Models for Experimental High Density Housing

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Abstract. The article presents the effects of research on models of high density housing. The authors present urban projects for experimental high density housing estates. The design was based on research performed on 38 examples of similar housing in Poland that have been built after 2003. Some of the case studies show extreme density and that inspired the researchers to test individual virtual solutions that would answer the question: How far can we push the limits? The experimental housing projects show strengths and weaknesses of design driven only by such indexes as FAR (floor attenuation ratio - housing density) and DPH (dwellings per hectare). Although such projects are implemented, the authors believe that there are reasons for limits since high index values may be in contradiction to the optimum character of housing environment. Virtual models on virtual plots presented by the authors were oriented toward maximising the DPH index and DAI (dwellings area index) which is very often the main driver for developers. The authors also raise the question of sustainability of such solutions. The research was carried out in the URBAN model research group (Gliwice, Poland) that consists of academic researchers and architecture students. The models reflect architectural and urban regulations that are valid in Poland. Conclusions might be helpful for urban planners, urban designers, developers, architects and architecture students.

1. Introduction

"In a virtual urbanism, the concepts of density are directed related to the material problems of transforming the city", [1].

Contemporary urbanization is progressing and a large part of it is housing. The demand for housing estates is rising globally, and so is the consumption of space, [2, 3]. Multi-residential buildings are being constantly redefined by a new challenge: housing estates in cities has become one of the most popular building types of our times. Many new housing estates are being built or planned and only some of them can be considered as high density settlements. Winny Mass et al. published a research on maximising density in FARMAX on a global scale [1]. A wide research has been described on model examples including an algorithm that could propose one of the possible solutions for a kind of building or settlement depending on input parameters. The model examples were different types of buildings that offer different densities. Although the methodical/procedural approach was perfect, we must keep in mind that not every design solution is appropriate in every space. The Spacemate calculator published in 2004 [7] appears to be much easier to use and understand, since most of the case studies were individual and existing builds or settlements. The advantage of the Spacemate calculator research was that most of the cases were studied locally in Holland, and so a comparison of the findings was not difficult. Many researchers put a lot of effort to demonstrate the possible solutions or criticize...
realized objects. The website [14] made by Roger Sherwood is a great example of methodical worldwide approach to presenting the problem. On his website, all the necessary information is presented: photographs of finished buildings, plans, elevation, ratios and indexes and also comments. There are several indexes that can easily describe the housing density. These are FAR (floor attenuation ratio - housing density) and DPH (dwellings per hectare). Density is a variable whereby in principle the built surface area, floor surface area or built mass is related to the surface area of the plot or the entire urban area. In city planning a FAR of 1.5 to 1.8 was long considered the optimum [1]. Fernandez Per considers Floor Area Ratio, rather than dwellings or population, as a measure of density [5].

The authors raised the question: Why density is an important project guideline? Density can be delivered in different ways, but some may be wrong, some may be good. The only way to find out was to test several solutions and use the experience gathered during research. As Gokhan Karakus states in the introduction to *High density housing architecture* ‘the popularity of housing projects due to urbanization has had the effect of generating new building types and interpretations of residential living for this quickly-growing segment of urban residents’, [3]. Such a statement has justification in many contemporary implementations. The most obvious and simple answer would probably be: Because we want more space, more total built area. The scale of Wohpark Altaa Erla [8] in Vienna with nearly 10,000 inhabitants is a one of a kind. In some cases, the quantity is not the only reason. There are examples of both quality and quantity experiments such as those described in several case studies by the a+t research group in Why Density [4]. For example, the ‘8 houses’ case study designed by Bjarke Ingels and built in 2010 in Copenhagen in Denmark can be called a megastructure since that multifunctional building offers a variety of dwelling types and spaces on a plot that is 2 ha big. Even though the density of it was not so high (2.98 – the FAR index and 50% of site coverage), still the idea needs to be tested in time to proof that it works.

