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Exploring Architectural Design Philosophies and Planning Strategies to Enhance User-Driven Spatial Customization and Responsive Building Envelopes

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Abstract

Over the recent decades, standardization of residential floor plans in urban housing has prioritized construction efficiency and cost optimization at the expense of spatial personalization. This leads to a reduction of user satisfaction and limited responsiveness to diverse occupant needs. However, customization within floorplans to enhance spatial usability and user comfort results in façade inconsistencies, ad-hoc external solutions. The study investigates the connection between user-driven floorplan customization and standardized façade optimization by exploring established design philosophies, and principles, systematically comparing the architectural case studies, examining how the integrated planning strategies can translate the interior configurability without compromising the façade's compositional coherence. Employing a qualitative analytical framework, the study identifies design strategies, discusses the regulatory constraints, and procedures that conciliate the interior flexibility with façade comprehensibility, and the findings presents a transferable design solutions applicable to contemporary mass-housing, contributing to the discourse on user-centric personalization in urban residential architecture.

Keywords: Spatial customization; Façade articulation; Layout standardization; User-centric designs; Design philosophies.

1. Introduction

In contemporary residential architecture, the high-rise building typologies has increasingly adapted to the changing pattern of family structure, working patterns and other lifestyle goals of residents. Nevertheless, the housing layouts are rarely accommodating the evolving needs of users due to standardization. This leads to an informal spatial modification by residents, which results in fragmented building façades through self-alterations like Balcony extensions, enclosures, shading systems, windows and other fenestration modifications. Such informal personalization and visible alterations in façade cause compositional discontinuities that undermines the architectural coherence and affects the urban image, representing a systemic design challenge in mass-housing typologies. Studies such as, (Kousidi, 2025) emphasize that more than treating as an aesthetic envelope, the building façade should function as a spatial interface that mediates - social, environmental and urban dynamics. Rather than an outer skin, façade acts as a performative element that controls the indoor heat gain and heat loss, daylight arrival, ventilation and the acoustic comfort of the building (Atthaillah et al., 2025). The traditional design process often treats façade (exterior) and floorplan (interior) as independent elements, though they are the part of a single interconnected system. The placement and the arrangement of windows and fenestrations are always based on the room function; the positioning of balcony influences the spatial use and likewise, the depth of the façade influences the interior comfort, and the structural grid influences both plan and the elevation. In this way, the façade mediates the interior space and exterior expression by balancing the tension between the outer form, while managing the inner spatial requirements. As an integral part of the contemporary housing and urban environment, façade optimizes the indoor-occupant comfort, ensures indoor tranquility and promotes the overall performance of the building.

Furthermore, understanding interior-exterior spatial interdependencies enables design professionals to anticipate the future needs of the users and maintain architectural coherence over time (Majeed & Alsultani, 2025). In order to maintain a unified architectural expression, understanding the necessity of spatial customization is also essential. Spatially responsive floorplan design improves user satisfaction, and reduce unauthorized modifications (Shiksha et al., 2026). Ignoring this core need leads to compositional conflicts, as spatial customization within a dwelling unit inevitably manifests outside the façade. While prior studies have examined the theoretical grounding of the façade (Kousidi, 2025) ; (Atthaillah et al., 2025) and interior flexibility as user-centric design concern (Majeed & Alsultani, 2025) ; (Shiksha et

al., 2026) have largely been investigated as separate domains. The reciprocal influence of user-driven floor plan personalization on façade's compositional coherence remains theoretically underexplored and practically unresolved with in the context of urban housing.

The study addresses that gap by examining how user-driven spatial customization of floorplans influences façade articulation, and by identifying design principles drawn from the established design philosophies and comparative case studies, that reconcile interior flexibility with façade coherence in contemporary mass housing design.

2. Materials and Methods

The study adopts a qualitative research approach, appropriate for investigating design relationships, understanding of spatial principles, and architectural interventions rather than quantitative measurement. The research comprises two major components: a systematic literature review and comparative case study analysis structured through a periodisation framework. The literature review examining three thematic domains: '*Form-function relationship in architecture, the façade as both an expression of internal programme and an autonomous external system, and the determinants of façade variation in residential design*'. Complementing this, a theoretical and phenomenological review section examines seven key thinkers – including *'Adolf loos, Christopher Alexander, and Juhani pallasmaa'* – shares knowledge about interior-exterior spatial logistics, provides direct relevance to spatial configurability, façade expression and user experience. The case study analysis organised across five chronological phases, from pre-digital era to advanced parametric and responsive systems spanning 1985 to 2025, defined by the evolution of design tools and spatial customization methodologies, architectural significance of the interior flexibility and façade relationship, geographic diversity spanning Indian and International housing typologies. One to two case study projects were selected in each phase, yielding ten case studies in total. Each phase is examined on four analytical parameters: '*Employed design tools, the degree of interior spatial customization offered to occupants, the nature of façade responds to the internal spatial variations, and the key limitations in reconciling interior flexibility with façade coherence.*' These parameters are applied consistently in all phases, enabling cross-case comparison and the findings are presented in result (Table 01). In discussion section, the theoretical principles drawn from established design philosophies are mapped against the empirical case study evidence, producing a set of transferable design strategies applicable to contemporary mass housing design, which is presented in (Table 02).

2.1 Literature review

2.1.1 Form-Function relationship in Architecture

The relationship between a building's exterior (form) and its purpose (function) has been deeply embedded in architecture. Following the concept "*Form follows Function*", early modernists believed that the building's shape (form) should directly reflects its purpose (function). However, the contemporary idea has changed to see form and function has influencing each other, rather than existing in a hierarchy one-after-another (Sareh & Loudon, 2024). Recent researches on housing adaptability and function highlights that, the *functional requirements evolve over time*. As people change the way of using space, the change of convenience and necessities leads to spatial modifications and subsequently it gets reflected in the external form of a building. Hence in contrast to traditional design approaches, the contemporary architecture accepts the inherent condition of flexibility within a building, able to adapt the change and accommodate in form, rather than being amenable to change (Bernardello & Borin, 2022). Critically, the evolution from hierarchical to reciprocal form -function relationships from one-way system (where the building controls how people use it) to a two-way system (where spatial changes done by the occupants inside the building, affects how it functions). It suggests that the interior modifications done by users are not aberrations but legitimate expressions of evolving functional requirements, therefore professionals should build a system that can adapt and respond to changes rather than resist this reciprocity.

2.1.2 Façade: As an expression of internal program vs Autonomous skin

Building façade as an expression of internal program, it reflects certain characteristics of the building such as internal spatial organization, spatial circulation and voids, hierarchy of each floor-level's function. The differences in room size and height, and the circulation pattern creates a rhythmic variation in façade depth, fenestration placement and articulation. As a major spatial indicator, it enhances the daylight and ventilation extensively (Li et al., 2025). In contrast, considering it as an independent layer led to get separated from the internal layout. As an autonomous skin, the modern façade focuses on adapting technology, branding and environmental features. Examples include, *'double-skin'* and '*parametric facades',* where the envelope acts more like a protective or a performative system rather than an expression of inner-spatial function (Xu et al., 2025). The tension between these two positions is particularly consequential in mass housing. The '*Autonomous skin*' approach offers efficiency and visual uniformity but often blocks the natural connection between the interior-exterior relationship where the user-driven customization depends up on. The critical question the study explores is that not which approach is better in absolute terms, but how the design frameworks can accommodate spatial flexibility, expressive interiors with the clear, functional performative walls without losing the benefits of an efficient façade system.

