Title: Rhythm and Balance in Modular Façade Renovations: A Case Study on Prefabricated Large Panel Buildings" "Visual and Functional Interventions in Prefabricated Large Panel Façades:
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Rhythm and Balance in Modular Façade Renovations: A Case Study on Prefabricated Large Panel Buildings"

"Visual and Functional Interventions in Prefabricated Large Panel Façades: A Gestalt Approach"

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Abstract
This research examines the effects of aesthetic and practical modifications on the façades of existing buildings made with huge panels. The examined changes encompass the incorporation of volumetric features like balconies, the rearrangement of windows, and further alterations impacting the aesthetics and functionality of the structures. The research uses two-dimensional models to assess visual and functional alterations between the original and changed façades, including Gestalt concepts to elucidate the impact of visual perception and organization on façade harmony. The primary aim is to evaluate the impact of these changes on architectural coherence in the urban environment, increase interior living circumstances, and elevate the occupants' aesthetic experience. The research examines the difficulties of preserving visual coherence and utility, providing pragmatic suggestions for architects and designers seeking to restructure the façades of large-panel structures. The findings indicate that well-designed interventions may revitalize old structures, enhancing their modernity and functionality, while also fostering improvements in the built environment and people's quality of life.

Introduction

Prefabricated architecture is an arena where composition is essential for harmonizing practical, economic, and aesthetic requirements. This architectural style relies on standardized and prefabricated components that are assembled on-site to form full structures. The composition process in prefabricated architecture transcends basic technical organization; it is a creative endeavor wherein compositional principles facilitate the creation of a cohesive and functioning entity. (Ford, 2003) The façade represents the contact between the building and its urban or natural environment, necessitating a design that fulfills both aesthetic and functional criteria. The process of re-composition entails reinterpreting the visual and structural components of the facade to create a cohesive conversation between the individual aspects and the entirety. Building façades are the most apparent and exposed components of a structure, playing a crucial role in both aesthetics and functionality. The necessity for involvement in structures created using huge panel technology, which prevailed in mass construction throughout the 20th century, is becoming increasingly apparent. These constructions, while originally successful in addressing housing needs during an emergency, today encounter several hurdles, including outdated aesthetics, usability problems, and frequent inadequacy in fulfilling contemporary living standards. Alterations to building façades yield a dual effect: they augment the aesthetic appeal of the structure, rendering it more attractive and congruent with the urban environment, while simultaneously enhancing functionality, thereby creating more practical and appropriate spaces for occupants. Interventions may encompass the incorporation of volumetric features like balconies, the alteration of window configurations, and other adjustments that directly influence user experience and façade aesthetics. This study seeks to evaluate the effects of these adjustments on the aesthetics and functionality of existing big panel structures. The utilization of 2D models facilitates the assessment of these interventions from both a visual and functional standpoint, excluding the examination of energy or structural performance. The main aim of this research is to elucidate how visual and functional interventions might alter existing structures, enhancing the built environment and the living circumstances of inhabitants.

Theoretical framework

Characteristics of Prefabricated Architecture and Composition

In prefabricated architecture, the large concrete panels are manufactured in standardized configurations, with modules replicated and methodically interconnected. Modules function as fundamental components that are replicated and amalgamated, establishing a discernible rhythm within the structure. Modular Composition: The employment of uniform or diverse modules to achieve visual and functional coherence. In prefabricated architecture, composition frequently emphasizes establishing a harmonious relationship between bulk (prefabricated panels) and space (windows). The interstitial areas between modules frequently fulfill functions like ventilation, natural illumination, and aesthetic representation. Rhythm is a fundamental idea in prefabricated architecture, wherein the repetition of modules creates a sense of harmony and order. Prefabricated architecture prioritizes production and assembly efficiency, whereas composition guarantees that these pieces function as a unified and structured entity. Composition transforms into a pragmatic procedure whereby each piece possesses a specific function and exact positioning inside the design.

Study on the Principles of Composition in Prefabricated Architecture

Unity and Harmony

Prefabricated elements should be integrated in a way that the building appears as an indivisible whole, despite its modular nature.

Balance

Due to the repetitive nature of modules, it is important to distribute them in a balanced manner to avoid monotony or visual heaviness.

