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Original Research Article

Multidimensional Analysis of the Aesthetic and Environmental Sustainability Aspects of Commercial Façade Design on User Perception and Preferences (Case Study: Tehran Metropolis)*

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Abstract

Problem statement: To date, many studies concerning the façades of commercial centers have tended to focus either on aesthetic dimensions or on performance-based criteria—particularly environmental sustainability. Consequently, a notable research gap persists in Iran regarding integrative approaches that simultaneously examine both technical aspects (such as thermal transmittance, green cladding, and solar radiation control) and perceptual-cultural dimensions (including urban users' expectations and compatibility with local identity).

Research objective: Addressing this gap, the present study adopts a mixed-method approach—quantitative and qualitative to explore how visual and environmental features of commercial building façades influence the preferences and perceptual experiences of users in the Tehran metropolis.

Research method: In the initial phase, energy simulations and analysis of physical data (including thermal and daylighting indices) were conducted to evaluate the environmental performance of four selected commercial complexes. Subsequently, qualitative data were gathered through semi-structured interviews and perceptual questionnaires to assess user preferences concerning aesthetic and cultural dimensions.

Conclusion: The results indicate that façades which simultaneously reduce energy consumption and exhibit strong visual presence along with discernible cultural cues are significantly more effective in eliciting positive emotional responses and encouraging user engagement. Unlike most previous studies—often limited to either aesthetic or technical aspects—this research introduces an integrated mixed-method framework that systematically demonstrates the interrelation between environmental parameters and users' psychological reception. This framework offers a strategic model for designing façades that fulfill both ecological goals and perceptual satisfaction among the target community.

Keywords: *Aesthetics, Environmental Sustainability, User Preferences, Commercial Façades, Tehran Metropolis.*

Introduction and Problem Statement

In contemporary architectural discourse, the building

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façade functions far beyond a mere protective shell; it increasingly serves as a communicative medium conducted under the supervision of Dr. “Mansour Nikpour” and the advisement of Dr. “Mohsen Ghasemi” at Islamic Azad University, Bam Branch.

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for conveying aesthetic values, brand identity, and architectural character (Chupin et al., 2015). This transformation is particularly pronounced in large-scale structures such as multipurpose commercial complexes, wherein the façade must not only address climatic responsiveness and the protection of interior environments but also deliver a spatial and emotional message to a diverse audience—ranging from consumers to investors (Alishah et al., 2016; Zuraida et al., 2023). Tehran, as one of the largest metropolises in Iran and the broader Middle East, has in recent decades experienced a surge in high-rise developments—predominantly for commercial and administrative use—emerging across heterogeneous urban fabrics. The city’s broad climatic spectrum (from harsh winters to scorching summers) coupled with its intricate cultural landscape presents a complex design challenge: how to craft façades that are both climatically responsive and contextually resonant within the urban and cultural milieu (Guy & Farmer, 2011; Beyaz & Erçin, 2024). At the core of façade design lies the dual imperative of achieving visual appeal and environmental performance—namely, optimizing thermal and daylight conditions, reducing energy loads, and maintaining ecological harmony (Aksamija, 2015). However, these objectives often conflict in practice: innovative façade solutions (e.g., green walls, specialized glazing systems) may not always align with users’ aesthetic preferences or cultural expectations (Li et al., 2024). A critical design question thus arises: How can architects create façades that simultaneously incorporate sustainability criteria while aligning with the emotional and cultural expectations of urban dwellers? This question is particularly pertinent in the context of supermalls and large-scale shopping centers, where users from a wide array of social and cultural backgrounds engage with the space. A human-centered design approach necessitates prioritizing these users’ perceptual and experiential inputs (Van den Berg et al., 2016; Stamps, 1999). A review of the existing literature reveals a disciplinary split: while numerous studies concentrate on the aesthetic and branding functions of façades, others focus on quantifiable sustainability metrics and energy optimization. Although some international research has attempted to integrate these perspectives, a substantial gap remains

in the Iranian context—particularly concerning large-scale commercial architecture—where the simultaneous application of quantitative (environmental simulations) and qualitative (user perception and preference) methodologies is rare. Scattered investigations may address physical or visual aspects, but a systematic, mixed-method inquiry that assesses both environmental performance and user reception in Iranian commercial centers is notably absent. Thus, a research void becomes apparent: How can technical evaluations of façades (e.g., solar gain control and cooling load management) be combined with diverse Iranian users’ perceptions, expectations, and aesthetic-cultural sensibilities to produce a holistic assessment of design success or shortcomings? The innovation of this study lies in the deployment of a comprehensive mixed-method framework that concurrently evaluates two core axes—environmental sustainability and aesthetic performance—through energy simulation, in-depth interviews, and perceptual questionnaires. This approach is particularly significant given that prior Iranian research on commercial façades has largely focused on either superficial visual appeal or technical climatic performance, with little attention to the systematic integration of both domains along with real user perspectives. Focusing on four exemplary commercial complexes in Tehran—Andisheh Mall, Palladium Mall, Arg Tajrish, and Atlas Mall—this article seeks to answer the following central research question:

How do environmental factors and visual characteristics of commercial façade design influence user preferences and perceptual experiences in the Tehran metropolis?

