NON-STANDARD HOUSING

Exploring Generative Design Strategies for Differentiated Residential Projects

JEROEN VAN AMEIJDE
1School of Architecture, Chinese University of Hong Kong
1jeroen.vanameijde@cuhk.edu.hk

Abstract. This paper presents arguments and experiences around generative design applied to housing, combining the potential of computational tools with an agenda to increase internal differentiation. It argues for a more varied and mixed approach to the clustering of apartment types and building typologies to increase the social diversity within projects and in relation to this, the sustainability and resilience of urban environments towards future societal changes. Through the discussion of two residential projects operating at different scales, it is shown how carefully calibrated complexity can be introduced in the design process, communicating with clients and collaborators and keeping the complexity of the workflow minimised. It is argued that this avenue of work points to significant opportunities to rethink how computational architectural and urban design processes can be linked to social sciences and a more human-centred approach within the understanding of performance of the built environment.

Keywords. Generative Design Methodologies; Urban Planning and Design; Housing; Generative Architectural Design.

1. Introduction

Housing is a topic where the requirements of many different inhabitants, as well as of the individual resident are being addressed. The are many contradictions between the interests of the individual and the interests of the collective, such as desire for space, privacy and flexibility versus the need for sustainable and economically productive urban density. Policies of optimisation, both in public housing as well as in private developments, often lead to suppression of individual differences, through homogeneity within urban clusters and repetition within building and apartment designs. In these types of neighbourhood, changes in life-style, career or family structure often force residents to move out of their building or area to find adequate housing. All these factors are counter to the widely accepted understanding that successful neighbourhoods contain medium and long-term residents that take responsibility for safety, social and cultural life of the area. As Jane Jacobs famously argued, successful city spaces are activated through a mixture of people of different ages and backgrounds, ensuring ‘a feeling
for the public identity of people, a web of public respect and trust, and a resource in time of personal or neighbourhood need” (Jacobs 1981, p56). She argued that the mixing of different types of programs and residents creates active public spaces, which in turn helps to create trust and collaboration amongst members of an urban community. These qualities of openness and resilience cannot occur in monocultural or gated communities, which feature either too much social control or social isolation:

The more common outcome in cities, where people are faced with the choice of sharing much or nothing, is nothing. In city areas that lack a natural and casual public life, it is common for residents to isolate themselves from each other to a fantastic degree. (...) As a practical result, the ordinary public jobs like keeping children in hand- for which people must take a little personal initiative, or those for which they must band together in limited common purposes, go undone. (Jacobs 1981, p65).

This paper explores the theoretical and pragmatic aspects of mixing different building and apartment typologies in residential neighbourhoods, to contribute to the social and economic resilience and sustainability of urban areas. A lack of governmental oversight, minimised regulations or emphasis on economic growth targets may lead to urban developments which within a short number of years will be out of touch with the demands of the ever-changing population. Within the planning and design of new residential projects, it is necessary to incorporate an understanding of life style changes and adaptation, incorporating a rich mixture of apartment typologies and supporting facilities such as public spaces, retail and leisure facilities.

An increasing interest by many local governments into a more human-centric approach to urban planning is apparent in the programmes being implemented by cities such as Barcelona, Shanghai, Singapore and New York, using programmes that refer to ‘citizen spaces’, ‘liveable cities’, ‘heartlands’ and ‘great public spaces’ (respectively), amongst many other initiatives aimed at increasing the quality of city life. However, as urbanist Jan Gehl points out, these improvement programmes seem to be most frequently occurring in established cities in developed countries, while the development of many new urban areas are still based on orthodox urban practices that involve the separation of functions and car-based infrastructure (Gehl 2010). New urban areas in China and the Middle East are still being developed through oversimplified land use planning, leading to monofunctional neighbourhoods or ‘mega-plots’ filled with repetitive housing.

Exploring the mixing of building typologies and apartment types within newly planned housing developments, this paper argues for social and cultural differentiation of urban neighbourhoods to promote mutual understanding and exchange between different segments of society. It examines the potential opportunities of addressing these issues through newly emerging strategies in computational design, exploring how the role of the architect could change from a single mastermind to that of a process designer, collaborating with stakeholders, consultants and computational tools. Different approaches to ‘generative design’ are discussed, using examples of housing projects developed by the author and collaborators in the context of several research and design commissions received
in China. The projects demonstrate how generative tools can help produce differentiation in residential projects at the scale of the urban block as well as at the building scale, while managing the complexity of each project in relation to their performance criteria and goals.

2. Housing Planning as Social Policy

The design and planning of mass housing is a complex process that has large-scale consequences as well as a direct effect on individuals’ quality of life. Appearing in many different forms across the world, housing is a manifestation of the political frameworks prevalent in each society, showing various degrees of intervention in the organisation and supply of housing for its people.