Rhythm and Repetition The repetition of modular units creates a visual rhythm that gives the building a clear and organized structure.

Hierarchy

Although prefabricated architecture is based on repetition, certain elments can be emphasized to create focal points, such as main entrances, prominent balconies, or atriums.

Flexibility

Prefabrication offers the opportunity to experiment with different combinations while maintaining a regular framework of composition.Rudolf Arnheim, in his seminal work Art and Visual Perception: A Psychology of the Creative Eye, examines the ways in which human perception responds to visual organization and structural transformations within a composition. He posits that visual harmony emerges when the elements of a design are balanced and adhere to the principles of Gestalt theory. Arnheim further asserts that rhythm in visual design is achieved through the systematic repetition of elements and gradual variations. In this context, the integration of additional elements can have distinct effects: additions that conform to existing parameters, such as shape, color, and size, serve to reinforce the visual structure, fostering a sense of coherence and continuity. Conversely, additions that deviate from the established organizational logic may disrupt the composition, introducing visual chaos or dissonance. (Arnheim, 2004)

Colors that create harmonic contrast facilitate the integration of additions without disrupting the overall cohesion of the composition. Contrasting colors in specific areas can be employed to establish focal points, provided they do not overwhelm the façade. Textures that differ significantly from the existing ones may dominate visual perception and cause a separation between the figure and the background.

Proximity: Additions situated near existing modules are regarded as components of a unified visual structure, whereas increased distances may lead to the perception of additions as distinct aspects.

Similarity: Additions that possess congruence in shape, color, and size with the existing modules enhance visual coherence.

Continuity: Additions that align with the current rhythm's lines and directions are seen as a rational extension of the structure.

Figure and Background: Notable disparities in color or shape might lead additions to be interpreted as figures, so altering the optical equilibrium between items regarded as the background. When additions harmonize with the current rhythm, they foster a sense of order and visual tranquility. Additions that contradict the structural principles might generate conflicts viewed as tension or confusion. Extensions must be harmonized with the existing façade, preventing any portion from overshadowing the others.

Application of Gestalt Principles in Prefabricated Façades

The Gestalt principles, based in perceptual psychology, offer a framework for comprehending how individuals visually perceive and organize components within a composition. These ideas may be employed to improve visual coherence, practicality, and aesthetic appeal in prefabricated façades. The following are essential Gestalt concepts and their significance to prefabricated façades:

1)Proximity

Elements in close physical proximity are viewed as belonging to the same group. In prefabricated façades, closely positioned modular parts provide a sense of uniformity and cohesiveness, whereas excessive space might disrupt the visual integrity.

2)Similarity

Elements exhibiting analogous characteristics, such as hue, form, texture, or dimension, are regarded as being grouped together. Implementing this approach guarantees that further modules or façade alterations blend effortlessly with the current design , preserving visual coherence.

3)Continuity

The human eye favors uninterrupted patterns or lines. Prefabricated façades advantageously preserve uniform lines and rhythms in modular configurations, fostering a natural flow that improves the overall aesthetic of the project.

4)Figure and Ground

The differentiation between a focus piece and its background is essential in design. Prefabricated façades may employ contrasting materials or colors to highlight certain elements, such as entrances or balconies, while maintaining the overall composition's coherence.

5)Closure

The mind has a propensity to finalize imperfect forms into a full entity. The strategic arrangement of modular panels in prefabricated façades can generate inferred shapes, so augmenting the sense of a unified and deliberate design.

6)Symmetry and Balance

Symmetrical compositions are intrinsically appealing and evoke a sense of stability. In prefabricated façades, the strategic arrangement of modules guarantees an orderly and aesthetically pleasing framework.

7)Rhythm and Repetition

The recurrence of modular components creates a rhythmic structure that ensures organization and consistency. Rhythmic variations, like alternate textures or hues, can enhance vitality while maintaining cohesiveness.