Polish experience with the growing housing substance is not that spectacular. Still, over 50% of housing are single family houses built on the outskirts of the cities. Contemporary urban planning in Poland faces several different problems with housing developments such as: suburbanization, sustainability issues, low design and implementation quality. Dense housing estates are very often raised in centres of the biggest cities and their form is driven by the maximum FAR index. Since housing typology is strictly connected with local tradition, regulations, and local law (Local Development Plans, that limit the density), the authors decided to perform their own research on the housing estates that have been built in Poland recently.

2. Case studies

During the period of three months from November 2016 to January 2017 a research on existing housing estate models was carried out. The main goal of the research was to create an analysis of the estates that have been built in recent years in Poland under certain criteria. 34 multifamily housing estates were chosen for the research. The following research criteria were applied: construction after year 2003, location in various cities across Poland, accessibility of essential data and attractiveness as a place to live. Estate area size was a significant criterion as well. The estates chosen for the research were in the form of several buildings, individual city blocks or several blocks. Single buildings were rejected as subjects of the research as they do not play an important role in landscaping the surroundings. Large-scale housing estates are sparsely developed in Poland; therefore, they were not a subject of the research.

The most essential data concerning the selected models, such as: area, gross covered area, biologically active surface, cubic capacity, the number of floors, the number of dwellings, the number of car parking spaces and the number of dwellings with adjacent gardens were gathered in a collective table. Data concerning vicinity of the estate, such as: the distance to the nearest basic services and public transport stops were taken into account as well. For every housing estate model, there was a site
plan, a figure-ground diagram of the surroundings and a 3D model developed. Based on collected data and developed materials, the following urban indicators were computed: FAR (floor area ratio), the number of dwellings per ha, building area, housing density and the number of car parking spaces per dwelling.

The examples of housing estates (that were laid down during the research) presented below reach a particularly high value of DPH (dwellings per hectare) ratio. They show interesting concepts which take effect in reaching the maximum housing density, while being in accordance with building laws.

Figure 1. Bird’s eye view (source: www.googlemaps.com) and a 3D model of the Aura Gdańsk estate [14]

The Aura Gdańsk (Figure 1) housing estate is located in the dense downtown area of Gdańsk. The estate reaches extremely high housing density of 5.19 (with 478.5 flats per ha by 8 floors). Such a high density is achieved through developing over 90% of the site. It is also achieved at the cost of size and form of the dwellings - most of them are small and only have windows facing one direction.

Figure 2. Bird’s eye view (source: www.googlemaps.com) and a 3D model of the Cynamonowy Dom estate [14]

The Cynamonowy Dom housing estate (see Figure 2.) is located in the suburbs of Warsaw. The estate is composed of three tower blocks, which are connected by an underground car park. The entire estate can be described as high density development (with 344 dwellings per ha by 11 floors). High density of the estate is achieved at the cost of green areas and spaces between buildings.
Figure 3. Bird’s eye view (source: www.googlemaps.com) and a 3D model of the Qbik Woronicza estate [14]

The Qbik Woronicza housing estate (see Figure 3) is located in the midtown area of Warsaw. The estate outstands the surrounding buildings due to its form of a solid block and its high density of 4.30 (with 263.82 flats per ha by max 11 floors). Consequently, the form of the block causes minimization of public spaces and insufficient insulation of the dwellings.

The research conducted on existing multifamily housing development induced the team to draw the following conclusions: a) a significant minority of new housing estates are being built in city centres or in a close range of city centres; b) the main factor impinging on the form of new housing estates is the pursuit of achieving the highest dwellings per ha rate; c) housing estates composed of urban blocks or semi-open blocks reach the highest density and the rate of dwellings per ha; d) housing estates which are built in the suburbs mainly achieve low density rate, as compared with the values achieved in single family housing.

3. Models for experimental high density housing
Some of the case studies show extreme density. The DPH ratio is often the main driver for developers, when composing a new multifamily housing estate. This, as well as the conclusions of the research, inspired the research team to carry out an experimental project to seek the answer to the following question: How far can we push the limits? Is there a boundary of how many flats per ha can we achieve? Therefore, the main goal of the experimental project was to design virtual estates on virtual plots oriented toward maximizing the dwellings per ha ratio (considering limitations resulting from the building law).

