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Parametric Design Approaches as Interfaces for Semi-Open Public Spaces in Historic Environments: The Metropol Parasol Case

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ABSTRACT
Historic environments require contemporary interventions to negotiate new spatial demands without treating heritage, public use, climatic affordances, and structural logic as separate concerns. This study examines parametric design as an architectural interface in a historically layered semi-open public space. Interface denotes the built relational system through which rule-based geometry negotiates historic and archaeological constraints, public-space organization, environmental affordances, and structural-geometric requirements. A qualitative critical single-case analysis of Metropol Parasol in Seville applies a literature-informed 12-criterion framework to published drawings, sections, photographs, project and engineering documentation, and academic sources. The project is not reconstructed through parametric modelling; no simulation, measurement, user survey, behavioural observation, accessibility audit, or comparative canopy test is conducted. Evidence is coded as supported, qualified, not supported, or not established and synthesized across spatial mediation, environmental responsiveness, and structural-geometric logic. The analysis supports relationships among variable grid geometry, support placement, ground-level permeability, programmatic layering, shading affordance, modular coordination, and documented constructability. Contextual continuity, access provision, daylight mediation, ventilation affordance, and structural organization remain qualified, while thermal-comfort outcomes are not established. The study contributes an interface-centred analytical lens that integrates domains usually treated separately in HBIM, performance-led parametric research, and historic public-space studies. Its transferability is methodological and conditional rather than predictive; the findings do not verify social vitality, universal accessibility, environmental performance, visual acceptance, or conservation outcomes.

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1. Introduction

Historic urban environments comprise layered physical, cultural, and temporal systems rather than static artefacts (Wang et al., 2024; Fernández-Baca Casares et al., 2017). Contemporary interventions must therefore accommodate new uses while addressing conservation obligations, tourism pressures, and the legibility of inherited fabric (García-Hernández et al., 2017; Penjor et al., 2024). Public space is central to these negotiations because continuity, access, and perception shape how historic settings are used and interpreted (Banerjee, 2001; Carmona, 2021; Birer & Çalışır Adem, 2022).

Semi-open plazas, canopies, and transitional zones can operate as interfaces between enclosure and exposure, movement and pause, and historic continuity and contemporary use. Research on public-space perception and vitality shows that claims about social interaction require behavioural, survey, or multi-source evidence (Speranza, 2016; Birer & Çalışır Adem, 2022; Long et al., 2025). Likewise, shading geometry can create a climatic affordance, but credible claims about outdoor thermal comfort require field measurements, simulation, thermal indices, or user responses rather than visual geometry alone (Taleghani, 2018; Palomo Amores et al., 2023; Mandić et al., 2024).

In this study, parametric design, architectural interface, heritage mediation, and semi-open public space are connected as a single conceptual chain rather than treated as separate themes. Parametric design denotes the rule-based organizational logic embedded in the realized intervention; it does not denote a modelling procedure carried out by the researchers (Woodbury, 2010; Caetano et al., 2020). The architectural interface is the built relational manifestation of that logic across spatial, environmental, and structural-geometric conditions. Heritage mediation refers to how this interface negotiates archaeological constraints, inherited urban character, and contemporary requirements, including points of contestation rather than presumed harmony (García-Esparza, 2022; Kurnaz & Anıktar, 2024). The semi-open public space is the setting in which mediation becomes observable through circulation and visual continuity, canopy porosity and shading affordances, support placement, programmatic layering, and geometric adaptation.

Existing scholarship addresses individual parts of this conceptual chain, but not their integration. HBIM and parametric-heritage studies primarily reconstruct, document, semantically enrich, diagnose, or manage historic fabric (Banfi, 2016; Simeone et al., 2019; Moyano et al., 2022; Croce et al., 2022; Liu et al., 2023; Penjor et al., 2024; Cui & Wu, 2025; Banfi & Liu, 2026). Performance-led parametric studies model and optimize defined shading, daylight, thermal, or energy objectives (Chi et al., 2021; Zhang et al., 2021; Palomo Amores et al., 2023; Şenalp et al., 2025). Historic public-space and contemporary-intervention research examines perception, accessibility, continuity, and vitality, generally through spatial, survey, or multi-source evidence, without making the rule-based structural geometry of a realized addition the principal unit of analysis (Birer & Çalışır Adem, 2022; García-Esparza, 2022; Kurnaz & Anıktar, 2024; Long et al., 2025; del Bosque et al., 2025). The specific gap is therefore the lack of an integrated, evidence-bounded framework for examining how a realized parametric semi-open intervention relates simultaneously to heritage constraints, public-space continuity, environmental affordances, and structural-geometric organization. Table 1 makes this distinction explicit.

