers of people with varying degrees of housing quality. Within it the housing units are closely grouped, according to rules of horizontal or vertical assemblage, generating spaces with public, semi-public or private character in which certain social practices of housing unfold. Collective housing draws its name origin from the way in which the building is accessed, namely by a common path serving all the units [12].

In an attempted typological classification of contemporary collective housing models of high-density, a generic formal classification has been carried out, which is not exhaustive and is partially based on the studies of Mozas J and Per AF within the "Density Series" books.

Following categories of architectural forms with different degrees of density are identified: *"houses"*, *blocks*, *city blocks*, *high-rise buildings* and *mixed solutions* [13]. Each typology uses as a starting point the individual housing unit, the apartment, which is multiplied in an identical or variable pattern of configuration. The typological categories vary according to composition principles, size and by the way the building relates to the urban tissue.

3.1 Houses

Starting from the singular and abstract typological unit represented by the individual house, the first category is driven by multiplying, joining or overlapping multiple units. The configurations generated by those operations are either classical attached or row houses, either contemporary types of folded row or stacked houses (Fig. 6).
The individual unit is usually related to the terrain, benefitting of a court or a terrace and benefitting of direct, individual or paired accesses from the ground level. This category makes the transition from individual housing to collective housing of a higher degree of density.
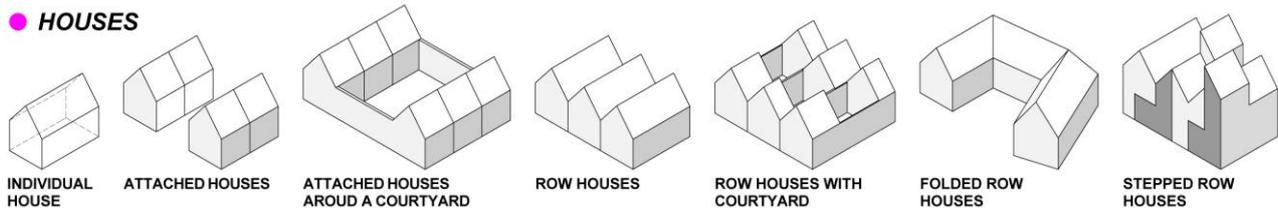

Figure 6. Houses – adaptation after the typologies of *Density: New Collective Housing*.

3.2 Blocks

The second typology is that of the *block* (Fig. 7), which represents a quantitative increase in size, number of individual units and scale compared to the "house" typology. The block height is moderate, usually ranging between 3 and 5 levels; this height is traditionally justified by the number of levels convenient for walking. Its relative low configuration, its flexible footprint related to the ground surface and its scale allow the object to enroll organically within the context.

Blocks can be freestanding on the plot, can have free sides or can continue an existing building by cleaving onto a party wall.

● **BLOCKS**

LINEAR BLOCK   PARALLEL BLOCKS   L-SHAPED BLOCK   T-SHAPED BLOCK   U-SHAPED BLOCK   LINEAR BLOCK WITH COURTYARDS   SUPERPOSED BLOCK