Literature Review

In recent decades, the role of façades in the architecture of commercial centers has evolved beyond their traditionally decorative function, emerging as a critical medium for achieving a balance between aesthetic expression and environmental performance (Kim & Patel, 2018; Nady, 2017). Scholars have adopted diverse approaches to examine this evolving domain. Some have concentrated on the technical and engineering dimensions of façades, assessing parameters such as thermal transmittance, solar radiation control, and natural ventilation in pursuit of energy reduction and

improved thermal comfort (Khaleghi Babae et al., 2025; Mahdavejad & Kia, 2019; Sattari & Moatazedian, 2020). Others, drawing on environmental psychology and aesthetic theory, have prioritized the sensory experiences of users, the visual identity of buildings, and the façade's harmony with the cultural context of the urban fabric (Esmaili et al., 2020; Haghgoo & Molasalehi, 2020; Mahanfar et al., 2021). While each of these perspectives sheds light on essential facets of façade design, neglecting the intersection between environmental performance and perceptual-aesthetic experience risks producing fragmented or even contradictory understandings of how façades ultimately affect users. Certain theorists, drawing upon the Stimulus–Organism–Response (S-O-R) model, locate the façade's psychological impact in its environmental and physical stimuli. From this viewpoint, every technical element of the façade—such as shading devices or solar control glazing—can serve not only to enhance thermal efficiency but also to function as a visible and affective signal, shaping emotional and cognitive user responses (Rami & Nobuo, 2018; Muraj et al., 2023). This approach transcends purely climatic theories by integrating energy-control mechanisms with the semiotic dimensions of place, thereby situating sustainability strategies within the domain of collective perception (Roetzel et al., 2015). In other words, while sustainable systems may contribute to thermal efficiency, they achieve symbolic value only when embedded meaningfully within the cultural and visual sensibilities of the community. Emerging paradigms in contemporary literature emphasize this convergence of sustainable technologies and aesthetic values. Cultural-ecological studies, for example, have examined the role of vegetated façades in evoking a sense of connection with nature and in crafting distinctive identities within urban environments (Sheweka & Mohamed, 2012; El-Zoklah & Refaat, 2021). However, within the Iranian architectural context, there remains a dearth of comprehensive evidence. While some findings attest to the efficacy of such strategies in reducing cooling loads or enriching architectural identity, few studies present a mixed-method synthesis that integrates quantitative environmental metrics with qualitative user insights (Convertino et al., 2022; Kamelnia, 2017). Furthermore,

debates around cultural coherence and the localization of green technologies suggest that environmental strategies can only be holistically effective when they align with the aesthetic expectations and cultural values of users (Askarizad & Jafari, 2019; Ilbeigi et al., 2019). Absent this alignment, façades that perform well technically may still be perceived by the public as alienating, costly, or lacking in appeal. To summarize the theoretical landscape, many scholars identify technical-performance and perceptual-aesthetic dimensions as central to façade design, but underscore the concurrent significance of socio-cultural dimensions. Elements such as form, color, materiality, and the presence of green features must not only comply with environmental design principles but also resonate within the cultural and historical context of the society (ibid.). For this reason, hybrid approaches that simultaneously analyze energy performance and user expectations offer a more holistic pathway for evaluating façade success (Mahdavejad & Mohammadi, 2018; Zolfaghari et al., 2015; Khatibi et al., 2022). Such integrated frameworks not only advance thermal comfort and energy efficiency but also forge a meaningful connection between local community needs and the potential of green technologies. According to several recent studies, this intersection enables the creation of spaces that reinforce climatic sustainability while also evoking an engaging, identity-rich experience for users (Jafariha et al., 2022; Ahmadi et al., 2024). What remains notably absent in Iran—especially concerning commercial façades and large-scale retail complexes—is an evaluative model that simultaneously addresses both the functional (e.g., energy management and sustainable materials) and the perceptual-cultural (e.g., aesthetic expectations and cultural symbolism) dimensions. The issue, therefore, is not merely how efficient or beautiful a façade appears, but rather which integrated factors from both domains collectively contribute to a satisfying user experience within the intended social and urban context. From this perspective, the façade is not merely an urban image, but an active agent in shaping human–environment interactions and, indeed, the economic dynamics of commercial centers (Ghozatlou & Sharghi, 2024). Thus, studies that adopt mixed-method approaches—analyzing both

environmental signals and users' cultural-psychological experiences—offer valuable insights into the interface between these dimensions and can identify opportunities for design innovation within urban contexts.

A review of domestic and international sources reveals that studies concerning the façades of commercial centers have predominantly concentrated on two divergent domains: one focusing on aesthetic dimensions and semantic perception, and the other addressing physical factors and environmental sustainability. Nevertheless, few investigations have employed a mixed-method (quantitative and qualitative) approach that evaluates both dimensions concurrently within a coherent framework. According to a domestic study, Yousefi & Varmaghani (2022), in their analysis of the semantic quality of commercial façades in the city of Qazvin, assert that the semantic perception of façades by users is influenced by familiarity with the environment and cultural expectations; thus, local individuals tend to value the emotional and social aspects of the façade, whereas non-local users are more attuned to its functional and physical attributes. Similarly, Alborzi et al. (2022) emphasize the central role of form and façade in shaping the visual identity of commercial complexes in Tehran, asserting that visual coherence and design innovation not only attract users but also contribute significantly to the urban branding of the complex. These findings underscore that the aesthetic dimension of façades, particularly within Iranian urban contexts, plays a fundamental role in fostering a sense of identity and facilitating the social acceptance of buildings. Conversely, international approaches in recent studies of shopping center façades have tended to focus more intensively on elements such as color, materiality, and psychological modeling. For instance, Zhu et al. (2024), within the framework of the Stimulus–Organism–Response (S-O-R) theory, evaluated consumers' emotional responses to different façade color schemes and concluded that neutral and warm colors exert a positive influence on users' aesthetic perceptions; additionally, the brightness level of the façade enhances attractiveness by generating positive emotional responses among users. In another study, İsmailoğlu & Çavdar (2024) demonstrated that users' initial perception of Corten steel façades was negative due to the oxidized appearance of the material; however,