The estates investigated during the research were developed on diversely sized sites. Their scale varied from 0.33 ha (the tenement houses quarter in the Old Town of Gdańsk) to 5.84 ha (the Wróbla Staw housing estate in Gdańsk). However, most of them were built on sites of the area ranging from 0.5 ha to 2 ha. In order to develop models in a similar scale to the studied estates, the model estates were planned on a square site of 1ha area. That specific site area allowed to develop virtual models of medium scale, and of size that facilitates calculations of indicators.

3.1. Experimental housing estate - model no. 1
The housing estate is composed of a semi-open urban block and five tower blocks (Figure 1). Every part of the urban block was given a different height, which was the outcome of a research aimed at finding the most advantageous numbers of storeys for each building in terms of insulation. The main inspiration for the designed estate is Mozaika Mokotów in Warsaw, well described as ‘ideal for a family’ on the site of the estate, [9].
Figure 4. Site plan and perspective view of the experimental housing estate no. 1.

Table 1. Urban indicators of the experimental housing estate - model 1.

| value         | index            | value         | index            |
|---------------|------------------|---------------|------------------|
| 296           | number of dwellings | 35.72%        | built area (%)   |
| 296           | number of dwellings per hectare | 18.52%        | paving area (%)  |
| 450           | number of underground car parking spaces | 45.76%        | green area (%)   |
| 20            | number of car parks | +             | urban landscape quality |
| 1.59          | number of car parking spaces per dwelling | 11            | number of floors |
| 28,432        | total area [m²]   | 0.36          | built area       |
| 18,480        | usable floor area [m²] | 2.19          | housing density  |

Eleven floors of the eastern part of the urban block are designed in the corridor layout. There are 16 dwellings on every floor. A smaller number of floors in the northern and western parts of the block allows to ensure enough lighting in the courtyard. The housing estate is complemented with five four-storey tower blocks. There are four dwellings on each floor. The inner areas of the estate are designed as public spaces, containing generally accessible green areas, relaxation zones and playgrounds. Most of the parking spaces are located in the underground car park on the -1 floor under the whole area of the estate. Twenty of the parking spaces are generally accessible, located outside.

The entire estate can be described as high density development (296 flats per ha by 11 floors) with the density rate of 2.19 (Table 1). High density is achieved at the cost of a very small distance between the buildings, spaces between the buildings seem to be confined.

3.2. Experimental housing estate - model no. 2

This experimental housing estate is comprised of two identical multifamily blocks, in the form of letter “E”, facing south (Figure 5). In each block the ground floor is dedicated mainly to parking spaces. Part of it can also be used as commercial premises, due to its location on the ground floor of the building. The underground car park is also located on the -1 level. There are 536 parking spaces under the building (Table 2). Thirty-four parking spaces are located outside the unit and are generally accessible.
Both buildings consist of five-component blocks. Three of them achieve the height of 11 floors over level 0 (which is the level of the car park). In between of those three blocks there are semi-public spaces on the roof of the parking floor, consisting of greenery, playgrounds for kids and relaxation zones. The remaining two parts, located in between, reach the level of 6 floors. Due to this arrangement of the component blocks, a very high DPH rate was achieved (324 dwellings per ha) while maintaining the level of insulation as determined by the building law. However, a density this high was achieved at the cost of large, inhuman scale of the estate and very little public space.

The main inspiration for the virtual model were the Adria and Przy Promenadzie housing complexes, located in Warsaw, and the Cynamonowy Dom housing estate in Sosnowiec [10,11].

### 3.3. Experimental housing estate - model no. 3

This experimental housing estate model is designed as a semi-open urban block composed of two tower blocks and one block in the form of letter “E” (Figure 6). This composition is the outcome of a research aimed at finding the most advantageous dwelling location in terms of insolation. Two tower blocks, located on the south side, are low – consisting of 4 floors. Due to their height and form they do not shade the areas situated to the north. The building in the form of letter “E” is shaped in a cascade way – its height rises towards north, where it reaches 10 floors. This form allows an assurance of a proper length of form for every dwelling (a length which is precisely specified by the Polish building law). The main inspiration for this model was the Dębowe Tarasy estate in Katowice, well described as portraying ’the modern, urban elegance’ on the website of the estate, [12].
Figure 6. Site plan and perspective view of the experimental housing estate no. 3.