PERFORATED PARALLEL BLOCKS   BLOCK IN FISHBONE ARRANGEMENT   L-SHAPED BLOCK AGAINST PARTY WALL   PARALLEL BLOCKS AGAINST PARTY WALL   GROUPED BLOCKS
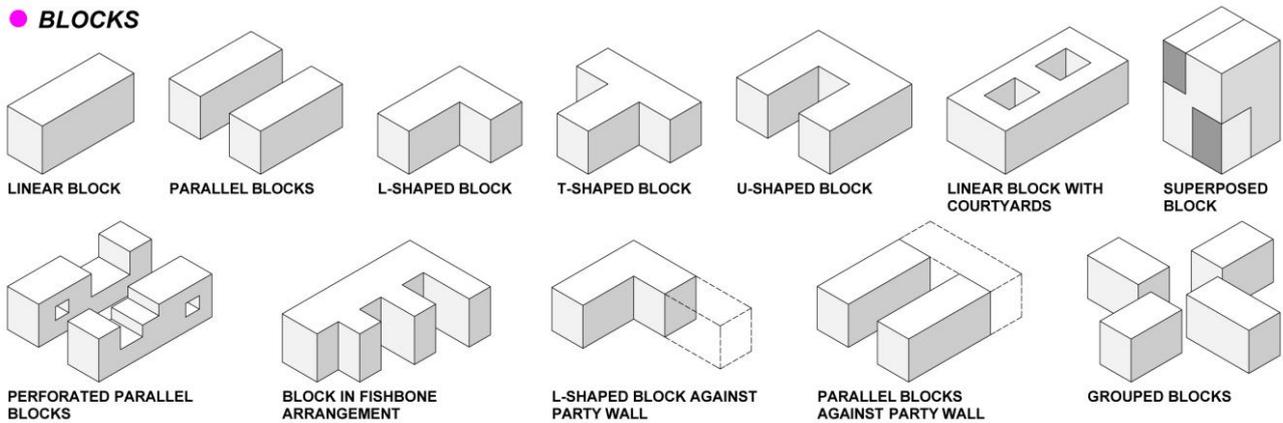
Figure 7. Blocks – adaptation after the typologies of *Density: New Collective Housing*.

3.3 City Blocks

The *city block* (Fig. 8) is an urban building flanked on all sides by streets in relation to the urban fabric [14]. Its scale is directly related to the scale of the city. The city block generally involves a large spatial diversity and a relatively high privacy degree. It can have the same height as the block typology or higher, depending on the context. Buildings ranging between 4 to 7 levels are ideal in terms of energy footprint, which is lower than that of taller buildings.

● **CITY BLOCKS**

U-SHAPED CITY BLOCK   HALF CITY BLOCK   CLOSED CITY BLOCK   FOLDED CITY BLOCK   PERFORATED CITY BLOCK   SEMI-OPEN CITY BLOCK

OPEN CITY BLOCK   STEPPED CITY BLOCK
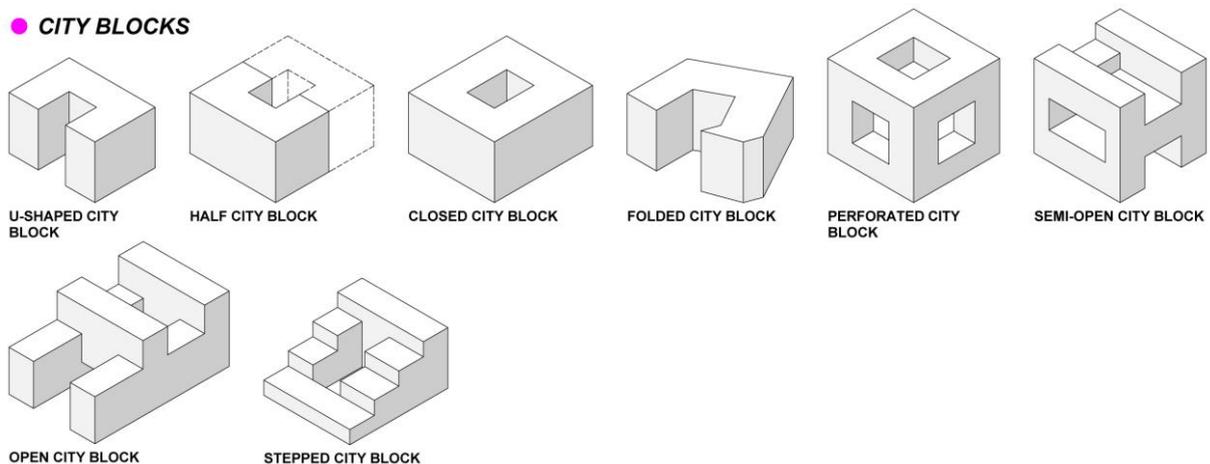
Figure 8. City blocks – adaptation after the typologies of *Density: New Collective Housing*.