Table 1. Position of the proposed framework relative to adjacent research streams.

Research stream	Typical unit and method	Established contribution	Boundary addressed here
HBIM and parametric heritage	Historic asset; scan-to-BIM, semantic modelling, diagnosis, or management	Detailed digital representation and conservation information	Rarely treats a contemporary semi-open addition as a cross-domain relational interface
Performance-led parametric design	Proposed system; modelling, simulation, and optimization	Tests defined environmental or structural objectives	Cannot be inferred for a realized case without the corresponding model and performance data
Historic public space and contemporary intervention	Urban setting; spatial, perceptual, accessibility, survey, or multi-source analysis	Assesses continuity, compatibility, access, use, and vitality	Rarely connects these findings to the rule-based structural geometry of the addition
Present study	Realized intervention; traceable qualitative evidence and rival interpretations	Integrates spatial, environmental-affordance, and structural-geometric relations	Records support, qualification, contestation, and non-establishment without claiming performance validation

On this basis, the study asks four analytical research questions:

RQ1. How is parametric design logic manifested as an architectural interface through the spatial, environmental, and structural-geometric organization of the realized intervention?

RQ2. Through which observable interface mechanisms does the intervention negotiate between archaeological and historic constraints and contemporary semi-open public-space requirements?

RQ3. What convergences, tensions, and trade-offs emerge among spatial mediation, environmental responsiveness, and structural-geometric logic?

RQ4. How do visual prominence, contextual compatibility, and the limits of the available evidence qualify the interpretation of the project as a heritage mediator?

The questions are examined through four qualitative analytical propositions. Here, testability means that each proposition can be supported, qualified, not supported, or not established through traceable evidence in plans, sections, photographs, project and engineering documentation, and academic sources; it does not imply statistical hypothesis testing.

P1 – Interface manifestation. If the realized parametric logic functions as an architectural interface, recurring geometric rules and variations should correspond to observable relationships among circulation routes, canopy openings, support locations, and programmatic layers rather than being identifiable only as formal complexity.

P2 – Heritage mediation. If the interface mediates heritage and contemporary use, drawings and site documentation should reveal how support placement, ground contact, circulation, and vertical layering respond to archaeological constraints while maintaining or contesting public-space continuity.

P3 – Cross-domain trade-offs. If mediation is genuinely multi-domain, the evidence should reveal both alignments and trade-offs among spatial permeability, shading and daylight affordances, structural-geometric requirements, and contextual continuity. Because no simulation, measurement, or user survey is conducted, this proposition cannot be used to verify thermal comfort, airflow, or social-performance outcomes.

P4 - Contextual compatibility and contestation. If the interface operates as a heritage mediator, the evidence should reveal not only accommodation of archaeological layers but also whether scale, silhouette, material expression, and visual prominence sustain or contest the inherited urban character. Divergent evidence qualifies mediation rather than being suppressed.

Seville provides an information-rich setting in which morphological, climatic, cultural, and archaeological layers intersect. At Plaza de la Encarnación, the Metropol Parasol combines a large timber grid-shell canopy with a market, archaeological museum, elevated plaza, and public walkway. Project and engineering documentation confirms the digitally coordinated variable grid, modular laminated-veneer-lumber system, and multi-level program (Mayer, 2012; Koppitz et al., 2011). These intersecting conditions make the project a critical case for examining mediation mechanisms and tensions; they do not make it representative of all historic environments or validate its environmental, social, or conservation performance.

Accordingly, the study makes a bounded conceptual and methodological contribution. Conceptually, it defines a parametric architectural interface as the relational organization through which a contemporary semi-open structure negotiates connections and tensions among historic fabric, public circulation, climate-related affordances, and structural-geometric logic. Methodologically, it synthesizes these relations into three linked domains—spatial mediation, environmental responsiveness, and structural-geometric logic—and operationalizes them through a criterion-based matrix for the qualitative analysis of a realized case using drawings, sections, visual documentation, and published sources. In contrast to object-centred HBIM reconstruction and simulation-led performance optimization, the framework is intended to identify cross-domain relations and trade-offs within a built intervention. Its application to Metropol Parasol constitutes an exploratory demonstration of this analytical lens rather than empirical validation of environmental or social performance or a universally transferable model.