when the sustainability and durability properties of the material—such as resistance to climatic conditions—were clearly explained, users' evaluations shifted towards a more favorable view. The analysis of these two cases suggests that user perception of façade materials and coloration can be significantly shaped by prior knowledge or by promotional narratives and explanatory frameworks regarding their functional attributes. A synthesis of the reviewed literature indicates that domestic studies have predominantly emphasized the semantic, cultural, and identity-related appeal of façades in commercial complexes, highlighting the significant influence of psychological dimensions and user expectations on the evaluation of façades in Iranian contexts (Yousefi & Varmaghani, 2022; Alborzi et al., 2022). In contrast, international studies have devoted greater attention to physical and sustainability-related elements (such as color, material composition, and energy performance) and the measurement of users' psychological responses (Zhu et al., 2024; İsmailoğlu & Çavdar, 2024). Nonetheless, a study that systematically and simultaneously investigates both dimensions within the framework of Iranian shopping centers has yet to be identified in the existing literature. Accordingly, the principal research gap in this domain appears to be the absence of an approach that concurrently examines environmental performance aspects alongside users' aesthetic perceptions and cultural expectations. On this basis, the present article endeavors to address this gap—specifically in the context of commercial façades in Iran and particularly within the metropolis of Tehran—by employing a mixed-method strategy (energy simulation and perceptual analysis) to provide a systematic response to the question of how environmental and visual factors influence users' experiences and preferences.

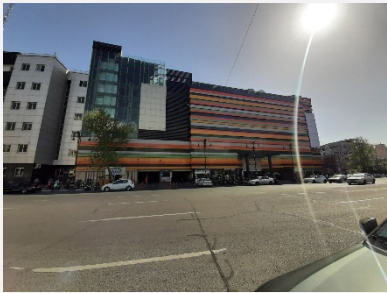
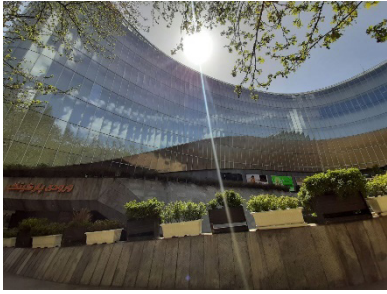


Research Methodology

This study employed a mixed-method approach to provide a multidimensional analysis of large-scale shopping mall façade design in the Tehran metropolis. The research structure was divided into two primary sub-studies, whose findings were then integrated to yield a comprehensive perspective on the convergence of quantitative aspects (thermal performance, materials, and energy simulation) and qualitative dimensions

(perceptual preferences, cultural identity, and aesthetics). In the initial phase, a series of high-resolution images were collected from four selected shopping centers (Andisheh, Palladium, Arg Tajrish, and Atlas Mall) at varying times and angles (Table 1). These buildings were chosen based on criteria such as architectural style diversity, material typology, and their prominent presence in Tehran’s urban landscape. The collected images were analyzed using established image processing algorithms (Sobel for edge detection and SLIC for color segmentation) in OpenCV and scikit-image environments. This process extracted

color patterns, the ratio of transparent to solid materials, as well as indicators of green coverage or repetitive formal elements. For semi-quantitative evaluation of green surfaces, shading, and thermal insulation characteristics, Gaussian filters and quasi-3D modeling were utilized. The resulting data were then imported into Radiance software to estimate indicators such as U-values, annual cooling loads, and daylight quality within interior spaces. These outcomes formed the basis for identifying differing façade strategies among the four case studies. The subsequent phase addressed the subjective and

Table 1. Specifications of the shopping centers examined in the Tehran metropolis. Source: Authors.

Shopping Center	Architectural Description	Façade View
Andisheh Shopping Center	Constructed in 2001 near Palizi Square, adjacent to District 7 Municipality of Tehran, Andisheh Shopping Center encompasses a total built-up area of approximately 13,000 m ² . The ten-story structure comprises four commercial floors and six parking levels.	
Arg Tajrish Commercial Complex	Commissioned in 2013 in northern Tehran on a 10,931 m ² plot, Arg Tajrish spans 76,500 m ² of gross floor area. The building includes five levels of underground parking (accommodating up to 1,000 vehicles) and five commercial levels housing 202 retail units. A key architectural highlight is its 3,800 m ² green roof, integrated as a sustainable design feature.	
Palladium Mall	Developed in 2012 in the Zafaraniyeh district, Palladium quickly gained prominence for its distinctive architectural language. Built on a 10,000 m ² site, it houses 270 retail and service units, along with 25 restaurants and a food court. The structure exhibits vertical variation, ranging from 6 to 13 floors across different sections.	
Atlas Mall	Situated in the upscale Niavaran district, Atlas Mall stands among Tehran’s most luxurious commercial-office complexes. Spanning 11,000 m ² of built area, the 19-story development includes 8 office floors, 4 levels of retail, 1 floor of food court, and 6 levels dedicated to parking.	

cultural aspects not directly visible in simulation outputs. A set of semi-structured interviews was conducted with three key groups: 18 general users (customers and staff), 5 experts in architecture and environmental design, and 4 operational managers of the selected malls. Each interview lasted approximately 30 to 45 minutes and addressed themes such as “aesthetic quality of the façade,” “sense of comfort and sustainability,” “mental imagery and branding,” and “innovation in materials and form.” Simultaneously, field observations—such as users’ interaction with sunlight, duration of spatial occupancy, and inclination to take photographs—provided complementary data for understanding patterns of spatial engagement. To quantitatively assess users’ perspectives, a 15-item questionnaire was developed based on themes extracted from the literature review and the interviews. The questionnaire covered five key constructs: (1) visual quality of the façade, (2) thermal comfort, (3) perception of sustainability, (4) navigability and accessibility, and (5) willingness to revisit. Each construct comprised, on average, three items measured using a five-point Likert scale (from “strongly disagree” to “strongly agree”). For example, under the “visual quality” construct, statements such as “The façade of this shopping center has an attractive combination of color and form” or “This façade evokes a sense of modernity and visual appeal” were included. These items were developed based on established concepts in environmental psychology (emphasizing form, color, and visual diversity), thermal performance studies (user awareness of climatic responsiveness), and cultural dimensions (presence of green elements, urban identity). To ensure the reliability of the questionnaire, a preliminary pilot test was conducted to estimate Cronbach’s alpha for each construct. After minor adjustments, the average Cronbach’s alpha ranged from 0.78 to 0.84, indicating a satisfactory level of instrument reliability. The questionnaire was then distributed among 369 users of the selected shopping centers. Demographic data indicated that 62% of respondents were women, 38% men, and the majority held high school diplomas or undergraduate degrees. Less than 10% of participants reported familiarity with architectural or sustainability concepts; most assessed