3.4 High-Rise Buildings

The *high-rise building* type (Fig. 9), also known as *tower block*, is represented by tall buildings with multiple levels. There is no universal definition for the number of levels that determines a building to gain this status; this height is variable according to different geographic areas [15].

This typology is justified by economic considerations, not only in relation to construction costs, but also in relation to urban infrastructure and land resources. Their impact on the neighboring urban tissue is high and the main disadvantages are excessive shading and energy consumption.

The *stacked units block* is the most interesting type, being able to generate spatial quality and diversity. It derives from additive processes of small scale units or from overlapped uneven floors.
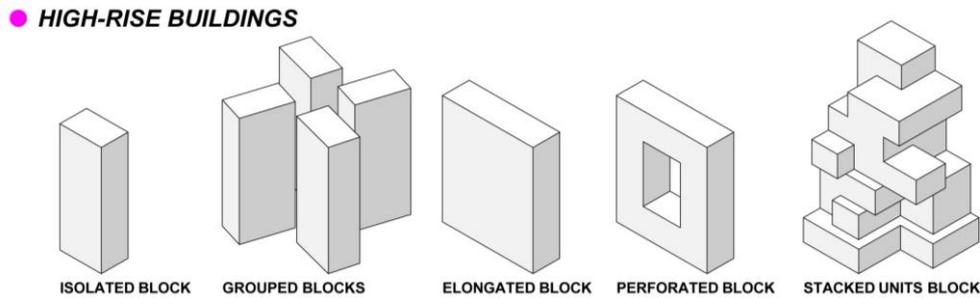
Figure 9. High-rise buildings – adaptation after the typologies of *Density: New Collective Housing*.

3.5 Mixed Solutions

The *mixed solution* typology involves combinations of the above, justified by context and project brief. There are no precise formal categories for this typology.

4. Principles of High-Density Architecture Design

Starting from the general issues, it may be considered that the most appropriate forms for high-density in the current architecture are those that can generate diversity, that can act as flexible supports for their inhabitants and have intrinsic spatial and functional qualities. The major principles to be followed in high-density contemporary architectural design are consequently the *social*, *environmental*, *urban* and *quality* principles.

The *social principle* involves accurate reporting on prospective tenants, but to truly assume their needs in the case of collective housing is impossible. In order to fulfill this principle it is required to design flexible or neutral spaces that allow greater freedom of use and the ability to adapt to changes in circumstances through simple and economic measures, equivalent to lesser control by a rigid architectural environment. Adapting to the changing needs of the inhabitants as well as to contextual changes increases sustainability of a built environment.

The *ecologic principle* refers to the way in which resources are used. The design of dense architectural forms in relation to the urban environment is a necessity for a rational and limited consumption of resources such as urban land, but also in relation to energy consumption. Integrating sustainability into planning is a key feature for future developments.

The *urban principle* involves the organic integration of the object amidst its proximal context, regardless of its urban or natural qualities, and the generation of balanced relations with the public space. Keeping a fair ratio of urban greenery with easy acces in relation to the built environment is a must. Designing volumes derived of additive processes and granulation would generate better relations to the context. The *quality principle* refers to the quality of the environment as well as to spatial or detailing quality. Spatial quality can be achieved in multiple ways, but the most obvious measures are including diversity and flexibility into design. Other principles to be followed in the pursuit of correct dense environments are integrating technical and conceptual innovation in the design process.

4.1 Case studies of the stacked units block

Further on, the analysis of a series of study cases based on the typology of the *stacked units block* highlights the use of different principles that lead to quality of high density and high rise

architectures. Additive processes first came to be used as means of generating quality of large scale objects. This occurred due to the fact that the scheme of vertically extruded identical floor plans used by standard high-rise buildings proved to be unable to generate the right support for inhabitants in need for diversity and balanced relationships to the immediate context. Still, introducing diversity in the building concept is not new. An example with reference value is *Moshe Safdies*'s *Habitat 67* [16], (Fig. 10.a) which was built as a pavilion for Expo 67, comprising 354 identical prefabricated modules, diversely organized and creating 146 residences. Each residence is variable in size and configuration, and each housing unit is connected to at least one private terrace. The concept combines the qualities of a dense housing environment, such as economy of land, costs and resources with the benefits of suburban homes with private green areas, in relation to the constant crowding of cities, while offering affordable housing. The configuration of modules generates rooftop gardens on top of the units below and good relations to the surrounding. The building redefined high-density housing of the period and boosted social integration through its qualities, such as large open spaces with variable degrees of density.