2. Methodology

2.1 Research Design and Approach

This study adopts a theory-guided qualitative critical single-case design. A case study is appropriate where spatial, technical, and contextual relations must be interpreted within their real-world setting, while analytical generalization is directed to propositions rather than to a population (Yin, 2018). The design is exploratory: it demonstrates how the proposed framework can organize traceable evidence, not whether the framework is statistically valid or universally transferable.

Metropol Parasol was selected purposively as an information-rich and theoretically critical case in which a documented parametric design process, archaeological constraints, a semi-open public-space program, and an engineered timber mega-structure coincide (Mayer, 2012; Koppitz et al., 2011). Its iconic scale and singular procurement and engineering history also restrict direct transferability. The case is therefore used to examine the explanatory adequacy and limits of the interface concept, not to establish a typical effect of parametric design.

The study treats parametric design as embedded organizational logic rather than a modelling procedure performed by the researchers. The evidence corpus consists of published plans and sections, photographic documentation, project and engineering descriptions, and peer-reviewed academic sources. Each proposition is mapped to criterion-specific observable indicators, and every finding is recorded with its documentary basis and inferential boundary. Figure 1 summarizes the workflow from literature positioning and case selection to criterion coding, proposition-level synthesis, and limitation reporting.

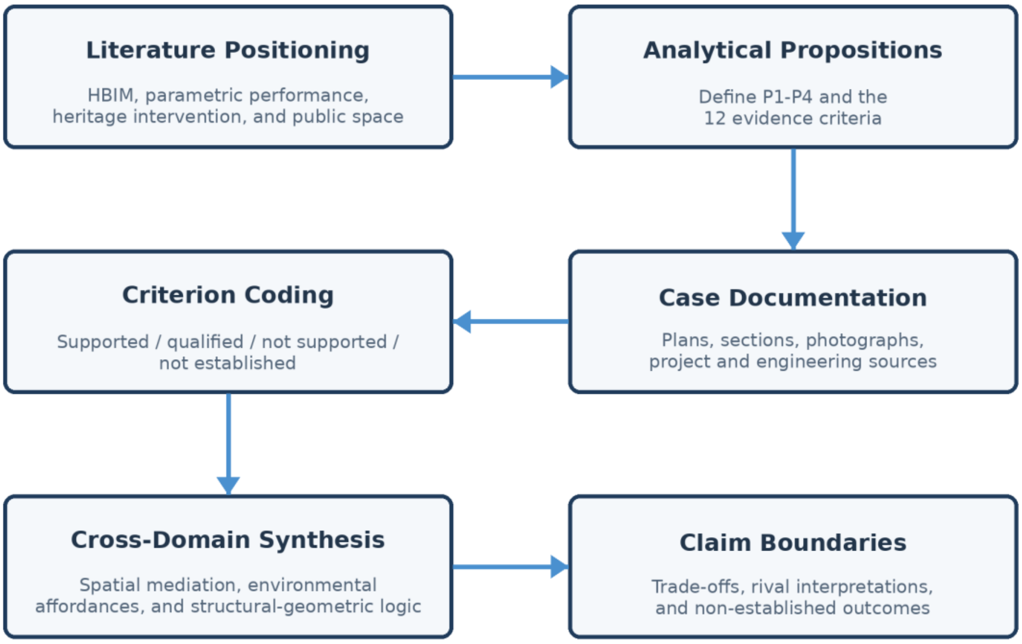


Figure 1. Overall research methodology and qualitative analytical workflow adopted in this study.

Methodological rigor is pursued through a predefined 12-criterion rubric, an explicit audit trail linking interpretations to source types, retention of conflicting or negative evidence, and separation of observable configuration from outcomes requiring direct measurement (Yin, 2018). Source convergence can strengthen a documentary interpretation, but it is not equivalent to independent replication. Because the framework was not applied by a second independent evaluator, inter-rater reliability was not calculated and is not claimed. The present application should therefore be read as an exploratory framework demonstration requiring later comparative and inter-rater validation.

2.2. Conceptual Basis: Parametric Design as Embedded Logic

Parametric design organizes form through explicit dependencies among variables, rules, and constraints rather than through isolated fixed geometry (Woodbury, 2010; Oxman, 2006; Caetano et al., 2020). In heritage research, related parametric and HBIM workflows commonly focus on capturing irregular existing geometry, enriching semantic representation, supporting diagnosis, or coordinating restoration information (Banfi, 2016; Simeone et al., 2019; Liberotti & Gusella, 2023; Alshawabkeh, 2024). These applications establish the value of relational digital models but do not by themselves explain how a realized contemporary addition mediates among public-space, climatic-affordance, structural, and heritage concerns.