The Assessment of Visual Compositions and Aesthetic Principles

The evaluation of visual compositions, their perception, and their underlying principles is framed within the broader context of aesthetic pleasure. A central component of this is venustas, the third element of Vitruvius's triad, representing beauty or aesthetic delight (Vitruvius, 1914). Vitruvius places significant emphasis on aesthetics and harmony in architecture, discussing the concept of beauty and its influence on ancient architecture through the triad of firmitas (strength), utilitas (functionality), and venustas (beauty). This component of architecture is the most intricate and diverse, as it relates to how architecture interacts with our senses and shapes our perception and experience of the built environment. It deals with subjective responses that often vary between individuals, making it a challenging domain to reconcile universally (Lynch, 1960) Lynch’s work examines the concept of visual perception in urban spaces, exploring how humans interpret their surrounding cities and architectural elements. It highlights the influence of urban spaces and visual components on individual perceptions and provides insights into how architects can design visually appealing spaces.

The Role of Perception in Visual Delight

The aesthetic interest of architecture starts with its perception. To fully comprehend the creation of visual satisfaction or beauty, it is crucial to first understand how humans perceive and interpret visual stimuli. The human mind is intrinsically designed to derive meaning from sensory input, a characteristic that arose from the survival instincts of our ancestors, who depended on environmental signals for protection and sustenance.

Gestalt psychology, established in the 1930s, elucidates the manner in which the mind perceives shapes and patterns. The term gestalt derives from German and denotes "the shape or complete form of an entity." This theory asserts that the mind functiwaptivating the observer through nuanced variances.

Case Study

From 1978 the year when the building was built until 2025, the building experienced many notable changes that enhanced its appearance and utility. The façade was improved in terms of thermal performance (Guri, Krosi, & Klodjan, 2023), substantially improving its aesthetic appeal and offering a more contemporary clean, and tidy look. Several windows were changed or renovated, including shutters and other contemporary elements to improve insulation, privacy, and functionality. Modifications were implemented to the balconies, encompassing possible enclosures or structural enhancements, thereby increasing their functionality and providing improved protection against adverse weather conditions. The electrical

and antenna cables were restructured, yielding a more orderly and systematic configuration than the prior chaotic layout. The vicinity of the building was tidied and systematically arranged, eliminating prior disorder and establishing a more orderly and aesthetically pleasing atmosphere. Furthermore, observable repairs to the outside resolved maintenance concerns, enhancing the durability and preservation of the façade. These modifications demonstrate a deliberate endeavor to enhance both the aesthetic and functional dimensions of the structure and its environment.

Figure 1: Before and after renovation of the building.

The Application of Gestalt Principles The Application of Gestalt Principles in the Design and Aesthetic Improvement of Prefabricated Building Façades

In the examples below, the facades of prefabricated buildings are analyzed through the lens of Gestalt principles. The approach focuses on the division of the facade into solid and void spaces, which is interpreted as a visual language that conveys the perception of modular segmentation. In the case of the Figure above, the façade has an equal division between modules. Additionally, in this instance, the façade does not feature a uniform color or an overlay to conceal the panels or create uniformity. In Figure b, there is an equal division of the panels, where the wall and the spatial partitioning are consistent. Similarly, in Figure c, we observe a distribution of void spaces in the façade, which clearly demonstrates the uniformity in the arrangement of the modules and their voids. In all cases—Figures a, b, and c—the principle of similarity is present. This

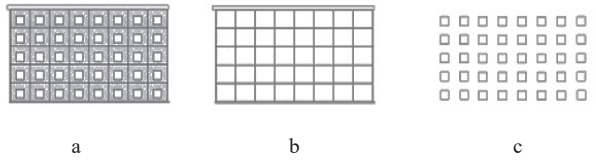


Figure 2: Facade type 1 front.

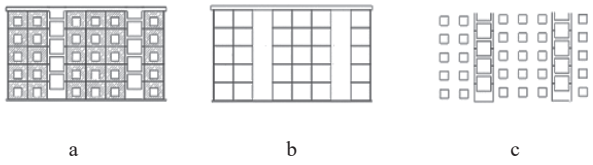


Figure 3: Facade type 1 in the back

division creates a sense of unity and visual harmony. In the case of Figure above, the facade is composed of grouped divisions, where its elements are arranged in clusters. The rhythm of the segmentation follows a 2-1-3-1-1 pattern. Additionally, the panels in the first group (2) and the second group (1) are visually distinct, resulting in a greater sense of discontinuity compared to the facade in Figure 1. When considering interventions on this type of facade, achieving visual harmony becomes more challenging due to the inherent disjointedness in the design. In Figure b, this discontinuity between elements is also evident, even though the distribution is organized using panels as whole spaces, without considering the size of the window openings. In the case of Figure b, the distribution of elements is defined by the openings and the relative sizes they create. Here, the segmentation is also organized into groups of elements, resulting