2.1.3 Determinants of façade variation

The modifications made on spatial layout considering factors such as "*Program driven variation, contextual response and user customization*": The tailoring of internal spatial configurations to specify the needs, frequently leads to changes in the external envelope. Such changes can be obvious or subtle but the major internal changes through things like fenestration placement, change in shape or volume, different material usage and structural details are clearly distinguishable (Shan & Junghans, 2023). The other prominent factors such as, '*building adaptability, climate and cultural factors'* also lead to façade modulation by following a flexible-spatial planning, strategies based on orienting multi-

functional spaces, and positioning of movable partitions – such internal personalization and circulation systems like staircase, corridors and voids will significantly defines the façade character (Abu Dabous & Hosny, 2025). These existing studies do not propose integrated design frameworks that incorporate facade proactively, this constitutes the precise gap that study addresses.

2.1.4 Theories and Phenomenological perspectives

Existing theories and phenomenological discourse on the interior-exterior relationship in architecture can be organized into three analytically distinct positions, '*Theories based on establishing that interior spatial complexity need not produce exterior incoherence; theories placing user experience as the generative force in spatial and façade decisions; and theories addressing the collective urban dimension of façade articulation.'* Together these theories constructs a unified theoretical argument that directly informs this study's analytical framework.

Adolf Loos's idea of Raumplan – focuses on volumetric planning with inside levels rather than a conventional organization of stacking floors one above the other. The study highlights that complex arrangement of inner spaces may not directly reflects the complexity towards external façade (Talašová & Achten, 2009). This is critically important precedent for the present study, it establishes that user-driven spatial variability is not inherently incompatible with façade coherence, but may requires a deliberate separation of the interior configurability logic from the external expression system. *Tom porter's – The Architect's eye*, further supports the position - interior modifications drive the façade articulation through elements like windows and balconies, but only when the design system consciously mediates this relationship (Porter, 2006). Considering together, these theoretical positions that the apparent conflict between interior customization and façade coherence is not an architectural inevitability but a consequence of framework failed to integrate both.

Considering theories based on placing user experience as the generative force in spatial and façade decisions, *Christopher Alexander's -Pattern language*, suggests designing spaces based on user-centered approach, using common patterns helps to create places that are practical and adaptable for users. Design patterns such as 'light enter from two-sides', 'courtyards', and using transitional spaces called 'thresholds'- directly influences the façade elements and reiterates that spatial pattern focuses on needs and experiences of user leads to adaptive façade that changes and evolves over time (Yamano et al., 2024). *Juhani pallasmaa's – the eyes of the skin* signify the multi-sensory perception on architecture experienced through all lenses and expresses how the interior impacts the user experience through light, texture, and room depth, and how such changes influence the exterior look in form of windows, openings and materials (Pallasmaa, 2019). *Robert Venturi's – complexity and contradiction in Architecture* supports the idea of complex and diverse user expressions within a building need not produce visual coherence, provided the design framework can accommodate multiplicity without uniformity becoming the default (Hauska et al., 2025). Critically these three studies argue that user-centered interior design is not a threat to façade coherence, it's a legitimate source that challenges the standardized housing model's assumption that uniformity is necessary for coherence.

The theories addressing the collective and urban dimension of façade articulation are, *Gordon cullen's theory of townscape* – emphasize the importance of visual and experiential qualities of urban environment, which creates a meaningful spatial composition and facilitates a positive user experience. The articulated building façade contributes to the urban legibility and enhance the experiential quality (Spada & Molinari, 2025). *Sigfried Giedion's – Space, Time and Architecture* explain how architecture evolves with the changing lifestyle of people and their spatial usage in building over time, so the façade will reflect the interior layout. The modern architecture breaks the traditional (fixed) boundaries, blur the lines between inside and outside, creating dynamic facades that match the internal changes (Molella, 2002). Together these theories establish that the goal of any integrated design framework is not to suppress individual expression but to channel it through a system that maintains urban coherence while enabling interior responsiveness.

Across these theoretical and phenomenological perspectives, a consistent analytical position emerges - *The interior and exterior part of the buildings are not independent systems but reciprocally the connected expressions of occupant need and spatial logic*. The current study draws on this unified theoretical position, examining how design philosophies and architectural case studies have negotiated this mediation in practice, and what transferrable principles can be derived for contemporary mass housing design.

2.2 Architectural case studies

The case study section is structured through a periodization framework across five chronological phases spanning 1985 to 2025. Design tool evolution is adopted as the primary criterion for three reasons: tool capability directly determines the degree to which interior spatial variability can be integrated with the building envelope, each technological shift has historically coincided with a corresponding shift in the profession's capacity to simulate and manage user-driven customization, and the selected cases represents projects whose design approaches are defined by the tools available at the conception. This framework doesn't imply technological determinism-based design philosophy, and regulatory context are examined within each phase but establishes tool capability as the primary variable against which the evolution of interior-exterior integration accessed across cases (**Figure 01**).

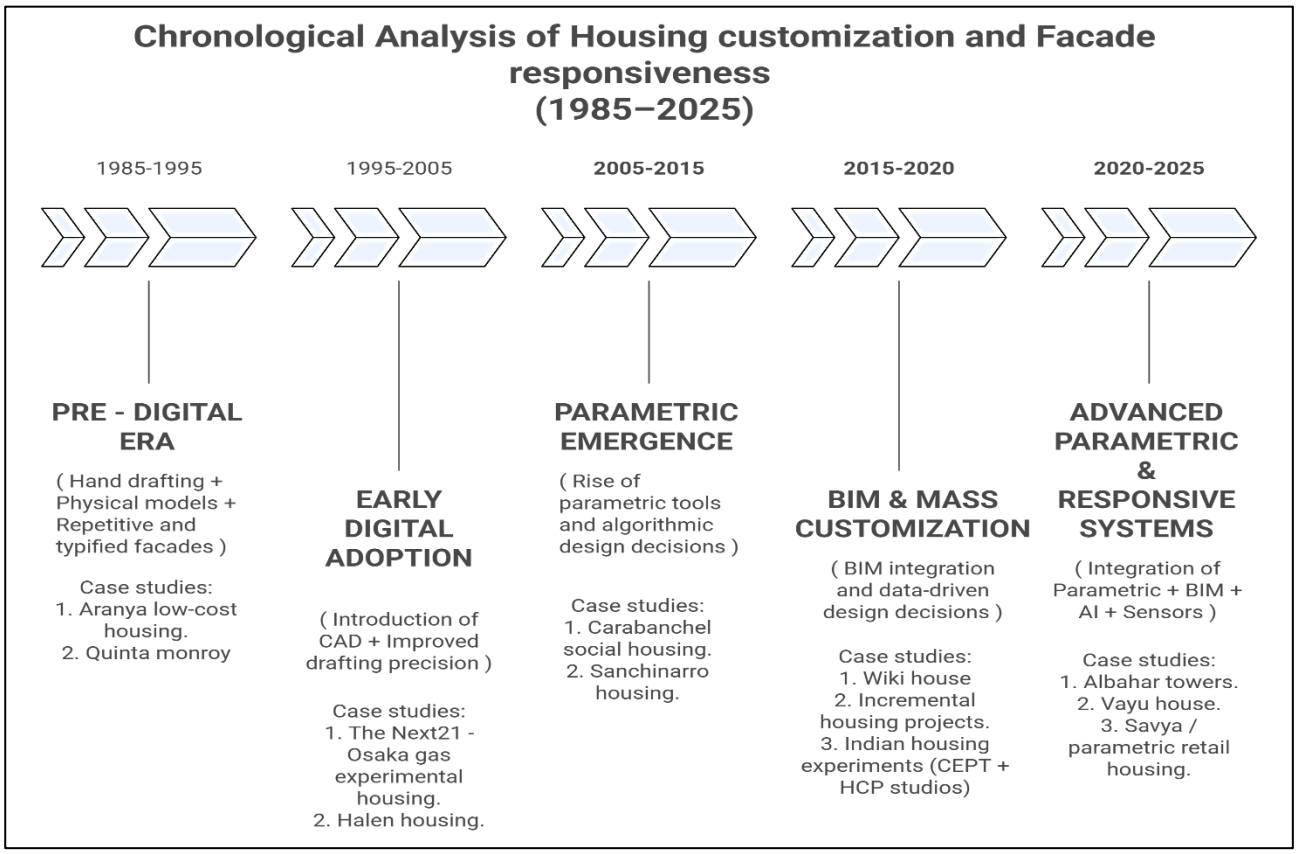


Figure 01. Chronological chart of Housing customization and Façade responsiveness (1985 – 2025).