The metabolism movement in architecture has integrated concepts of impermanence and change earlier, but through a much more technological approach towards the building and the building process itself. *Kisho Kurokawa*'s *Nakagin Capsule Tower* [17] (Fig. 10.b) represents a prototypical architecture, introducing the concept of a granulated building, generated by adding up a single type of housing capsule, able to interconnect to form larger spaces. Every capsule is plugged into a central core. Metabolists regarded the city as being dynamic. The main targets of the project were technology, prefabrication, capsulation, minimally configured spaces, sustainability and recyclability. Each capsule can be replaced or exchanged when necessary. Although the building, completed in 1972, is currently rejected by its users since it hasn't been refurbished for the last 30 years, it represents a milestone for the flexible design of dense residential architecture.

A contemporary approach that uses the same concept is *56 Leonard Street* [18] (Fig. 10.c), an innovative skyscraper project of the architecture firm *Herzog & de Meuron*, currently under construction. The building contains public functions on the lower levels and 145 highly customizable and uniquely configured residences on the upper levels. All residences have a unique floor plan and private outdoor space, while their interior blends with the exterior surroundings by fully glazed walls inspired by the permeability of modernist houses. The architects describe the concept as "houses stacked in the sky", making use of floor slabs that vertically progress by turning off the axis of the building as they ascend. The effect is a constant variety of the apartment floor plans and a sliced facade that creates a non-linear surface of variable degrees of transparency and opacity.

10.a   *10.b*   *10.c*

Figure 10. Case studies that use principles for designing quality high-density residences.
10.a – Habitat 67, *10.b* – Nakagin Capsule Tower, *10.c* – 56 Leonard Street

Aside constructed buildings, an entire new wave of concepts and designs appear from students and

young architects. New and fresh ideas arise challenged by current competitions, based on similar conceptual principles of social, ecological, urban and quality design. One of the main platforms for experimental architecture is the annual international contest *E-Volo Skyscraper Competition*. From the large spectrum of conceptual projects, the ones that could be mentioned in relation to the previous case-studies are: *Hanging Gardens*, a skyscraper designed by *Yan Jie Chen* and *Camille John*, designed as a dynamic growth derived from a Chinese puzzle game of interlocking rectangles based on repetitive design and *Green Catalyst* residences by *Kamvari Architects*, that responds to the reduction of green space in the urban centers by proposing high-rise buildings made up of multiplied same scale units with various orientations and green terraces.

5. Conclusions

The defining principles in designing high-density architecture can be stated clearly. Their sum generates an integrated design strategy that can result in correct architectural objects, but not necessarily. Their application requires to control by design aspects that are influenced by high-density, but architectural design cannot be purely the result of a mathematical generation matrix, being also a process with subjective implications. Applying an integrated design strategy can maximize the benefits of high-density and can avoid high-density developments with severe social or ecological problems.

This study is structured in three major registers. At first, it provides a review of the most important definitions of density in relation to the built environment. Subsequently it offers a review of present typologies of high-density residential architecture, followed by a synthesis of design principles for high-density future residential environments that can generate quality dense environments, supported by the analysis of a series of case-studies. The original aspects of this study are the interpretation and the continuation of constructive typologies of high-density architecture (with the stacked units block typology) adapted after the categories laid down by Mozas J and Per AF in *Density: New Collective Housing*, as well as the synthesis of design principles for high-density architectures, supported by a series of case-studies.

The study suggests that the next stage of research shall determine how architectural design and the implications of the contemporary context converge and determine high-density architecture forms.

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