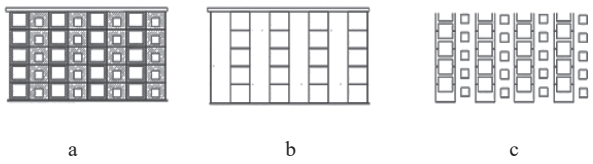
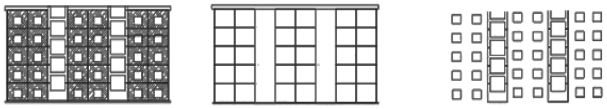


Figure 4: Facade type 2 front.

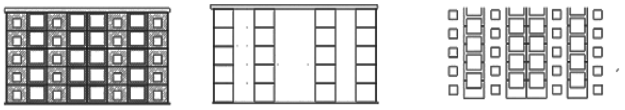
in a facade that is not visually unified but instead composed of clusters of components. In the case of Facade above, there is a unified distribution of module groupings, following a consistent pattern of 1-1-1-1-1-1-1-1. This regular arrangement presents vertical elements as parallel, repeating lines. Through the principle of proximity, the vertical elements are perceived as a group of rhythmically repeating components. Additionally, the principle of continuity enhances the perception of these elements as part of an interconnected rhythm of modules that follow a logical flow, naturally guiding the viewer's eye facade. In Figure,b where two different repeating forms of spaces are presented, the principle of continuity ensures that the division of intercion nected spaces appears harmonious.In Figure c,where the division of the modules remains evident. Despite the emphasis on the division of spaces ,the rhythmic



a b c

Figure 5: Facade type 2 back.

uniformity is preserved and remains clearly perceivable. In the case of Facade 4, the distribution of modules reflects the principle of proximity, where elements arranged in a 2-1-2-1-2-1 pattern form groupings of two as a result of their spatial closeness. The vertically aligned elements appear as unified groups because of their proximity, creating the perception of spaces between groups of two rows, which are separated by spaces containing single rows. The small distances between modules contribute to perceiving the facade as an integrated whole. In Figure b, this grouping of panels is more apparent because the elements composing the facade lack distinct graphic differentiation, making them perceived as unified groups. In Figure c, the division of grouped elements becomes



a b c

Figure 6: Facade type 3 front.

clearer through the combined application of the principles of continuity and proximity. In this scenario, any additions to the facade must align with and become part of the established rhythm to maintain visual coherence.

In the case of the Facade of Figure 5, the facade exhibits varying rhythms in the repetition of its elements, following the pattern 1-1-1-2-1-1-1. This arrangement results in a centered composition, with mirrored rhythms on either side of the central element. In Figure b, the repetition of panels makes this rhythm more clearly perceptible. Similarly, in Figure c, the void spaces emphasize the rhythm further, where the principle of proximity creates a visually larger central space within the building. Due to the proximity of the panels, a stronger sense of unity is established, particularly around the central area.

An Analytical Approach to the Combination of Panels for Façade Design

The figure above shows the modular arrangement of prefabricated concrete panels used to construct the building's facades. In total, there are 6 types of panels (PJ^1) used for the façade 3 of which are used for the side façade (PJ1; PJ2, PJ3) and 3 of them are used for the front and the back facade (PJ4, PJ5, PJ6) (AQTN, n.d.) (Guri, Krosi, & Klodjan, 2023). Each element plays a specific role in the building and can be categorized into several types. Panels with windows are presented with different frames for window openings and predefined sizes that can be adapted to various layouts. The

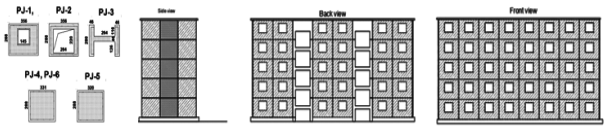


Figure 7: Analyses of case study building.

external panels that do not have any windows or any openings on them and are located on the shorter side of the façade are used for comprehensive insulation in walls devoid of openings, with materials for thermal and acoustic insulation chosen according to standard of the period when they were built. Load-bearing panels, conversely, incorporate specialized structures for both horizontal and vertical connections, thereby guaranteeing the structural integrity of the facade system.