façade performance and attractiveness through tangible cues such as color and greenness. In the final phase, simulation outcomes (e.g., U-values, proportion of green coverage, and annual cooling load) were juxtaposed with the average scores of the five perceptual constructs to determine which technical façade attributes manifested as positively perceived qualities among users. One-way ANOVA and Tukey’s post hoc test were applied to analyze differences across the four complexes in terms of perceptual constructs. Additionally, Pearson correlation coefficients and heat map visualizations were used to examine interrelationships among these constructs. This statistical integration emphasized the overlap between “actual environmental indicators” and “user perceptions of sustainability and aesthetics,” while also identifying areas where energy-oriented strategies either went unnoticed by average users or lacked perceptual appeal. Demographic analysis further revealed that the majority of participants (approximately 70%) were between the ages of 20 and 45, and women comprised the dominant share (62%)—a reflection of behavioral realities in Tehran’s retail environments. The low level of specialized familiarity with architectural principles (under 10%) underscored that user perception was shaped more by “visually accessible cues” and emotional-cultural narratives than by technical comprehension. This point is emphasized in the study’s final discussion and opens pathways for future research.

Fidings

• First sub-study

At first observation, Atlas Mall registers the lowest average weighted thermal transmittance coefficient (U-value) among the examined cases, with a value of 1.22 W/m²·K. This indicates the application of advanced insulation systems, integrating multilayer façades, low-emissivity coatings, and vertical greenery. Coupled with a solar absorptance coefficient of 0.59 - markedly more controlled than that of Arg Tajrish (0.81)- this performance suggests a successful synthesis of functional and aesthetic strategies for reducing thermal loads and enhancing internal environmental quality. Accordingly, the annual cooling demand at Atlas Mall stands at 268 MWh, comparatively lower than Arg Tajrish (315 MWh) and even Andisheh (282 MWh). In contrast,

the evaluation of effective shading coefficient and envelope air permeability reveals that Palladium Mall adopts more efficient mechanisms to regulate solar gain and mitigate thermal bridging. Notably, a shading coefficient of 0.34, significantly higher than Andisheh's 0.21, indicates the strategic incorporation of overhangs and curved surfaces that effectively mitigate direct solar radiation during peak hours. In combination with an air infiltration rate of 0.54 $\text{m}^3/\text{h}\cdot\text{m}^2$ —slightly above Passive House thresholds but significantly better than Andisheh's 0.78—Palladium achieves a balanced degree of thermal comfort and energy efficiency. In terms of daylighting quality, Atlas Mall once again outperforms its counterparts, with a Daylight Factor (ADF) of 27.2% and a Useful Daylight Illuminance (UDI) of 65%. This performance is attributed to a thoughtful synergy between reflective glazing and optimally recessed parapets, which together ensure even daylight distribution throughout interior spaces. While Arg Tajrish also registers a respectable ADF of 23.1%, it fails to achieve adequate distribution in mid-level zones, resulting in only 56% of usable space falling within the comfort range of 300–2000 lx (UDI), which could lead to localized glare and increased reliance on artificial lighting in deeper interior zones. Annual thermal comfort and hours of PMV-index dissatisfaction provide further insight into the thermal-psychological interaction of building users. Arg Tajrish records 845 annual hours beyond the acceptable PMV threshold ($|\text{PMV}| > 1$)—the highest among the cases—highlighting challenges in maintaining thermal satisfaction. In contrast, Palladium and Atlas Mall perform more favorably, with 410 and 365 hours, respectively. The disparity between Andisheh and Palladium is particularly significant: although high air infiltration in Andisheh may assist in humidity regulation during certain seasons, the absence of effective shading and weak insulation results in 695 hours annually of thermal discomfort. Finally, analysis of visible light reflectance reveals that Arg Tajrish—with 50% façade reflectivity—poses potential risks of glare for pedestrians and adjacent areas. In contrast, Atlas Mall, with a lower reflectance of 31%, benefits from its vertical green walls and controlled glass surfaces, fostering a more contextually integrated and visually comfortable urban presence (Table 2).

Based on the data presented in Table 2, it can be concluded

that Atlas Mall has adopted the most effective integrated strategy in terms of thermal regulation, daylight penetration, and overall user thermal comfort. The combination of a green wall system, low-U-value glazing, and efficient shading devices has significantly reduced the building's cooling load while simultaneously enhancing indoor environmental quality. Palladium Mall, through its use of stone cladding on lower levels and curved glass façades with well-calibrated shading coefficients, successfully conveys a sense of luxury while maintaining commendable energy performance. Conversely, Andisheh Shopping Center, despite its visually vibrant façade, suffers from weaknesses in air sealing and ineffective shading, leading to elevated cooling demands and a heightened risk of thermal losses during winter months. Arg Tajrish, though architecturally dynamic in form, relies heavily on high-absorptance curved glazing and lacks adequate shading provisions. As a result, it offers fewer hours of thermal comfort and presents issues such as glare and thermal hotspots in its interior spaces.