Many developed countries are currently governed on neoliberal principles that favour market-driven mechanisms in the construction industry. Here, the meeting of demand for housing is left to private developers, with government setting out minimal regulations to determine the density and programming of newly available land, while the choice of type of apartments is left to the developers. The aims of maximising profit and minimising risk usually lead to the targeting of higher income home buyers, with very little internal variation in the apartment typologies or buildings types within developments. The result is that new residential projects are occupied by people of similar income level and life style preferences. Cities made up of isolated social enclaves contribute to a society characterised by a lack of interaction between people of different cultures. Separated neighbourhoods by social class can contribute to decreased opportunities for its residents, including health, employment and other life opportunities (La Grange 2010), thus leading a self-reinforcing status of social segregation.

Policies to promote demographic mixing and social mobility could be enacted through public housing programmes, but a decreasing number of countries are operating these. The share and size of public housing has declined in the United Kingdom and The Netherlands and more rapidly in Eastern Europe and in China, where there have been radical changes in economic and political systems (Lau and Murie 2017). A few notable exceptions include the Hong Kong SAR and Singapore, which operate active and evolving programmes of public housing construction that serve large parts of the population. Forrest & Wu (2014) point out that public housing in these two areas are not associated with only marginal groups within society but with a range of income levels and cultural groups. In the case of Singapore, the public housing programme plays an important role in the harmonious coexistence of different religious groups within society.

In Hong Kong, most new public housing estates are designed under the management of the government’s Housing Authority, who have developed an advanced expertise in the design and delivery of cost-effective estates that incorporate communal facilities and a range of apartment types for different family sizes. There may be further opportunities to incorporate flexibility of use or offer a range of apartment types, as Hong Kong’s society is experiencing an increase of non-standard family structures and live-work patterns associated with the new forms of work of the post-industrial society. By offering a range of apartment types
suitable for single or sharing young professionals, young people could choose life and work priorities that suit their abilities and ambitions, rather than feeling forced into an idealised standard model for how to progress one’s life and career.

Further opportunities can be identified for project in the private sector, where an abundance of supply might give rise to a need for differentiation in the appearance, programmatic mixing and cultural atmosphere of residential projects. Precedents such as the ‘Linked Hybrid’ in Beijing, ‘8 House’ in Copenhagen and ‘Interlace’ in Singapore show private developments designed with boundary pushing architecture, to offer a greater variety of living conditions and priorities to a discerning clientele. In a competitive housing market context, differentiation from the standard development model and internal differentiation is used to attract residents seeking to associate themselves with housing that expresses individuality and sustainability and that offers novel ways of living, working and socialising.

3. Generative Design for Housing

This paper builds upon the author’s earlier work exploring computational processes for programmatic and organisational design problems. The paper on data-driven urban porosity (Van Ameijde and Song, 2018) traces some of the recent academic publications on generative urban design and quotes Lima and Kős’ assertion that “this form of algorithmic or parametric modelling transcends the understanding of the computational paradigm as a mere promoter of complex forms and contributes to processes capable of forming models that contemplate several parameters involved in the functional, environmental and of the cities and the buildings they contain” (Lima and Kős, 2014). This understanding builds on the theoretical framework introduced by pioneers such as Leslie Martin and Lionel March, Christopher Alexander and Bill Hillier, who developed ‘configurational theories’ of architecture and urbanism, offering mechanisms of abstraction of the built environment. Current software package such as Rhino and Grasshopper that offer a graphic interface for coding make these theories accessible to architects and urban designers, using a collaborate, iterative and partially intuitive work-flow rather than a fully autonomous or automated computational process.

In our ‘East Gardens’ residential development project, such as process of generative design was used to explore spatial distribution patterns of differentiated building typologies. Located within a new urban district for Changyuan, Henan province, China, the project is aimed at middle- and higher-income residents including elderly, so emphasis was placed on the socialising opportunities in semi-private courtyards and shared green spaces. The entire development has access to shared leisure facilities and internal gardens, while retail, healthcare and recreational facilities embedded in the porous perimeter of the project are accessible to the surrounding urban area as well.

Using a rule-based computational process, the distribution of buildings across the site was explored as a balance between the planning guidelines of the client brief and environmental criteria such as maximising sunlight access, views and privacy. The range of building typologies include residential towers, low-rise apartment blocks and townhouses with private access, offers a range of social
settings related to the open or more closed version of the ‘courtyard module’ that was used as a basic urban element (Figure 1). These modules were distributed across the site and varied according to their proximity to certain design drivers such as plot edges, main road intersections and the location of an internal attractor point that drove the opening up of the block typologies. In a second stage of the computational design process, sightlines from each semi-public courtyard at the outer zone of the project towards the centre were generated and used to cull intersecting apartment units, to increase the visual porosity of the project at ground level and improve orientation and social cohesion of the community within the project (Figure 2). After several stages of iteration and refinement, a final version of the design was visualised for client approval of the spatial qualities of the proposal (Figure 3).

Figure 1. Catalogue of building typologies and access strategies, combined into courtyard modules distributed across the site.