-The side orientation reveals a straightforward facade featuring a combination of vertical and horizontal panels. This indicates a design devoid of substantial apertures, emphasizing thermal insulation. The front and back perspectives exhibit a symmetrical arrangement with windows positioned at consistent intervals. -The design utilizes rhythm and symmetry to achieve an aesthetically pleasing and functional facade.

-The panels are modularly designed, providing design flexibility and installation flexibility. The junctions between the support frameworks and glazed or solid panels form a facade that complies with the criteria for thermal insulation, acoustic efficacy, and longevity.

-This methodology seeks to offer a modular solution for buildings including large panels, enhancing thermal insulation and the visual design of the facade. Panel standards encompass measurements like length, width, and thickness, materials utilized such as concrete, insulation, or aluminum, and essential attributes pertaining to thermal insulation and structural integrity. A technical diagram may depict the horizontal and vertical connections between panels, demonstrating various combinations and their effects on performance.

-The analysis must emphasize thermal efficiency and assembly speed while elucidating how modular design diminishes expenses and building duration. The technological connections guarantee structural integrity and optimal performance, utilizing contemporary materials and technology for assembly and linking. This modular layout serves as an optimum option for the renovation of existing structures using big panels, striking a balance between energy efficiency and aesthetics.

Post-intervention analysis

Following changes on the building façade, major changes have been realized in functional, aesthetic, and energy-related dimensions. The images illustrate sections marked with red hatching, signifying volumetric expansions implemented to enhance the internal space of the flats or to establish additional functional zones, such as balconies or room extensions. These modifications not only increase the living space but also create a more diverse and modern aesthetic for the building's

façade. Regions marked with striped red hatching indicate modifications to the dimensions of windowed panels. The changes attempt to improve natural lighting and ventilation through the strategic positioning and sizing of openings. The modifications to the front façade have produced a more dynamic appearance, with the rhythm of the windows and the incorporation of volumetric extensions enhancing the building's modern and visually appealing design. The alterations on the back façade are seamlessly integrated with the volumetric extensions, facilitating an efficient arrangement of inner spaces and enhancing the outside aesthetic. The interventions display a consistent and harmonious profile from the side perspective, preserving a visual relationship among various elements of the façade. The volumetric extensions have been incorporated in

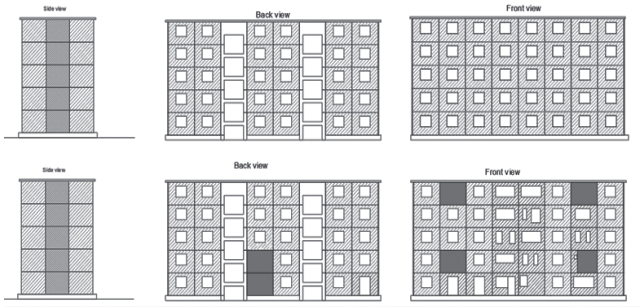
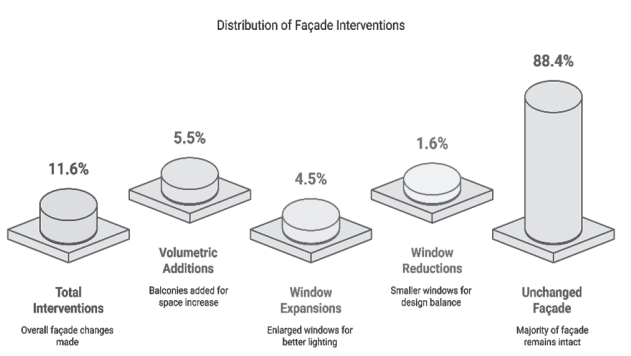


Figure 8: Before and after renovation facade.

a random way based on the decision of the apartment owner, maintaining the structural integrity of the building while not considering the structural behavior of the building. These modifications not only affect the aesthetics and functioning of the structure but also its thermal and energy efficiency, offering superior increases or decreases in energy usage based on the type of intervention.