2.2.1 Phase 01. Pre-digital era (1985 -1995)

The manual era, where the housing design is completely hand-drafted and scaled-physical models were used to represent the spatial structure of the project. Most of the housing layout were simple and typically designed with little variations. The external façade of the building was repetitive and typified. The case study examples are, Aranya low-cost housing in India (1989) by Architect Balakrishna Doshi and Quinta Monroy in Chile by Architect Alejandro Aravena, conceptual planning was started on 1990 but executed at 2004 (**Figure 02**).

In Aranya low-cost housing, the design allowed users to modify their place over time. The incremental housing adapts to the change, and allows façade to evolve informally as people make extensions. The whole design process was done manually, hand-drafted without computers (Binu, 2023). The initial idea of Quinta Monroy was to build 'half house' that allows for future extensions. The internal – external (façade) relationship of the building is meant to be a user-driven completion. The expandable housing unit followed the strategy as '*controlled incompleteness'* and designed façade as '*framework for growth*' (Carrasco & O'Brien, 2021). The case Aranya housing establishes that user agency without a systematic integration framework produces responsive interiors but fragmented facades. Qunita Monroy advances beyond Aranya housing by embedding façade evolution into design framework itself, controlled incompleteness transforms user modification from an informal act into a designed outcome. Interior configurability and façade integration are both high, making it as the strongest pre-digital precedent for the study's argument. The key challenges of pre-digital era were, the designers couldn't predict how people will personalize their homes, the evolution of façade was uncontrolled or un coordinated. Most of the housing projects lacks the connection between the proposed design and post – occupancy reality.

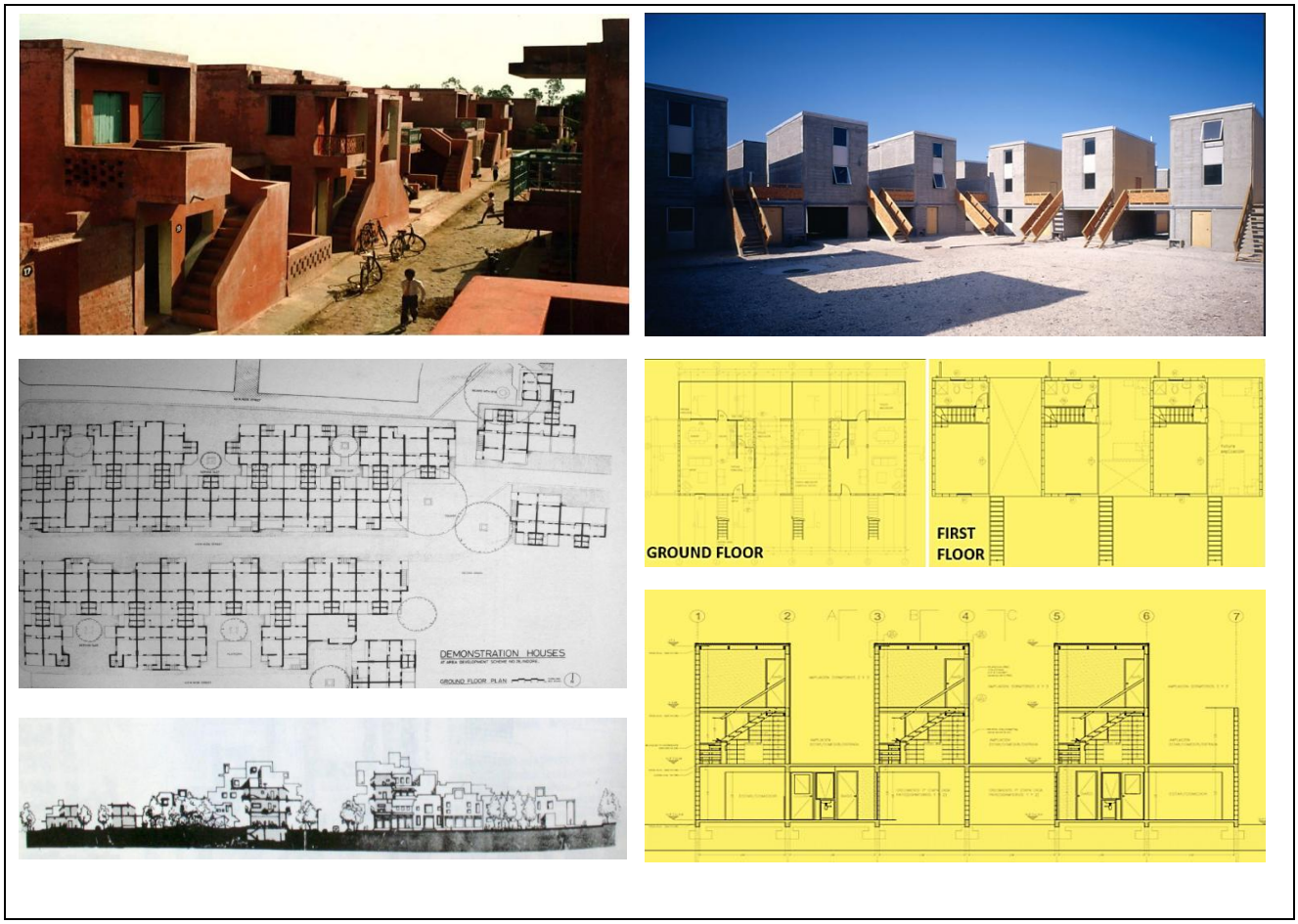


Figure 02. Architectural details of Aranya low-cost housing (left) and Quinta Monroy (right)
Note. Adapted from Doshi, B. V. (1989). *Aranya low-cost housing, Indore, India* [Project documentation]. Aga Khan Award for Architecture.; ELEMENTAL. (2004). *Quinta Monroy housing, Iquique, Chile* [Architectural documentation]. ArchDaily.

2.2.2 Phase 02. Early digital adoption (1995 -2005)

Between 1995 and 2005, early digital tools began to be used in Architecture field, especially CAD (Computer-Aided design). The digital tool helped designers and architects to make drawings precise but had limited flexibility for changing designs automatically and confined parametric options to explore based on conditions. The case study examples are, Next 21 – housing (Osaka gas experimental housing) in Japan (1993-2005) by Architect Yositika Utida and digitally re-interpreted 'Halen housing' in Switzerland by Atelier 5 (**Figure 03**).

Following the '*open building approach*', the next-21 housing has interiors with fully customizable units. The building envelope subtly showed the internal variations, and the entire design process follows the early CAD and modular building systems (Saigo et al., 2011). Although designed earlier, the Halen housing by Atlier 5 was digitally re-interpreted for adaptability studies. The digitalized plans and 3d-diagrams show how the three-story building is designed to compress and expand in certain ways. The units were connected to the shared spaces, allowing residents to enjoy good views, while keeping their privacy (Daglio & Kousidi, 2023). Comparitively, Next 21-housing represents the most complete realization of interior- exterior integration in the early digital phase, applying open building principles to achieve fully customizable infill units within a coherent support structure enables flexibility and façade coherence simultaneously.

The key challenges of Early digital adoption era are there were no practice of integrating user-inputs in the design and no tools were existed to do the real-time simulations. The period where customization was practiced but lacks in dynamically connected to façade. Digital tools like CAD were traditionally used as a representative tool, rather than autonomously generating new design solutions.