This subsection establishes the theoretical construct used in the analysis; it is not a report of a modelling workflow undertaken in this study. The built Metropol Parasol is read through published evidence of its rule-based geometric coordination and fabrication process (Mayer, 2012; Koppitz et al., 2011). Figure 2 models mediation as a sequence: historic and archaeological constraints and contemporary public-space requirements are registered by the interface; geometric differentiation, support placement, vertical programmatic layering, canopy porosity, and modular coordination provide observable mechanisms; and their convergences, tensions, and trade-offs are interpreted across three linked domains.

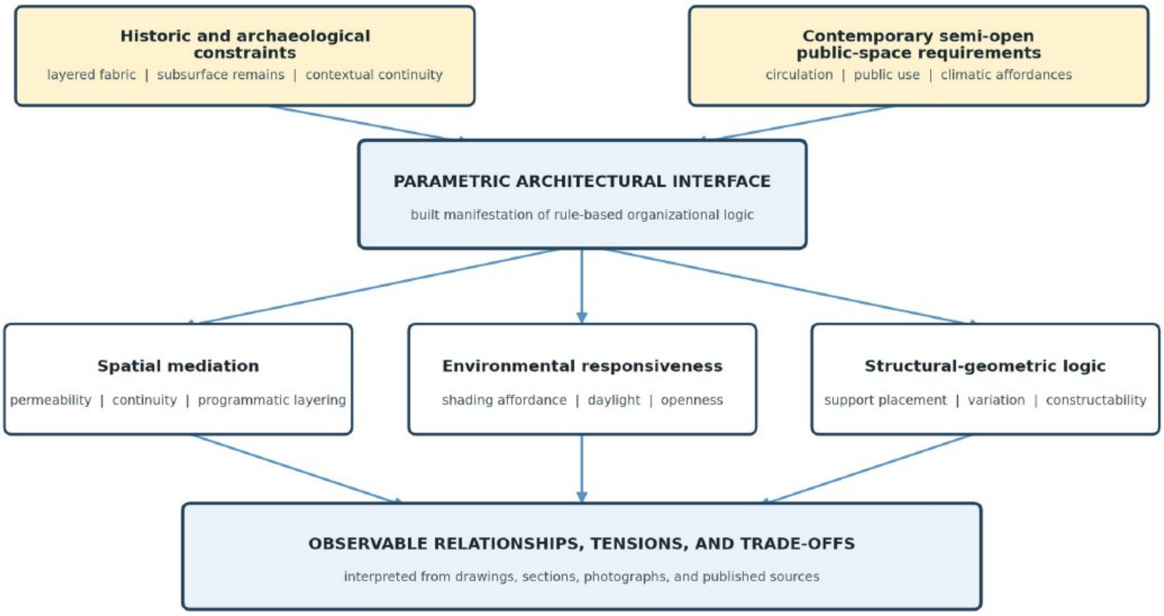


Figure 2. Conceptual framework linking parametric design logic, architectural interface, heritage mediation, and semi-open public-space analysis (developed by the authors).

Within this model, mediation is neither a causal variable nor an assumed benefit. It is an interpretive relationship supported only when documented geometric decisions correspond to criterion-specific spatial, environmental-affordance, or structural conditions. Conflicting evidence qualifies the relationship, while outcomes that require simulation, measurement, user data, or technical testing remain not established.

2.2.1. Spatial Mediation and Archaeological Sensitivity

Spatial mediation concerns observable relationships among ground contact, circulation routes, visual permeability, vertical programmatic layers, and the archaeological substrate. Heritage and HBIM studies show how geometric and information models can register irregular fabric and support conservation and retrofit decision-making (Moyano et al., 2022; Croce et al., 2022; De Falco et al., 2024; Shehata et al., 2024; Penjor et al., 2024), while public-space research demonstrates that continuity and perceived compatibility must be evaluated rather than presumed (Birer & Çalışır Adem, 2022; Kurnaz & Anıktar, 2024).

Plans, sections, and photographs can document open routes, support locations, visual connections, and programmatic layering. They cannot establish actual movement frequencies, social vitality, or universal accessibility. Those outcomes require behavioural observation, user evidence, space-syntax or multi-source analysis, and a dedicated accessibility audit (Speranza, 2016; Zencirkiran & Suta, 2025; Long et al., 2025; del Bosque et al., 2025).