• Second sub-study

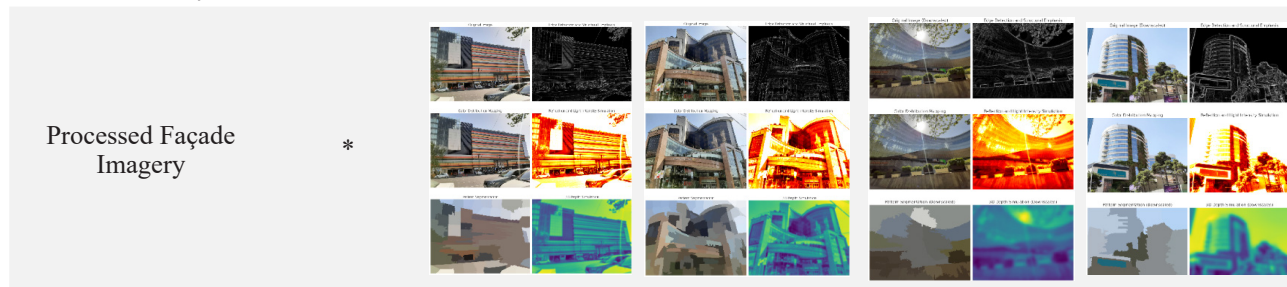
This section draws upon data obtained from 369 questionnaires distributed across four commercial centers—Andisheh, Palladium, Arg Tajrish, and Atlas Mall—to assess five principal perceptual constructs: (A) Visual façade quality, (B) Thermal comfort, (C) Perceived sustainability, (D) Navigability and accessibility, and (E) Willingness to revisit. The core objective is to examine how quantitative findings from the first sub-study (e.g., U-value, cooling load, façade greenery) correlate with ordinary users' subjective perceptions and preferences within the context of urban-commercial architecture. As indicated by the statistical outputs and corresponding correlation diagrams, there is a significant interdependence between aesthetic, thermal, and sustainability perceptions on one hand, and the intent to revisit the space on the other—demonstrating a strong interaction between physical design variables and psychological user responses.

• Perceptual construct correlation: convergence of aesthetics, comfort, and sustainability

The first analytical step involved constructing a correlation matrix across the five constructs (A–E). The output indicates statistically meaningful correlations among A (visual quality), B (thermal comfort), and

Table 2. Summary of energy simulation, daylighting performance, and thermal comfort metrics across the four selected shopping centers. Source: Authors.

Indicator	Unit	Andisheh	Palladium	Arg Tajrish	Atlas Mall
Weighted Average U-Value of Façade	W/m ² ·K	2.48	183	2.90	1.22
Envelope Air Infiltration Rate	m ³ /h·m ²	0.78	0.54	0.66	0.58
Solar Absorptance Coefficient	Dimensionless	0.73	0.66	0.81	0.59
Effective Shading Coefficient	Dimensionless	0.21	0.34	0.17	0.36
Average Daylight Factor (ADF)	%	17.6	25.9	23.1	27.2
Usable Area with Optimal Daylight (UDI)	%	44	63	56	65
Annual Cooling Load	MWh	282	259	315	268
Total Annual Hours of Thermal Comfort	Hours/year	3095	3475	2855	3590
PMV Dissatisfaction Duration	PMV	> 1)**	Hours/year	695	410
Mean Visible Light Reflectance of Façade	%	36	43	50	31



C (perceived sustainability), each with coefficients approaching 0.45. This finding suggests that, in users’ cognitive processes, positive experiences with the façade—including color and form appeal, thermal comfort, and signs of ecological design (such as greenery or modern materials)—are interpreted as a unified perceptual field. In other words, objective sustainability attributes (e.g., thermal insulation performance) and aesthetic aspects (e.g., form-color integration) are not perceived in isolation, but rather reinforce each other within the user’s evaluative framework. Enhancement in one domain may strengthen perceptions in the other. In contrast, construct D (navigability and spatial orientation) exhibits the lowest correlation with the other variables, with coefficients below 0.15. This may imply that, although spatial legibility is important for the overall user experience, it holds a discrete perceptual weight and is not tightly linked to other constructs such as beauty, comfort, or sustainability. Construct E (willingness to revisit) exhibits moderate positive correlations with

A, B, and C, indicating that aesthetic and comfort-related factors positively influence users’ inclination to re-engage with the space, though this influence is not absolute or exclusive (Table 3 & Fig. 1).

• ANOVA Results and Intergroup Variations in User Perceptions

According to the ANOVA output (Table 4 & Fig. 2), the calculated F-values across all five perceptual constructs (A through E) demonstrate statistically significant differences among the four examined shopping centers (p < 0.001). While all constructs exhibit variation, the magnitude of this disparity is most pronounced in Constructs A (Visual Quality), B (Thermal Comfort), and C (Perceived Sustainability). As illustrated in the corresponding box plots, Atlas Mall consistently ranks higher in distribution across most perceptual metrics. This aligns with the findings of the first sub-study, which reported Atlas Mall’s superior façade performance—namely its vertical green wall, reduced cooling load, and lower U-value. Conversely, Andisheh Shopping Center exhibited weaker performance

Table 3. Correlation Matrix Between User Perception Constructs. Source: Authors.

Construct	Visual Façade Quality (A)	Thermal Comfort (B)	Perceived Sustainability (C)	Navigability (D)	Revisit Intention (E)
Visual Façade Quality (A)	1.00	0.45	0.45	0.14	0.39
Thermal Comfort (B)	0.45	1.00	0.45	0.06	0.34
Perceived Sustainability (C)	0.45	0.45	1.00	-0.02	0.45
Navigability (D)	0.14	0.06	-0.02	1.00	0.12
Revisit Intention (E)	0.39	0.34	0.45	0.12	1.00

Correlation Matrix of Constructs



Fig. 1. Correlation analysis among users' perceptual constructs related to façade design. Source: Authors.

Table 4. One-way ANOVA results comparing perceptual constructs across shopping centers. Source: Authors.