Figure 2. Projection of sight lines and culling of volumes to increase visual connectivity.
4. Nesting Typologies

In a subsequent project located in the same new urban district, the author and collaborators developed a more detailed strategy for the materialisation of two residential towers, that included the organisation of internally differentiated apartment types and the automatic translation of this into the façade element arrangement. In a preliminary study, a range of apartment types was generated without specific building application but based on possibilities of the internal arrangement of rooms. The apartments were classified according to the social dynamics of the layout, distinguishing layouts more suitable for families who desire high internal social interaction versus people who prefer privacy (Figure 4). A connection between family size, life style and desired interaction with the surroundings was made, which could inform the placement of these apartments within a three-dimensional building envelope. Single elderly people for instance, or young people with an active social life could be located lower to the ground with sight lines to public spaces.
In a subsequent stage, a similar strategy of distributing different apartment types was applied to the design of two residential towers, using a customised generative process set up in Rhino/Grasshopper that created different nested apartment typologies based on the life style associations and spatial location criteria of each of the different apartment types (Figure 5). Different clustering combinations were arranged over the height of the towers to create a strategic mixing of apartment options and place the higher value units towards the top of the towers (Figure 6).

Figure 5. Possible clustering options of different apartment types within the building envelope.

Figure 6. Distribution of apartment types throughout the building envelope based on access, views, sun and client market research.

In the development phase of this project, our generative design process was
expanded to include the automated generation of a Building Information Model (BIM) for the building including the façades, using a modular system with a limited number of elements (Figure 7). The relational nature of the workflow allowed for changes in apartment distribution to be made, as the BIM model could be automatically updated. This enabled the client to finalise the specific apartment ratios and distributions at a late stage during the project development, giving more time for market research and predictive calculations of development scenarios.

![Figure 7. Generative modular façades based on the distribution of apartment types throughout the building.](image)

5. Evaluation

Both projects presented here show how carefully calibrated generative design processes allow to control organisational complexity. When combined with a consistent architectural language based in regular spatial grids and modular construction elements, construction cost increase would be limited as there is increased logistics complexity but no need for custom fabricated elements or construction.

The design methodology employed here has deliberately been kept as a linear and relatively simple generative process, controlling certain key parameters in the design of the projects related to the social mixing and interaction of future inhabitants. There are many key assumptions in this process that are open to criticism, as decisions about the general principles of how inhabitation will work out in the real world are based on subjective judgement, experience and precedent analysis by the designers. It is difficult to verify in a rigorous and scientific manner which of the many possible design options would perform best, the next section of this paper will offer suggestions on how to improve this in the future. However, in the case of the projects presented here, the process of computational design was deemed successful as it generated project versions in an effective and time-efficient way, while the clients for the projects could make judgements on the architectural and urban qualities in the subjective manner that they are accustomed to.
The central ambition to the projects presented here was to combine the emerging practice of generative design of organisational complexity with a specific agenda for the social, political and economic effectiveness of residential developments in urban areas. Although the design operations shown here might have limited effect with respect to such wide-ranging issues, it can be argued that there is a significant importance in these first attempts to address social sustainability through computational design.

6. Conclusions and Future Development

The projects described here show how generative tools can help produce differentiation in residential projects at the scale of the urban block as well as at the building scale, to increase the range of life style choices for residents and to stimulate the mixing and collaboration between people of different age groups, social class or cultural background. The computational work flows enabled the projects to incorporate greater organisational complexity than standardised repetitive housing solutions, while keeping the complexity of the design workflow relatively low. Computational tools alleviated the increased work load in producing detailed design and construction documents that otherwise would have been cost prohibitive.

The type of computational process shown in these projects was a straightforward linear workflow, translating top-down strategic design decision into detailed geometrical output. While this type of process opens up a wide range of new possibilities for architects, it still relies on the human designer to embed the right assumptions about constructability, costs, client preferences etc. from the outset. There are more advanced computational processes that allow for a more open-ended exploration of the design solution space, through the use of multi-objective optimisation algorithms which are also referred to as ‘genetic algorithms’. These processes have been employed by the author in other projects such as urban master planning research (Van Ameijde and Song, 2018), but not in these cases as there were not enough resources available at the time. It is anticipated that in future projects, when similar residential projects will reach a more detailed development stage, more advanced computational processes can be employed to test the complex reciprocities between the multiple and often contradictory aims related to residential buildings. A key potential in this future direction is the possible integration of construction characteristics and environmental analysis, as Rhino/Grasshopper is an open platform continuously expanding with improved plugins developed by third parties.

At the urban scale, there is a significant potential in the link between Building Information Modelling (BIM) and Geospatial Information Systems (GIS), the spatial databases at city level used by government agencies, planners and social scientists. Generative urban design processes for residential projects can be enhanced with data-driven or evidence-based design processes associated with the research field of urban analytics. An overlapping development is the introduction of new types data gathering methodologies at a large scale. Several ‘smart-city’ initiatives, a term popular with politicians, city managers and technology suppliers, are implementing urban management changes after the analysis of large data
sets, extracted through the increasing ubiquity of IT systems and sensors in the built environment. It can be speculated that if these sensing systems were to be integrated in a residential project, a feedback loop between usage patterns and building design can be established, offering the opportunity to establish continuously evolving living environments informed more directly by the complex and dynamic characteristics of everyday life.

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References