2.2.2. Environmental Responsiveness and Affordances

Performance-led parametric research couples geometry with environmental models, objective functions, and verification procedures to test shading, daylight, ventilation, or thermal-comfort outcomes (Chi et al., 2021; Zhang et al., 2021; Palomo Amores et al., 2023; Şenalp et al., 2025). Reviews of outdoor thermal comfort likewise show that thermal claims normally depend on meteorological measurements, simulation, thermal indices such as PET or UTCI, and/or user responses (Taleghani, 2018; Mandić et al., 2024).

The present study does not reproduce that performance workflow. It can identify canopy coverage, apertures, porosity, openness, and their potential relation to solar interception, daylight access, and air movement. These are environmental affordances, not verified levels of radiation reduction, illuminance, airflow, or thermal comfort. The environmental domain is therefore coded with explicit outcome exclusions.

2.2.3. Structural–Geometric Logic

Structural-geometric logic concerns the documented coordination of free-form geometry, support positions, repeated components, joints, and fabrication constraints. Computational design and digital fabrication research demonstrates how relational geometry can coordinate complex timber systems, while gridshell studies show that structural claims depend on system-specific analysis and construction evidence (Menges et al., 2021; Schling et al., 2023). Direct documentation of Metropol Parasol describes a digitally developed, modular laminated-veneer-lumber plate system integrated with steel and concrete components (Koppitz et al., 2011; Mayer, 2012).

Accordingly, drawings and engineering descriptions can support interpretations of geometric adaptability, modular coordination, and documented constructability. They do not establish comparative structural efficiency, material optimality, reversibility, durability, or superiority over an alternative canopy without calculations, testing, life-cycle evidence, and a defined benchmark.

3. Case Study

The case study situates the interface framework within a documented built setting. Metropol Parasol, designed by Jürgen Mayer H. and completed in 2011 at Plaza de la Encarnación, combines a large timber grid-shell, market, elevated plaza and walkway, and the Antiquarium above and around archaeologically sensitive remains. This conjunction of a digitally coordinated structure, protected subsurface fabric, and layered public program makes it analytically relevant, while its singular scale prevents treatment as a representative case (Mayer, 2012; Koppitz et al., 2011; Fernández-Baca Casares et al., 2017).

3.1. General description of the site

The site is situated within a dense and historically layered urban fabric where archaeological remains, urban circulation, tourism, and contemporary public use intersect (Fernández-Baca Casares et al., 2017; García-Hernández et al., 2017). Figure 3 and Table 2 locate the project and summarize its documented urban, visual, and sectional context. Excavations preceding the intervention revealed Roman remains and later historical layers, transforming the square into a constrained archaeological setting. The analysis therefore examines how foundation and support placement, vertical organization, and public-space continuity respond to this condition without assuming that physical accommodation alone establishes conservation success or contextual compatibility.

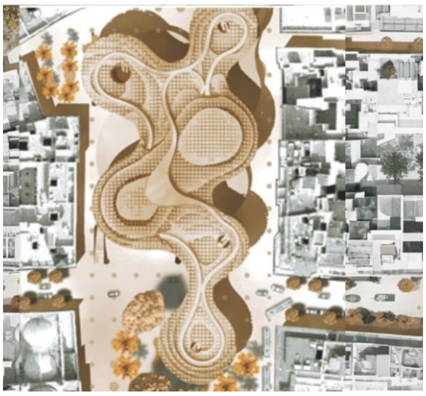
Figure 3. Location of Seville and aerial view of Metropol Parasol (sources: Wikipedia, Province of Seville; Iconeye, Metropol Parasol by Jürgen Mayer H.).

Structurally, the project is a hybrid timber, steel, and concrete system whose most visible component is a variable laminated-veneer-lumber plate grid. Project and engineering documentation records the digital coordination of component geometry, joints, prefabrication, and assembly (Koppitz et al., 2011; Mayer, 2012). This evidence supports analysis of geometric organization and constructability, but no independent structural calculation or comparison is performed here.

The intervention extends approximately 150 m in length and reaches about 28 m in height, producing an open yet visually prominent urban element (Koppitz et al., 2011). Its vertically layered program includes the Antiquarium, market and commercial areas, an elevated plaza, and a public walkway. The documented coexistence of these functions supports analysis of programmatic layering; it does not by itself demonstrate social vitality, inclusive access, or public acceptance (Carmona, 2021; Long et al., 2025).