Construct	Between-Groups DF	Sum of Squares (Between)	Mean Square	F-Value	P-Value
A: Visual Façade Quality	3	74.91	24.97	111.00	< 0.0001
B: Thermal Comfort	3	55.51	18.50	88.05	< 0.0001
C: Perceived Sustainability	3	80.28	26.76	129.60	< 0.0001
D: Navigability and Wayfinding	3	20.99	6.99	34.10	< 0.0001
E: Willingness to Return	3	44.65	14.88	77.64	< 0.0001

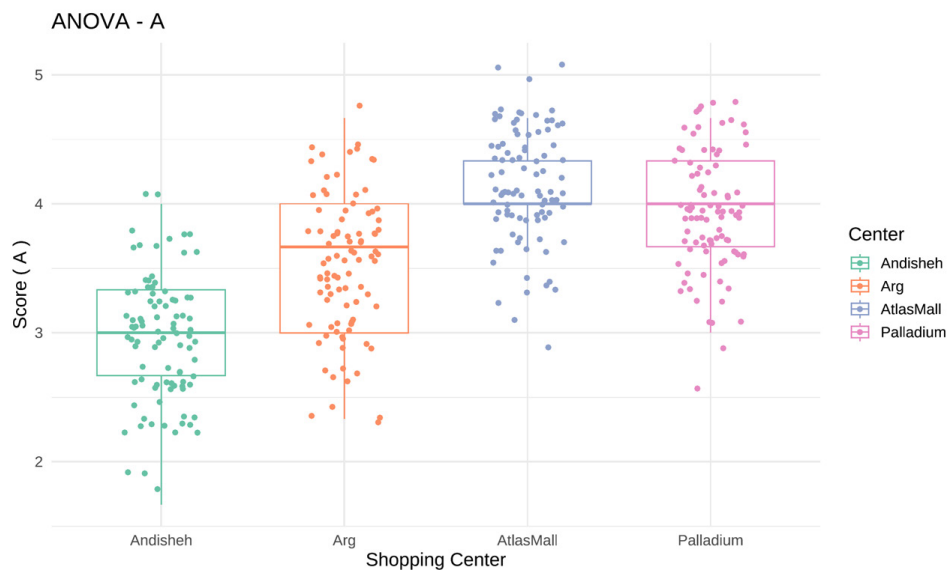


Fig. 2. User Perception Comparison of Façade Visual Quality Across Selected Shopping Centers Source: Authors.

in both aesthetic quality (A) and thermal comfort (B). Field interviews further validated this, revealing that the façade design prioritizes colorful paneling without incorporating sustainability considerations—leading to lower user satisfaction. Interestingly, although Construct D (Navigability) was initially presumed to show minimal variation across buildings, ANOVA results still indicated a statistically significant difference ($p < 0.001$), albeit with a narrower range of variation. For example, Palladium Mall scored higher in terms of internal circulation and clarity of entryways, reflected in elevated mean scores for Construct D. In contrast, Atlas Mall, despite its aesthetic and sustainable strengths, received relatively lower navigability scores, attributed by some users to ambiguous main entrances.

• **Continuation of the second sub-study: Thematic findings from user and expert interviews**

Interview data gathered from users further emphasize that mere visual appeal in façade design does not necessarily translate into a cohesive or satisfying spatial experience. For instance, while the Andisheh Shopping Center façade, with its contrasting colors, injects a sense of vitality and energy—particularly resonating with younger visitors—it is perceived by older customers as unrefined and impermanent, lacking architectural maturity. In Palladium, the stone–glass combination, although evoking a sense of luxury and durability, is perceived by some users as aesthetically cold due to the limited presence of natural elements. Additionally, the glare caused by reflective glass surfaces during peak daylight hours has been a source of discomfort in exterior zones. Users of Arg Tajrish acknowledged the presence of potted greenery at ground level but criticized the lack of vertical continuity, which disrupts a comprehensive sense of connection to nature. In contrast, Atlas Mall, through its integrated green wall, successfully fosters a positive association with calmness and sustainability within the bustling urban context. Many shoppers even reported a reduction in urban stress. However, ambiguity in the main entrance design was noted as a source of spatial confusion. Insights from architects and shopping center managers further reinforced the tension between aesthetic ambitions and functional performance. From a design perspective, although the Andisheh façade is effective in visually attracting trend-conscious customers,

it exhibits notable deficiencies in sustainable design principles. In the case of Palladium, while the balance between stone and glass materials is commendable, it lacks dynamic shading elements, which could have significantly improved solar control. Arg Tajrish, lauded for its elegant curved façade, is simultaneously burdened by high implementation costs and the overuse of glass, leading to financial strain and increased energy expenses, which have raised concerns among stakeholders. Conversely, architectural professionals have praised Atlas Mall for its innovative integration of a green wall, viewing it as a symbol of forward-thinking sustainable design. Yet, the technical complexity and maintenance demands of such a system are seen as potential barriers to its wider adoption. From an economic perspective, the design strategies employed—such as the use of iconic green elements at Atlas Mall and distinctive façades at Palladium—have largely succeeded in creating commercial differentiation. Nonetheless, questions remain regarding their long-term sustainability and future operational costs (Table 5 & Fig. 3).

• **Conceptual integration of quantitative and qualitative dimensions in the analysis of commercial façade design**

The significance of the present study lies in its attempt to construct a robust conceptual bridge between quantitative metrics—such as energy indicators, thermal regulation, and daylight efficiency—and qualitative dimensions, encompassing visual perception, psychological satisfaction, and spatial experience. At first glance, these domains may appear to be at odds, as sustainability criteria are typically grounded in technical and engineering disciplines, whereas user perception and preference fall within the scope of environmental psychology and urban sociology. However, the lived experience of users within commercial urban architecture—where economic imperatives, environmental responsibilities, and aesthetic paradigms intersect—clearly illustrates that these realms are not only interrelated, but also mutually reinforcing in shaping architectural identity and spatial branding. From a theoretical standpoint, environmental psychology posits that humans assess space—either consciously or subconsciously—through sensory reception (light, color, texture, temperature, etc.) and symbolic architectural cues. Consequently, materials, form, and sustainable technologies, while technically

Table 5. Key themes extracted from user and expert interviews. Source: Aothurs.