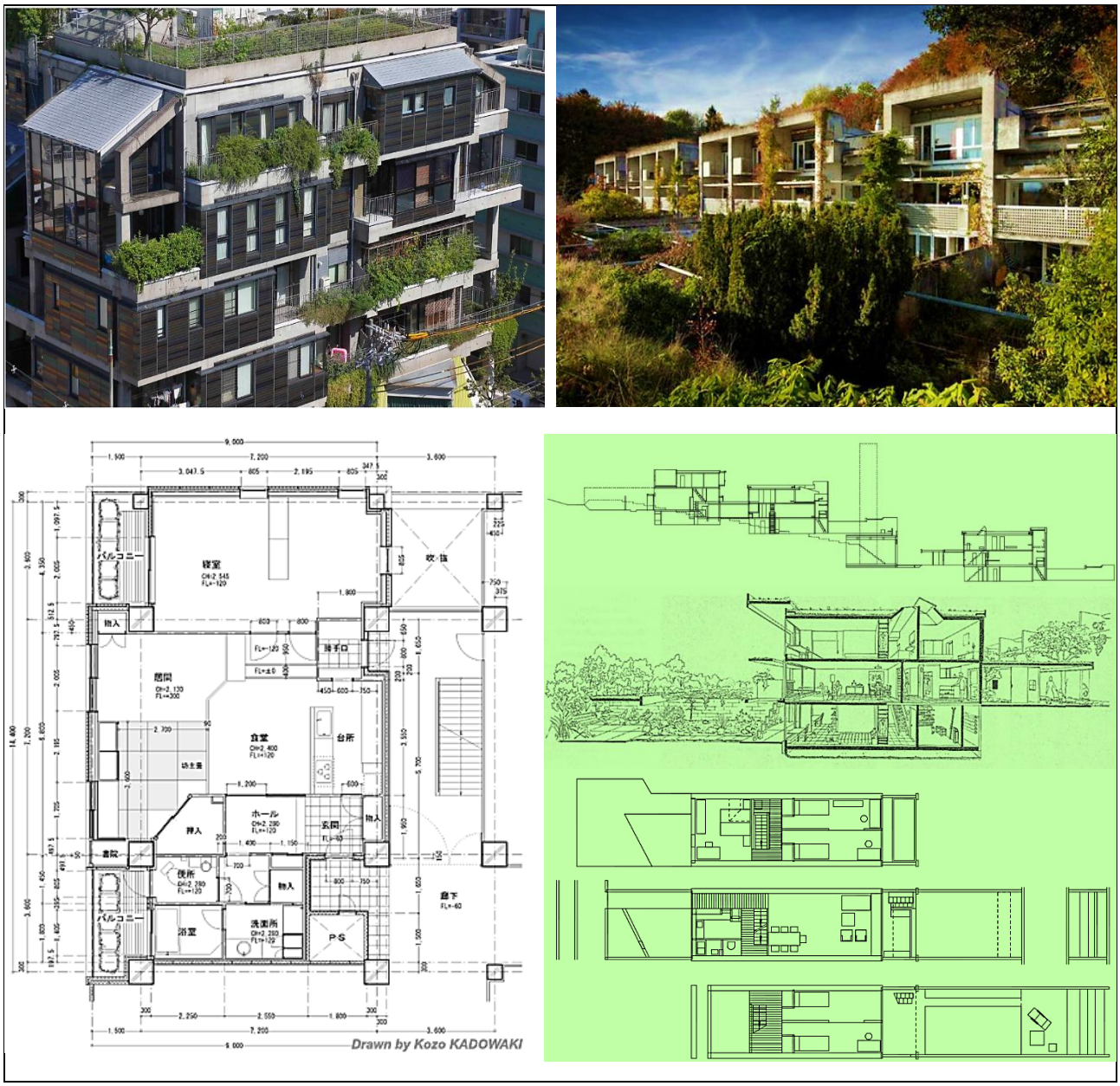


Figure 03. Architectural details of Next 21 – housing (left) and Halen housing (right).

Note. Adapted from Osaka Gas Company. (1993). *Next 21 experimental housing, Osaka, Japan* [Project documentation]. ArchDaily ; Atelier 5. (1961). *Halen Estate, Bern, Switzerland* [Architectural project]. Atelier 5 Architects.

2.2.3 Phase 03. Parametric emergence (2005 -2015)

Between 2005 and 2015, parametric design tools such as Rhino and grasshopper rose to prominence. These tools use algorithms to create designs where building facades can change or responds to different factors considering environment. The case study examples are, Carabanchel social housing in Spain (2007) by foreign office Architects and Sanchinarro housing in Spain (2005) by MVRDV-Mirador (**Figure 04**). The Carabanchel social housing had a simpler and standardized interior unit, but used bamboo shades on the façade, that responds to external climatic conditions, evaluated by using early environmental simulation tools (Milicevic & Alihodžić Jašarović, 2025). The Sanchinarro housing had repeated interior units with slight differences and had a *Pixelated facade*, designed like pixels to show diversity (Przemysław Bigaj, 2022). The major benefits of parametric thinking attained during that time were its ability to create variations based on rules, enable building respond to the environmental conditions, and generate facades through iterative experimentation. Comparatively, Carabanchel scores high on environmental performance but critically low on interior-exterior integration, whereas sanchinarro achieves through its pixelated façade that symbolically represents internal unit diversity without being structurally generated by it. The key challenges of this era include, limited integration of designs with the construction workflow, the predominance of form-driven parametric designs, lack of user-interaction, and limited option for interior customization.