As a hybrid canopy, circulation system, and public-space structure, Metropol Parasol visibly provides extensive overhead cover, an open perimeter, and patterned apertures. These characteristics justify assessing shading, daylight, and ventilation affordances. Actual reductions in radiant temperature, changes in airflow, or improvements in thermal comfort are outside the evidence available to this study and therefore are not asserted (Palomo Amores et al., 2023; Mandić et al., 2024).

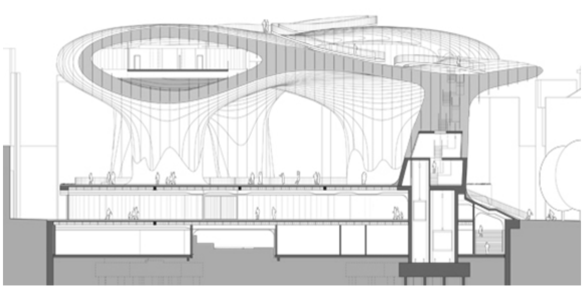
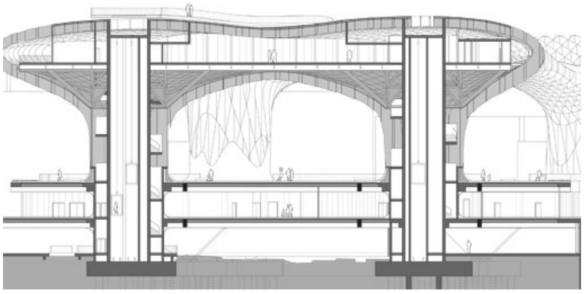
Table 2. Urban context of Seville and site configuration of Metropol Parasol.

Aerial Map 37°23'35.85"N 5°59'30.32"W	**Site Plan** Pl. de la Encarnación, Casco Antiguo, 41003 Sevilla, Spain
	

Visuals



Sections

Source: *Developed by the authors based on Google Earth (2026) and J. Mayer H. Architects; photographs © Fernando Alda.*

3.2. Case selection criteria

The selection criteria translate the three conceptual domains in Sections 2.2.1-2.2.3 and the four propositions into case-specific conditions. Metropol Parasol was selected because it combines: (1) archaeological and urban complexity, (2) a semi-open public interface with vertically layered programs, (3) a documented parametric and digital-fabrication origin, and (4) sufficient drawings, photographs, and project and engineering accounts to support a traceable documentary analysis. Selection was purposive rather than comparative, and no claim is made that the case represents all parametric heritage interventions.

- **Archaeological and urban complexity.** The site contains layered subsurface remains within a dense historic centre, creating visible constraints on ground contact, support placement, and spatial organization (Fernández-Baca Casares et al., 2017).
- **Public interface and programmatic layering.** The project combines a market, archaeological museum, elevated plaza, walkway, and semi-open ground-level space, allowing spatial relations to be examined without presuming observed social outcomes (Mayer, 2012).
- **Documented parametric and fabrication logic.** Direct project and engineering accounts describe variable digital geometry, modular LVL plates, joints, and coordinated fabrication, enabling analysis of embedded rule-based organization (Koppitz et al., 2011).

- **Evidence availability and critical tension.** The case offers multiple source types and an evident tension between archaeological accommodation and visual prominence, making it suitable for testing both supportive and rival interpretations rather than confirming an assumed benefit.

4. Analytical Framework

The architectural interface is operationalized as a relational unit of analysis rather than treated as a stand-alone object or a proxy for successful performance. The framework traces how documented geometry and organization correspond to spatial mediation, environmental affordances, and structural-geometric logic under heritage constraints. Its distinction from HBIM documentation, single-objective performance optimization, and conventional public-space evaluation lies in reading these domains together while retaining evidentiary limits (Chi et al., 2021; Penjor et al., 2024; Banfi & Liu, 2026).

The 12 criteria in Table 3 are derived from recurring concerns across the three adjacent research streams. Spatial criteria address ground-level permeability, contextual continuity, documented access provision, and programmatic layering (Carmona, 2021; Birer & Çalışır Adem, 2022; del Bosque et al., 2025). Environmental criteria distinguish observable shading, daylight, and ventilation affordances from thermal-comfort outcomes that require direct performance evidence (Taleghani, 2018; Mandić et al., 2024). Structural-geometric criteria address variable geometry, system organization, modular coordination, and documented constructability without equating them with optimized efficiency (Menges et al., 2021; Schling et al., 2023).

Four evidence statuses replace the previous Low-Medium-High ratings: supported, when a criterion-specific relationship is directly documented and corroborated by at least two source types; qualified, when evidence is partial, mixed, or dependent on interpretation; not supported, when available evidence directly contradicts the proposition; and not established, when the required evidence lies outside the dataset. These are evidentiary judgments, not performance scores. Table 3 is referenced throughout the criterion-level analysis.