The interventions demonstrate a deliberate strategy for rehabilitating existing structures, honoring their original structure while incorporating modern aspects. This technique maintains an equilibrium between modernization and the conservation of the building's architectural features. Moreover, these interventions fulfill current standards for comfort, energy efficiency, and aesthetics, rendering the structure more appropriate for the demands of contemporary users. These modifications not only elevate the living space but also cultivate



a more diverse and modern aesthetic for the building's façade.

Regions marked with striped red hatching indicate modifications to the sizes of windowed panels. The makeover seeks to improve natural lighting and ventilation through the strategic positioning and sizing of openings.

The Impact of Interventions on the Application of Gestalt Principles in the Design and Aesthetic Improvement of Prefabricated Building Facades

The studied building demonstrates a disruption in the rhythm of panel divisions due to earlier interventions, which altered the original modular sequence of 2-1-2-1-2-1-2-1. These irregular additions created visual inconsistencies, disturbing the harmony and balance of the facade. This disruption affects not only the aesthetic perception but also the overall structural readability of the facade, which previously relied on a clear modular repetition to guide the observer's eye and define the building's architectural language.

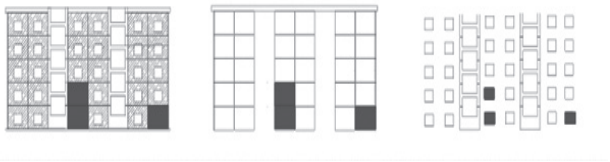


Figure 9: Rhythm of intervention analyses.

Proposal

The proposed intervention aims to address this issue by reconfiguring the facade through the application of Gestalt principles, which emphasize visual harmony, rhythm, and unity. Specifically, the intervention suggests a reflective addition of modular elements at the two points where the previous additions were made. By doing so, the proposal seeks to reintegrate the disrupted rhythm into the overall design.

This solution achieves two key objectives. First, it restores the original rhythm of 2-1-2-1-2-1-2-1, ensuring that the facade regains its modular clarity and balance. Second, it introduces a new, centralized rhythm that provides a focal point for the composition. This centralization enhances the visual coherence of the facade, creating a sense of symmetry and unity that was previously lacking.

By aligning the additions with the existing modular grid, the proposal minimizes the visual impact of earlier disruptions, integrating them seamlessly into the facade. This approach not only respects the building's original design language but also elevates its aesthetic quality by introducing a structured and

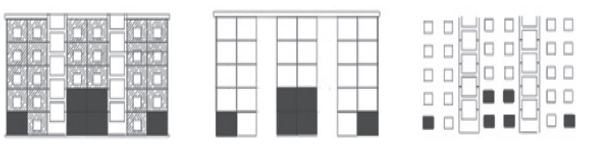


Figure10: Proposed new rythm.

harmonious rhythm. The resulting facade reflects a thoughtful balance between preservation and adaptation, maintaining the integrity of the original design while addressing contemporary needs for cohesion and visual clarity.

Conclusions

Restoration of Visual Harmony: Interventions according to Gestalt principles—such as closeness, resemblance, and continuity—are crucial for reinstating the broken rhythm and visual coherence of prefabricated facades, therefore maintaining aesthetic harmony and structural clarity.

The significance of modular rhythm: Preserving the original modular rhythm in prefabricated facades is essential for attaining balance, unity, and structural integrity. All interventions must adhere to this rhythm to prevent visual disorder and guarantee harmonious integration with the current design.

Harmonizing Preservation and Modernization: Effective interventions achieve equilibrium between maintaining the original architectural vernacular and accommodating modern requirements, so improving the facade's energy efficiency, comfort, and beauty while honoring its historical setting.

Gestalt Principles as a Design Framework: Gestalt principles offer a comprehensive framework for evaluating and reconfiguring prefabricated facades, ensuring that alterations promote visual coherence, rhythm, and enhanced urban presence while resolving functional and environmental issues.

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