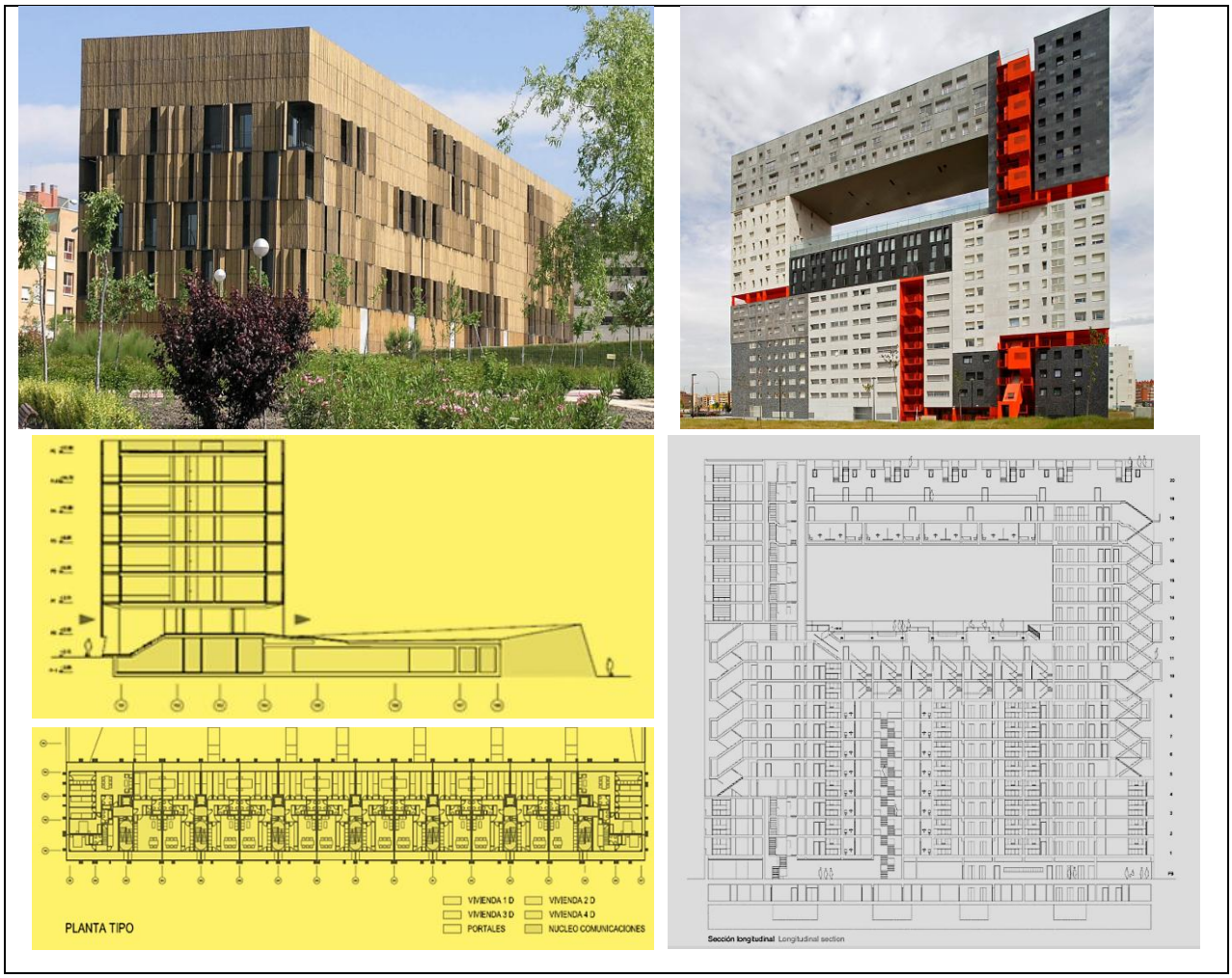


Figure 04. Architectural details of Carabanchel social housing (left) and Sanchinarro housing (right).
Note. Adapted from Foreign Office Architects. (2007). *93 social housing units in Carabanchel, Madrid, Spain* [Architectural project documentation]. Archiweb; MVRDV & Lleó, B. (2005). *Mirador residential building, Sanchinarro, Madrid, Spain* [Architectural project documentation]. MVRDV Architects.

2.2.4 Phase 04. Introduction of Building Information Modelling (BIM) and Mass customization (2015 -2020)

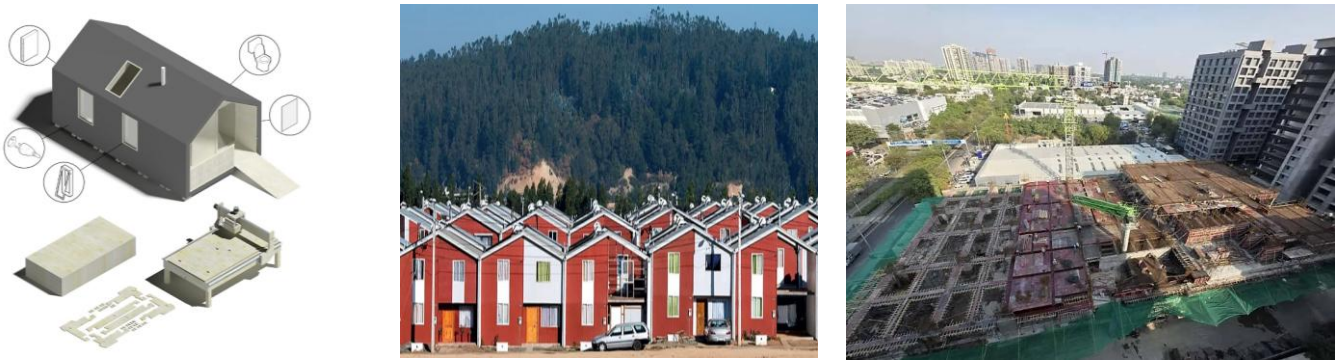


Figure 05. Digital fabrication of Wiki-house designs (left), Exterior view of Villa Verde (middle), and Integrated construction practices – studio works of CEPT university (right)
Note. Adapted from WikiHouse Foundation. (2019). *WikiHouse open-source construction system* [Project documentation]. WikiHouse.; ELEMENTAL. (2013). *Villa Verde housing, Constitución, Chile* [Architectural project documentation]. ELEMENTAL Architects.; CEPT University. (n.d.). *The urban rise* [Student project documentation]. CEPT University School of Architecture.

Between 2015 and 2020, Building Information Modeling (BIM) was combined with the mass customization in Architecture and mass housing projects. The digital tools such as Revit and Dynamo were used to make design-decisions based on data. A multi-disciplinary collaboration was undertaken in a project, where different experts work together closely. The case study examples are, Wiki-house from Wiki-house foundations in England (2015); Incremental housing

project at Villa Verde from Alejandro Aravena (2017); and Indian housing experiments from CEPT and HCP planning and management studies (**Figure 05**).

Unlike traditional architectural process, Wiki-house allows users to customize interior layouts and use digital methods like sketch-up, a free easy to use 3D-software to customize the plan according to their needs and use computer numeric control (CNC) prefabrication logic to create building facades (Esenarro Vargas et al., 2025). Incremental housing by Alejandro Araveno, improved computer models to understand how housing can evolve over time. The project proposes a two-story row house where each user gets half of the total allowed building space with good finished interiors. The major constructional benefits are, the final delivered model has shared party walls, single pitched roof, lower floor slab and beams for the first-floor slab – which means the residents only need to build one floor slab and two outer walls themselves (Carrasco & O'Brien, 2022). Indian housing projects focused on mass housing, majorly adapts BIM and parametric design techniques. Especially, housing researches in India within academic and practice-based environments such as CEPT University has explored the integration BIM and parametric workflows in addressing the high-rise structures and mass housing adaptability. Their studio works emphasizes the integrated construction practices combining BIM, Lean methods, LPS tracking, coordinated modelling, 4D-5D simulations, demonstrates how the structural workflow with digital models enhances the constructability of high-rise buildings (Yashwani Lad et al., 2025). Comparatively, Villa Verde refines the controlled incompleteness strategy of Qunita Monroy through improved computational modelling, demonstrating how incremental housing principles gain precision and predictability with digital tools without losing their fundamental user-participatory character. The façade-interior integration remains high, and transferability to mass housing context is strong given the low-cost structural framework.

The key benefits of adapting BIM include enabling associative design, changes on file updates automatically and promotes coordination among stakeholders. However, the digital medium has certain limits in managing complex spatial variability, customization features are restricted to size and dimensions and users don't get direct input in the design process.

2.2.5 Phase 05. Advanced parametric and Responsive systems (2020 -2025)

In recent phase (2020-2025), building design integrates the advanced responsive systems such as parametric logics, BIM, Artificial intelligence and sensors to create buildings respond in real-time with the surroundings. The modern buildings have smart facades and systems that users can control. The case study examples are, Al Bahar towers by Aedas Architects in Abu Dhabi (UAE), Vaayu house, and SAVYA hotel - Parametric facade interfaces by SOGA design studio in India (**Figure 06**).

Figure 06. Architectural details of Al Bahar towers (left), Vaayu house (Middle), and SAVYA hotel (right).

Note. Adapted from Aedas Architects. (2012). *Al Bahar Towers, Abu Dhabi* [Project documentation]. ArchDaily ; SOGA Design Studio. (2022). *Vaayu House — parametric façade with Para-Tile system* [Architectural documentation]. ArchDaily ; SOGA Design Studio. (2022). *Parametric façade design with Para-Tile system: Vaayu House and SAVYA Hotel, Kolkata* [Architectural project documentation]. SOGA Design Studio.