Table 3. Operational criteria, observable indicators, and excluded inferences

Domain	Criterion	Observable documentary indicator	Inference explicitly excluded
Spatial mediation	Ground-level permeability	Continuity of open routes and sightlines around supports in plans, sections, and photographs	Observed pedestrian flow, frequency, or social use
Spatial mediation	Contextual continuity	Relationships of scale, silhouette, edges, views, and circulation to surrounding historic fabric	Public acceptance, visual preference, or heritage compatibility as a settled outcome
Spatial mediation	Documented access provision	Mapped stairs, ramps, lifts, entrances, and vertical connections where documented	Universal accessibility or ease of use without a formal audit
Spatial mediation	Programmatic layering	Vertical and horizontal connection of market, museum, plaza, walkway, and commercial uses	Social vitality, inclusion, or interaction intensity
Environmental responsiveness	Solar-shading affordance	Canopy extent and position above occupiable public areas	Radiation reduction, surface-temperature change, or comfort improvement
Environmental responsiveness	Daylight-mediation affordance	Apertures, porosity, and visible balance between cover and sky exposure	Illuminance, glare, daylight autonomy, or visual comfort
Environmental responsiveness	Ventilation affordance	Open perimeter, voids, and lack of full enclosure	Air speed, airflow improvement, or pollutant dispersion
Environmental responsiveness	Thermal-comfort evidence	Measured meteorology, PET/UTCI, simulation, or user thermal responses	Thermal comfort inferred from shade or openness alone
Structural-geometric logic	Geometric adaptability	Documented variation of grid, surface, supports, and components in response to site constraints	Formal superiority or optimization
Structural-geometric logic	Structural organization	Documented hybrid system, support hierarchy, and load-bearing configuration	Comparative efficiency, material optimality, or safety verification
Structural-geometric logic	Modular coordination	Repeated LVL plates, joints, and digitally coordinated component families	Low cost, reversibility, or easy maintenance
Structural-geometric logic	Documented constructability	Published fabrication, prefabrication, assembly, and completed construction evidence	Comparative construction time, cost, or lifecycle performance

4.1. Analytical Interpretation of Parametric Design Logic

The unit of evidence is a criterion-specific relationship visible or stated in the source corpus. Sources comprise architectural plans and sections, project photographs, published project descriptions, direct engineering and fabrication accounts, and peer-reviewed research. Project sources establish what was designed and built; academic sources provide theoretical and comparative interpretation. Neither source type is treated as proof of outcomes it did not measure.

For each criterion, the analysis records: (1) the observable configuration or documented process, (2) the source type supporting it, (3) a supported, qualified, not-supported, or not-established status, and (4) the excluded inference. Convergence across independent source types strengthens a status, while conflicting visual or scholarly evidence is retained as a qualification. This audit-trail structure makes the reasoning inspectable even though the underlying evidence is qualitative.

4.2. Evaluation Strategy

The evaluation follows four steps. First, each proposition is mapped to relevant criteria and observable indicators in Table 3. Second, plans, sections, photographs, project accounts, and academic sources are reviewed for direct and rival evidence. Third, criterion-level evidence is coded using the four statuses and summarized in Table 4. Fourth, relations across the three domains are synthesized to assess P1-P4, with trade-offs and non-established outcomes reported rather than converted into a composite score.

This procedure deliberately avoids the previous Low-Medium-High scale because such ratings implied performance precision unsupported by the dataset. It also avoids comparison with a hypothetical conventional canopy because no benchmark case or counterfactual model is available. Source triangulation here means convergence among documentary types; it does not constitute inter-rater reliability or empirical validation. No independent second-coder test was conducted.

4.3. Scope and Limitations

The study is limited to a qualitative interpretation of secondary evidence. It does not reconstruct the parametric model, run environmental or structural simulations, take field measurements, survey users, observe behaviour, audit universal accessibility, or technically assess conservation condition. Consequently, canopy form can support claims about shading affordance or openness, but not actual thermal comfort, airflow, daylight quality, social vitality, accessibility, structural efficiency, or conservation performance. Technical conservation claims would additionally require direct diagnostic evidence of the kind used in non-destructive heritage assessment (Moropoulou et al., 2013). The single iconic case is analytically rich but atypical in scale, engineering, governance, and symbolic prominence. Secondary project documentation may emphasize design intentions and successful delivery, while photographs cannot represent all times, users, or operating conditions. The absence of independent coders also leaves interpretive consistency unquantified. The framework application is therefore exploratory rather than validated.