Table 3. Urban indicators of the experimental housing estate - model no. 3.

| value                  | index          | value                | index          |
|------------------------|----------------|----------------------|----------------|
| 336                    | number of dwellings | 33.60%              | built area (%) |
| 336                    | number of dwellings per hectare | 24.10%              | paving area (%) |
| 500                    | number of underground car parking spaces | 42.30%              | green area (%) |
| 30                     | number of car parks     | +                   | urban landscape quality |
| 1.58                   | number of car parking spaces per dwelling | 3-10                 | number of floors |
| 25,226                 | total area [m²]         | 0.34                 | built area     |
| 16,397                 | usable floor area [m²]  | 2.52                 | housing density |

The building located along the northern edge of the site is composed of a segment with individual staircases. There are 2 or 3 dwellings per floor in each segment. In the tower blocks, there are 4 dwellings per floor. This way the DPH indicator of 336 was achieved (Table 3). Along the northern edge there are 30 ground-level generally accessible car parking spaces. However, the majority of parking spaces is located in a two-storey underground car park, accessible via ramps located along the northern and southern edges of the site.

Thereby, the estate from the example reaches high density of 2.52 (Table 2). This density, however, was achieved at the expense of a decrease in distances between buildings and of decreasing the areas of public space.

4. Conclusions
The main conclusion resulting from the carried out research is the claim, that maximization of housing density (which is often the main factor for the developers) is not the most important value determining the quality of a residential complex. To achieve higher housing density, residential complexes lose other important indicators that ensure the residents’ comfort. The research showed that all high density housing estates are structurally complex. If we consider that time is one of the most needed goods – the researchers tried to wonder: how long does it take to get in and get out of such a complex housing estate? In most case studies corridors, elevators, underground car parks use a lot of space and so it probably takes a long time to perform basic things which we do nearly every day.

Depending on what the user pays heed to as a priority in terms of quality of the residence, overstating density can cause lack of satisfaction with: sizes of dwellings, the number of parking
spaces per apartment, areas of green space and recreation areas. A properly designed housing complex should serve the needs of citizens at all levels.

The psycho-social aspect is also significant. By increasing the housing intensity, we increase the number of residents in a housing estate. This may cause an increase in anonymity among the residents and may result in increasing the risk of degradation of space, which will cease to be a comfortable and - above all - a safe place to live. For that reason, instead of aspirations to maximize the housing density, the most advantageous designing method is the pursuit of optimizing it while taking the residents’ needs into account.

On grounds of the aforementioned observations, it is worth to draw a conclusion, that the most comfortable urban indicator, from the position of an estate user, is the dwelling per hectare (DPH) ratio, due to the data it is based on. The floor area ratio (FAR) can determine the density of a residential estate in a proper way, give the concept of the number of floors of a building and of the built area ratio. However, it does not indicate how housing density translates into the actual number of dwellings and their size. The DPH indicator, in contrast to the FAR indicator, is not distorted with additional information, such as: area occupied by commercial premises, interior car parks or communication. In addition, the DPH indicator is significant due to being frequently used as the main factor by developers when developing housing estates.

Conducting the research on existing residential estates in Poland induced the team to draw another conclusion: that case studies are an important element of scientific research and can bring substantial benefits for designing housing estates in the future. Research on the models of estates allows to discover particular methods of structuring residential complexes by referring to specific indexes, which enables indicating their flaws and assets. In this way, it is possible to compare current residential developments in terms of inhabitancy quality - both the quality of the location of an estate, as well as its architectural and site planning qualities. Case studies give architects an opportunity to learn on the experience of already existing buildings. Virtual tests can also show potential threats. If future development follows both proposals and tendencies, the risk of over density may materialize.

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