Al Bahar towers from Abu Dhabi have a responsive kinetic façade that reacts to the external atmospheric conditions and the sun movement. The special building screen made of triangular panels were designed using parametric logics, that withstand all the climatic conditions, respond to the sun position throughout the year. The curtain wall screen was placed two meters away from the building's outer wall on its own frame. Each triangular panel is covered with fiber glass and programmed to move based on the sun's position to reduce heat and glare inside the building (Cocho-Bermejo, 2025). Vaayu house by SOGA design studio has a Para-tile façade system makes the building breathe with the rhythm of nature. The climate responsive interiors and the parametric façade system made with Rhino - Grasshopper, and CNC tools helps the fabrication system to adapt effectively to the local climate. Similarly, SAVYA hotel by SOGA design studio features a '*Paratile-driven façade* system', uses adjustable fins on the envelope to optimize daylight penetration to the interiors and cast intricate shadow patterns on the building surface. The vertically arrayed fins provide a pleasing visual appearance and help to control the indoor temperature by reducing the need for artificial cooling (SOGA Design Studio, 2025). The parametric façade now serves as an *'Adaptive-environmental filters'*, using real-time data to improve building performance. However, still there are few limitations existing such as, expensive installation and requires technical expertise to handle the system which are hard to scale for mass housing, and users have to rely on designers for all the modifications. The kinetic and parametric systems respond dynamically to environmental conditions, but remains entirely autonomous from interior-spatial organization and user participation in spatial decisions is absent. The findings confirms that technological advancements without a user-participatory design framework doesn't resolve the interior-exterior integration challenge identified in this study. The (**Table 01**) represents the cross-case evaluation matrix and interior-exterior integration across five phases.

3. Results

Table 01: Cross-Case Evaluation Matrix and Interior-Exterior Integration Across Five Phases.

Case study	Phase	Interior configurability	Façade- Interior integration	User participation	Transferability to mass housing
Aranya housing	01	High	Partial	Direct	High
Qunita Monroy	01	High	Integrated	Direct	High
Next 21	02	High	Integrated	Direct	Conditional
Halen Housing	02	Partial	Partial	None	Conditional
Carabanchel	03	Low	Disconnected	None	Low
Sanchinarro	03	Partial	Partial	None	Conditional
Wiki-house	04	High	Integrated	Direct	Conditional
Villa Verde	04	High	Integrated	Direct	High
CEPT Studies	04	Partial	Partial	Indirect	Conditional
Al Bahar / Vaayu / SAVYA	05	Low	Disconnected	None	Low

Interior Configurability: *Degree of occupant-driven spatial modification capacity;*
Façade-Interior integration: *Degree to which envelope expresses or accommodates interior spatial variability;*
User participation: *Nature of occupant agency in design decisions;*
Transferability: *Scalability of design strategies to contemporary mass housing typologies.*

Cross-Case Synthesis:

The cross-case evaluation reveals that; user participation and façade-interior integration are directly correlated. The Case study examples (Aranya housing, Quinta Monroy, Next 21, Wiki-house, Villa Verde) embedded direct occupant agency into design framework, consistently demonstrate integrated or partially integrated interior-exterior relationships, while cases without user participation mechanisms (Carabanchel, Al Bahar) highlights systematic disconnection between façade expression and interior spatial organization.

The technological advancements do not correspond linearly with the improved interior-exterior integration. The Presented case studies (AlBahar, Vaayu house, and SAVYA hotel) – achieves higher environmental façade responsiveness but lacks internal-external spatial connection. Conversely, cases from pre-digital era achieves the most meaningful integration through design philosophy rather than computational compatibility, establishing the integration is fundamentally a design intent more than focusing only the technology.

Most significantly, the design strategies demonstrating the high transferability to contemporary mass-housing: Qunita Monroy – Controlled incompleteness, Next 21 – support infill separation, Villa Verde's incremental framework, all are governed by principled spatial frameworks rather than technologically dependent systems.

4. Discussion

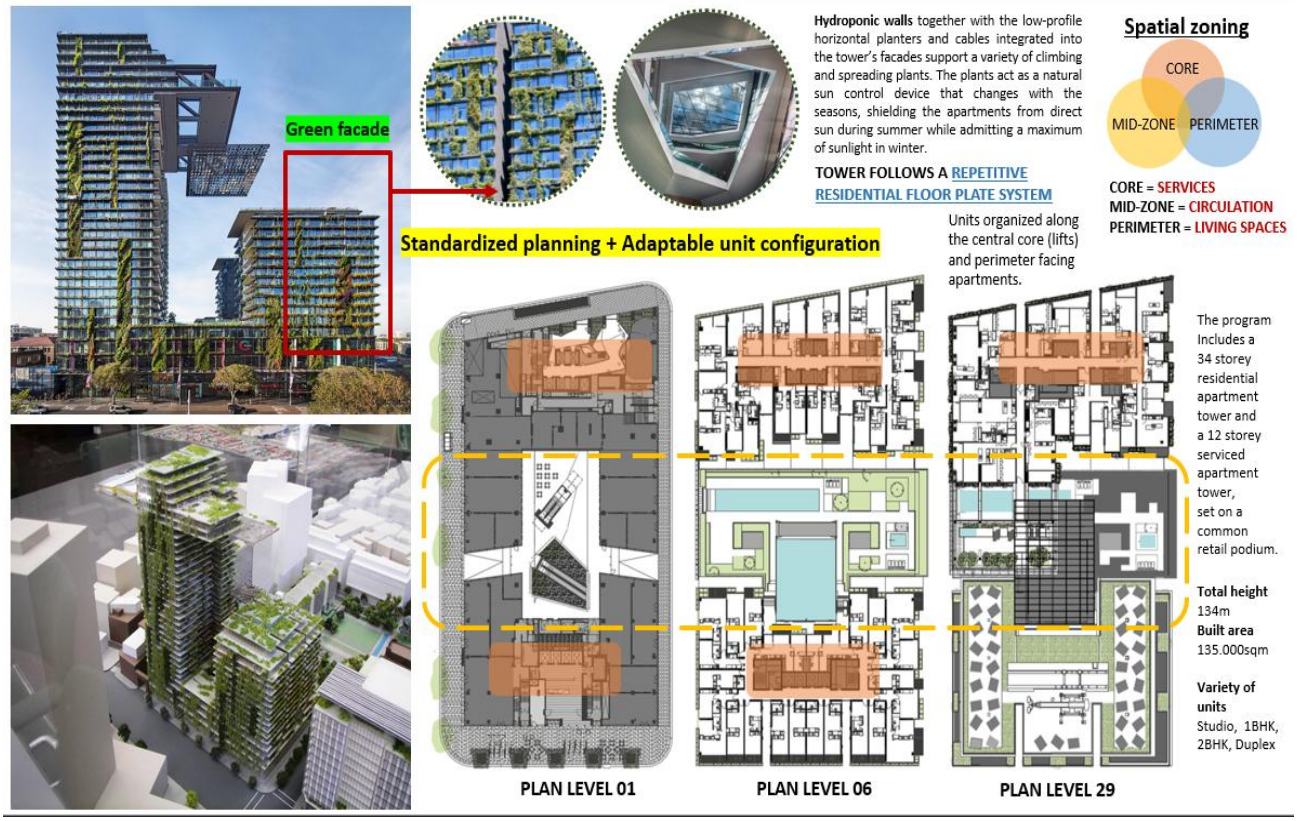
4.1 Potential design solutions for the typical and non-typical floorplan layout's façade articulation

From incremental adaptation to parametric responsiveness, the case studies on *phase01-phase05* explain, how building designs evolved from simple, fixed structures to ones that can be adjust and respond more flexibly. Based on the literature study and case study buildings, the findings advance the existing literature in a specific direction. It establishes that the determinant of interior-exterior integration is not technological sophistication but the presence of a design framework that treats occupant's spatial agency as a generative input rather than a post-occupancy problem. Further, (**Table 02**) presents the design strategies derived from the case study findings, mapping the transferrable principles from high integration cases on to a framework applicable to contemporary mass housing typologies. The analysis points out the improvements in the ability to anticipate the future needs and simulate the user preferences, consider how the external-environment factors affect the building performance, and connect the interior spatial changes to adjustments in façade system.