Interview Group	Shopping Center	Core Theme	Detailed Description
End Users / Visitors	Andisheh	Visual Disarray in Color Composition	The use of contrasting horizontal color panels in the façade has created a sense of visual fragmentation; some users felt the design lacks the permanence of a commercial facility.
		Youthful Vitality	The cheerful and colorful design appeals to younger audiences and encourages social interaction, yet older visitors described the aesthetic as unprofessional and ephemeral.
	Palladium	Luxurious Appeal and Sense of Permanence	Users reported a strong perception of luxury and authenticity due to the stone–glass façade composition. However, the absence of natural elements was associated with visual coldness.
		Glare Issues from Reflective Surfaces	Reflections from glazed façades at midday have led to discomfort among users and reduced the duration of outdoor occupancy.
	Arg Tajrish	Incomplete Connection to Nature	While ground-level planters were well-received, the absence of greenery in upper levels undermined the overall biophilic continuity of the design.
	Atlas Mall	Positive Impact of Green Wall Ambiguity in Entrance Identification	The vertical green wall has drawn positive attention, evoking tranquility and mitigating urban stress among users in the densely populated metropolitan setting. Extensive use of glazing and lack of clear visual cues have caused confusion in locating the primary building entrance.
Architects / Design Experts	Andisheh	Environmental Sustainability Deficits	The design emphasizes visual stimulation over sustainable strategies, with inadequate consideration for thermal performance or energy efficiency.
	Palladium	Material Balance but Lacking Dynamic Shading	While the stone–glass balance is well executed, the façade lacks integration of dynamic shading systems that could enhance solar control.
	Arg Tajrish	Curved Design and Cost Implications	Although the curved façade is aesthetically compelling, its execution has led to high implementation and maintenance costs, challenging economic efficiency.
	Atlas Mall	Green Wall as a Sustainable Innovation	The integration of a green wall is recognized as a significant architectural innovation, demonstrating leadership in sustainable design practices.
		Maintenance Challenges of Green Systems	Architects highlighted the system’s dependency on continuous maintenance and specialized technology, which could hinder replication in similar developments.
Managers / Operators	Andisheh	Economic Performance of Façade	The colorful façade has enhanced footfall and improved commercial performance, though investors expressed concerns over material longevity and potential maintenance demands.
	Palladium	Enhancement of Luxury Branding	The façade has successfully reinforced the mall’s luxury brand identity, attracting an affluent customer demographic.
	Arg Tajrish	High Cooling Energy Costs	The excessive use of glass has significantly increased cooling loads, drawing criticism from investors concerned with long-term operational costs.
	Atlas Mall	Economic Advantage of Green Wall	The green wall has contributed to reduced energy consumption and served as a distinctive commercial differentiator within the competitive retail market.

aimed at enhancing thermal performance or reducing energy consumption, can—when effectively articulated in the façade—evoke sensations of naturalness, coolness, freshness, or even innovation. These sustainability signals are often perceived visually or climatically, manifesting in features such as green walls, modular shading systems, or solar-controlling glazing. Thus, the quantitative layer of sustainability—initially focused on energy optimization—also shapes psychological perception and public

engagement. Even in the absence of interior access, the visibility of green elements or the gentle reflection of daylight can elicit a positive association or emotional alignment with the building. On the other hand, environmental aesthetics demonstrates that visual quality, beyond its momentary appeal, significantly influences the social and commercial impact of architectural space. A façade may succeed in energy performance yet fail to engage users if perceived as merely a “dry, uninspiring shell.” In commercial contexts,

are consistent with theoretical models that stress cultural coherence and localized adaptation of green technologies (Guy & Farmer, 2001), arguing that a façade's visual identity must also resonate semiotically with the values of its local audience. According to contemporary discourse, three principal layers are essential in façade analysis: technical-performance, aesthetic-perceptual, and socio-cultural (Nady, 2017; Kim & Patel, 2018). The present study confirms that when all three dimensions are simultaneously integrated into the design and evaluation process, the probability of achieving a façade that is both functionally efficient, culturally resonant, and visually compelling is substantially increased. In essence, the findings align with research that positions the integration of quantitative (energy and solar simulations) and qualitative (user perception of form, color, and utility) as the only viable pathway toward comprehensive façade success (Khatibi et al., 2022). This synthesis not only addresses public demands for comfort and visual quality but also supports broader urban objectives related to energy reduction and sustainable branding. Practically, the findings offer clear directives to architectural professionals and commercial developers: elements such as material selection, color palette, solar control strategies, and green façades can simultaneously reduce energy costs and shape user perceptions of spatial and cultural value. This is particularly relevant for megamall managers in Tehran, who operate in a highly competitive environment and must attract diverse user groups. A hybrid façade strategy, therefore, enables the dual goal of increasing commercial profitability and advancing urban sustainability agendas. Despite being based on an extensive dataset and a robust mixed-method approach, the study's generalizability to other metropolitan or cultural contexts must be approached with caution. Varying climatic conditions, cultural aesthetics, and contextual meanings of sustainability may alter how features like color, form, or environmental performance are perceived (Muraj et al., 2023). What is interpreted in Tehran as a "positive ecological signal" may, in another city, be read as costly or culturally incongruent, depending on economic, political, or cultural conditions. Therefore, future research should pursue comparative and localized investigations across other Iranian cities—or international contexts—to enable architects and planners to calibrate their strategies to regional dynamics. In light of

current findings, it is also recommended that subsequent studies adopt a longitudinal perspective, examining façade sustainability across the building lifecycle, as perceptual appeal and thermal performance may evolve with material degradation or urban change (Convertino et al., 2022). Moreover, expanding analytical tools—such as structural equation modeling (SEM)—could clarify the causal relationships between environmental performance and user behavior. Finally, the implementation of participatory and stakeholder-informed design approaches, beginning in the early stages of planning, may enhance the success of future projects by aligning architectural interventions more closely with local needs and cultural frameworks.

Conclusion

The findings of this study reveal that the design of commercial façades in the Tehran metropolis constitutes a multilayered phenomenon, shaped simultaneously by technical-performance criteria (including thermal metrics, shading devices, and sustainable materials) and perceptual-cultural dimensions (urban identity, users' aesthetic preferences, and alignment with historical context). On one hand, energy simulations and quantitative data confirm that the adoption of sustainable strategies—such as vertical greenery, low-emissivity glazing, or double-skin façades—can significantly reduce cooling loads and energy consumption. On the other hand, interviews and perceptual assessments demonstrate that such performance translates into successful urban architecture only when it also resonates psychologically and culturally with user expectations and societal values. In other words, the façade system of a megamall or multipurpose complex achieves coherence only when its technical components are translated into visually and cognitively intelligible elements for everyday users—thus reinforcing the local identity of the building through its physical form. This convergence not only enhances the social capital of the architecture but also enables the genuine realization of urban-scale environmental sustainability. Nevertheless, the generalizability of these findings to other cities or cultural climates requires cautious interpretation, as user perception is highly influenced by the social and lifestyle context of each locale. Future research is encouraged to adopt longitudinal approaches, utilizing advanced analytical

tools to evaluate how façades evolve—both physically and perceptually—over time. Additionally, by employing structural equation modeling (SEM), future studies could further elucidate the causal relationships between façade characteristics and user behaviors, such as increased spatial engagement or brand loyalty. Ultimately, the integration of energy modeling and perceptual-cultural insight offers a more holistic foundation for strategic decision-making in the design of commercial façades within the Iranian urban context (Fig. 4).

Declaration of No Conflict of Interest

The authors declare that they have no conflict of interest in conducting this research.

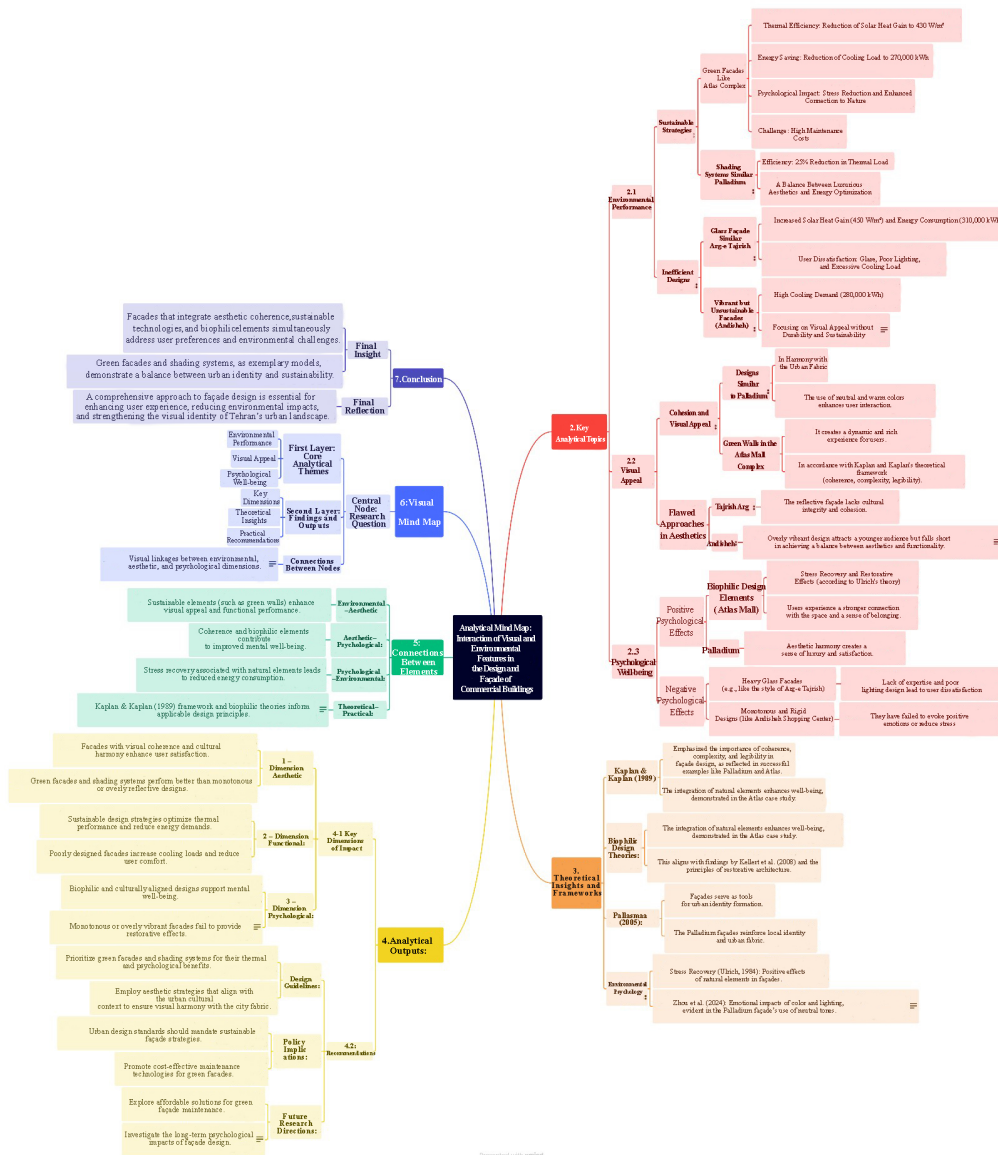


Fig. 4. Analytical framework for investigating the interaction between environmental performance, aesthetic coherence, and psychological well-being in commercial façade design. Source: Aoothurs.

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