Table 02: Spatial Logic Representation and Façade Articulation Through Adaptive Design Strategies.

1. One central park in Australia (2014) by Jean Nouvel and Patrick Blanc

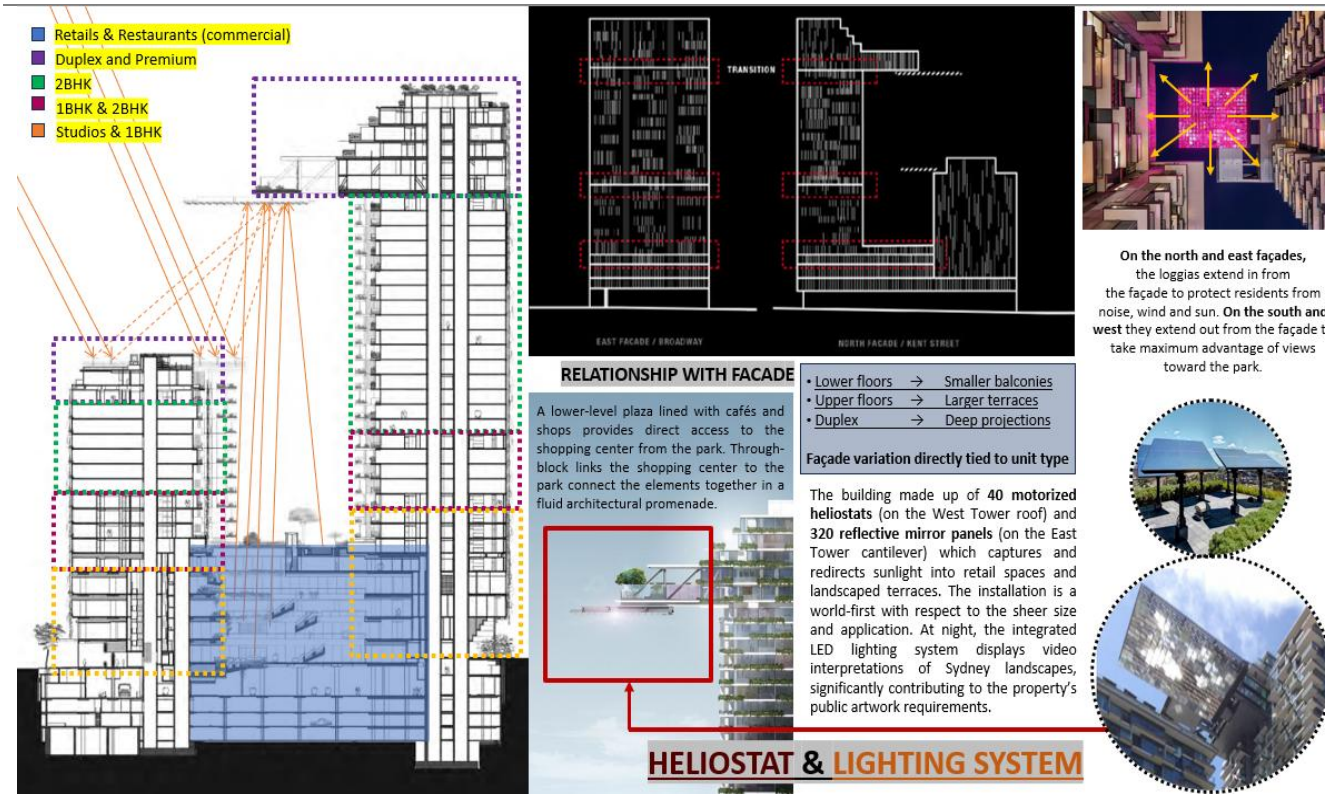
Note. Adapted from Nouvel and Blanc (2014). *One Central Park* [Architectural documentation]. ArchDaily.



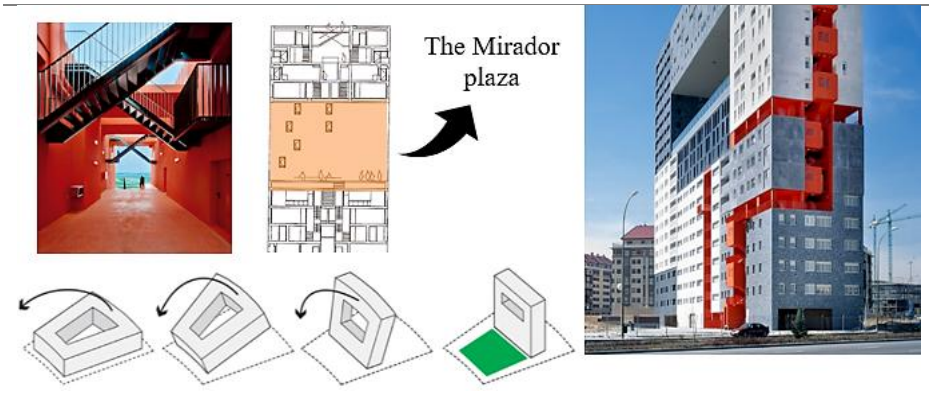
Spatial design strategies (Analysis: author)

Standardized façade and Uniform floor layout:

One central park, an iconic residential and commercial complex in Sydney, characterized by its vertical landscaping and usage of heliostats for the energy production. The building utilizes hydroponic walls and varied vegetations to inhibit temperature control and aesthetic values. The uniform floorplan layout follows a vertical spatial zoning, strategizing to place commercial retails and public circulation on the *'podium floors'* from basement to the level 06. The transitional zone contains gym and pools and within residential towers, apartment units are arranged asper hierarchy – studios and one-bedroom units on lower levels, following that upper floors are allocated for two-bedroom units and premium duplexes with sophisticated features such as, double-height spaces and private terraces. The façade is articulated by green covers with 50% of coverage, acts as a sun barrier. Overall façade acts not merely a skin but as a lively extension with occupied balcony and garden spaces. The cantilevered balconies, vegetation systems, and external shading devices shaping the façade by providing direct link to the interior spaces. The sustainable building carries heliostat system, that captures and redirects sunlight into the retail podium with an installation of 40 motorized heliostats from west tower and 320 reflective mirrors laid on the monumental cantilever from east tower. Such a way, it overshadowed park areas during the day, while at night, it serves as a public art installation using an integrated LED lighting system to display video interpretations of Sydney landscapes. The north and east façade features the recessed loggias, west and southern façade covered with projected balconies to capture the views of adjacent park. The building maintains a standardized structural framework, emphasizing a fluid connection between built environment to the shared public plazas and the cascaded greenery.



2. Sanchi Narro housing in Spain (2005) by MVRDV-Mirador;
Note. Adapted from MVRDV & Lleó, B. (2005). *Mirador residential building, Sanchinarro, Madrid, Spain* [Architectural project documentation]. MVRDV Architects.

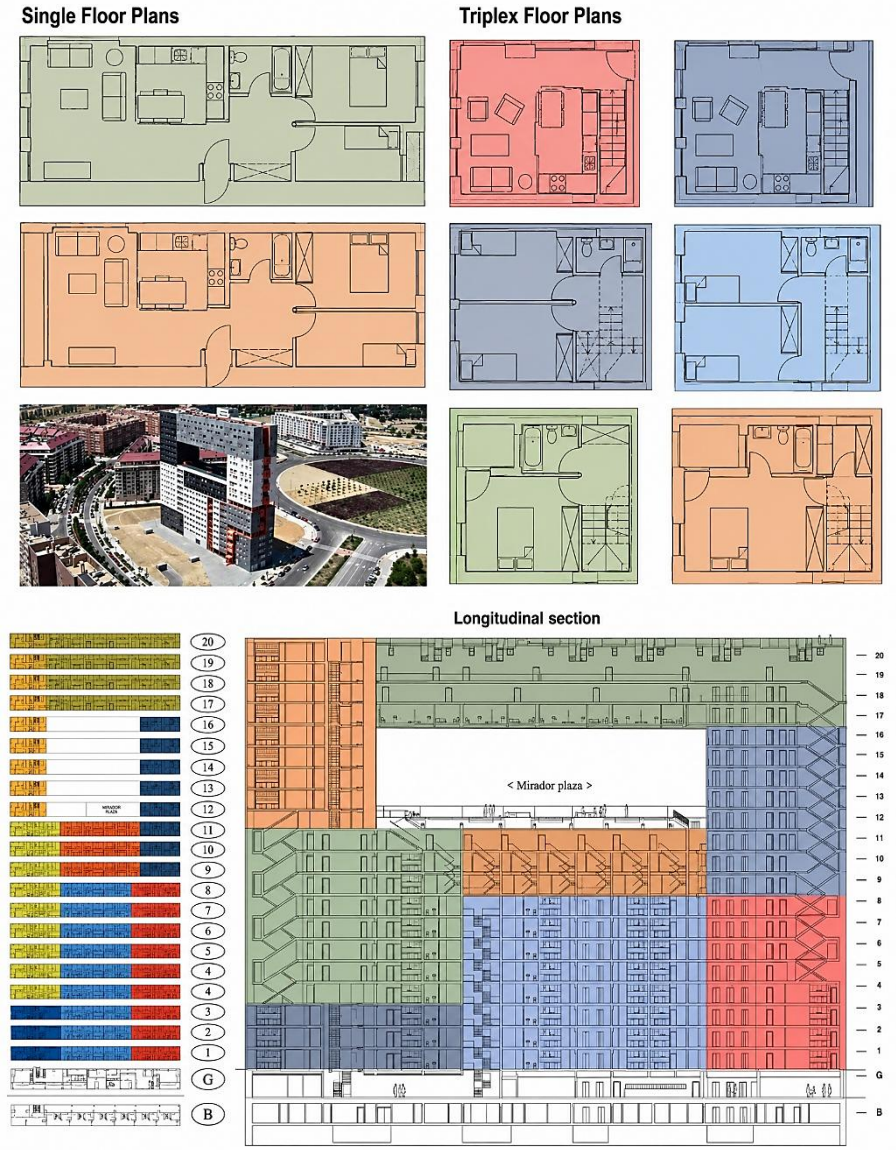


Floor plans of MVRDV-Mirador

Program driven façade based on unit variation in layout:

To accommodate a non-uniform spatial layout, Mirador was designed as a "superblock" composed of *nine distinct building blocks* that were "glued and stuck" together. The layout design, accommodating variety of small studios to large triplexes – which allows users with different lifestyles and social groups to live together within a single building. The sections were connected by *vertical streets* and *corridors,* which are emphasized in bright orange color. The service pathways go around the building blocks, linking different neighborhoods and gives access to all the apartment units.

The facade system was planned as a visual *"collage"* where the material treatment and window patterns of each building block represent the specific floor plans and apartment styles contained within. By using different grayscale cladding for each



section, the architects mapped the building's internal diversity onto its exterior, effectively using the facade to distinguish the separate neighborhoods that make up the whole.

The Mirador building's form generation was achieved by taking the traditional Spanish five-to-eight-story block with a central courtyard and flipping it onto its end to create a vertical tower that preserves open space and frames the distant Guadarrama Mountains through a large "lookout" 40 meters above the ground. Its spatial planning organizes 157 apartments into nine stacked neighborhoods interconnected by an "orange ribbon" of external stairs and vertical alleys that function as community meeting spaces.

The envelope design supports a sense of community by using a different materials and fenestration styles, where each side of the elevation has its own unique look on outside and directly reflects the internal program of a building. Such a way, the building focuses more on its creative appearance than the underlying structural framework.

4.2 Regulatory Frameworks as a Design Determinant in Spatial and Façade Interventions

The regulatory frameworks identified in the existing literature as major determinants of spatial flexibility and façade articulation in residential architecture. (Kasim et al., 2018) establish the planning and zoning parameters like floor area ratio, height restrictions and setback requirements that governs the overall building form and indirectly constrain interior spatial compatibility. (Sebi et al., 2019) demonstrates that environmental and energy regulations increasingly shape façade's design decisions and ensuring façade performance towards standardized compliance targets. (Osácar et al., 2021) confirms that approval processes requiring pre-submitted architectural documentation structurally exclude post-occupancy spatial modifications from the regulated design framework. Overall, these studies treat regulations as a constraint operating on design, a position where study's findings both confirm and critically extend.

The cross-case evaluation on case studies shows the constraining function of regulations. The parametric and BIM – phase cases such as *Carabanchel and CEPT studies*, operated within regulatory frameworks that standardized spatial parameters and pre-approved façade treatments, systematically excluding occupant spatial agency from design process regardless of tool sophistication. However, the pre-digital cases reveal a more nuanced regulatory dynamics that existing literature does not adequately address. For instance, *Aranya housing's* interior-exterior integration through Indore Development Authorities Institutional framework explicitly permitted those incremental spatial modifications as a legitimate design outcome – demonstrating regulations can functions as an enabler of controlled flexibility rather than solely as a constraint.

The existing regulatory literatures (Sebi et al., 2019) and (Kasim et al., 2018) addresses regulation as a performance standard applied to completed buildings, but do not examine how regulatory frameworks can be structured to permit and Channel occupant spatial agency during and after occupancy. The present study establishes this as a critical gap; the integrated design framework can be fully operationalized within regulatory environments that formally recognize controlled spatial flexibility at the dwelling unit level as a legitimate and governable design outcome. The operationalization of design strategies (*section 4.1*) in contemporary mass housing is not solely a design intent question; it is also a contingent on the regulatory frameworks within which the housing design operates.

5. Conclusions

Based on the evaluation of case study findings in terms of façade performance and spatial customization, a clear course of development is identified in the urban residential architecture. From pre-digital era to the current contemporary phase, integrating artificial intelligence in planning and utilizing advanced parametric digital tools, the progression shows a significant shift in accommodating diverse spatial needs of users and interior requirements within the spatial layout. The study investigated how user-driven spatial customization of residential floor plan influences façade articulation in mass housing and identified transferrable design principles that reconcile interior spatial flexibility with façade's compositional coherence through three objectives explicitly established in the introduction and systematically addressed through comparative case study analysis and theoretical framework review.

First, the cross-case evaluation empirically demonstrates that interior spatial configurability and façade compositional coherence are not inherently contradictory. Their apparent conflict is a consequence of a design frameworks that treat the building floorplan and façade as independent systems, rather than a structurally integrated continuity. The findings directly refute the foundational assumption of standardized mass housing design and supported by evidences discussed in case study buildings, where higher interior configurability co-exists with coherent façade expression across different phases, geographies and technological contexts.

Second, the findings advance the existing literature on parametric and AI – assisted façade systems by identifying the absence of user-participatory framework as the critical limitation of the current technological approaches. Third, the study positions regulatory permission for occupant spatial agency as a structural precondition for implementing integrated design frameworks - advancing the existing regulatory literature by reframing policy flexibility from a design preference in to a governance mechanism.

For architectural practice, the strategies presented offers directly implemented frameworks for mass housing design. For theory, the study advances the open building discourse by providing cross-phase empirical validation of support infill principle across diverse housing typologies. Future research should examine how the AI- assisted design tools can embed user spatial agency according to the contextual regulatory framework as a primary generative input during housing design. The study concludes by emphasizing, the utilization of digital tools and adapting new construction methodologies have made it possible to balance uniformity and variation, ensures control and adaptability in façade system with user-oriented spatial personalization possibilities. Instead of considering regulatory bodies as constraints, it serves as enabling frameworks to guide how buildings can be design flexibly with coherent articulation of façade, and ensures the personalized interventions fitting well to the external environment and contributes positively to the urban context.

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