Transferability is restricted to the method of asking cross-domain questions and documenting evidence boundaries. Application to another protected or archaeologically sensitive semi-open intervention would require local re-establishment of climatic conditions, heritage values, access requirements, governance, procurement, structural evidence, maintenance, and community perspectives. Neither the Metropol Parasol's form nor its criterion statuses should be transferred as a universal solution.

5. Findings

Table 4 reports evidentiary status rather than performance level. Six criteria are supported by convergent documentary evidence, five are qualified by partial or conflicting evidence, and thermal-comfort outcomes are not established. No criterion is coded as not supported because the available material does not directly demonstrate the absence of the relevant relationship; where evidence is insufficient, the more conservative qualified or not-established category is used.

Table 4. Criterion-level evidence matrix for Metropol Parasol.

Domain	Criterion and status	Traceable documentary basis	Evidentiary boundary
Spatial mediation	Ground-level permeability - Supported	Plans, sections, and photographs show a largely open lower plane organized around discrete supports.	No pedestrian counts or behavioural observation.
Spatial mediation	Contextual continuity - Qualified	Routes and views remain connected, but the structure's 150 m length, height, and silhouette introduce marked contrast (Koppitz et al., 2011).	No visual-preference survey; compatibility remains contestable.
Spatial mediation	Documented access provision - Qualified	Multi-level circulation and vertical connections are documented in project material.	No universal-accessibility audit or user testing.
Spatial mediation	Programmatic layering - Supported	Sections and project accounts document the Antiquarium, market, elevated plaza, commercial uses, and walkway (Mayer, 2012).	No evidence of social vitality or interaction intensity.
Environmental responsiveness	Solar-shading affordance - Supported	The extensive canopy is visibly positioned above occupiable areas and is described as a shading structure (Koppitz et al., 2011).	No radiation, temperature, PET, or UTCI data.
Environmental responsiveness	Daylight-mediation affordance - Qualified	Patterned apertures and variable porosity indicate simultaneous cover and sky exposure.	No illuminance, glare, or daylight-autonomy results.
Environmental responsiveness	Ventilation affordance - Qualified	An open perimeter and large voids avoid full enclosure.	No CFD, anemometry, or pollutant-dispersion evidence.
Environmental responsiveness	Thermal-comfort evidence - Not established	The source corpus contains no case-specific thermal measurements, simulation, index calculation, or user responses.	Shade and openness cannot verify comfort.
Structural-geometric logic	Geometric adaptability - Supported	Direct engineering accounts document variable free-form geometry and coordinated component differentiation (Koppitz et al., 2011).	No claim of optimality or formal superiority.
Structural-geometric logic	Structural organization - Qualified	Published documentation describes the hybrid timber, steel, and concrete system and support hierarchy.	No independent calculation or alternative-system benchmark.
Structural-geometric logic	Modular coordination - Supported	Repeated LVL plates, joints, and a digitally coordinated fabrication logic are documented (Koppitz et al., 2011).	No proof of low cost, reversibility, or easy maintenance.
Structural-geometric logic	Documented constructability - Supported	Fabrication, prefabrication, assembly, and completed realization are reported in project and engineering sources.	No comparative time, cost, or lifecycle assessment.

Spatially, P1 is supported with qualification. Repetition and variation in the grid correspond to observable support positions, canopy openings, circulation zones, and vertically layered programs, so the parametric logic is not readable only as formal complexity. However, actual movement, social interaction, and inclusive access remain outside the evidence.

P2 is qualified. The documented organization accommodates archaeological remains through vertical separation and concentrated ground contact while sustaining public-space functions. Yet physical accommodation does not settle questions of authenticity or contextual compatibility; the structure's scale and visual prominence introduce a rival interpretation that must remain visible.

P3 is supported as a proposition about cross-domain trade-offs, not outcomes. Openness and programmatic layering coexist with contextual contrast; extensive cover creates a shading affordance while limiting unqualified claims about daylight; and geometric variability supports site-specific coordination while leaving comparative structural efficiency untested.

P4 is qualified. The evidence supports archaeological accommodation and a legible contemporary identity, but it cannot determine whether users or heritage stakeholders judge the intervention compatible, dominant, or authentic. The interface therefore mediates through both connection and contestation rather than through demonstrated harmony.

6. Discussion

The study does not demonstrate that parametric design is inherently beneficial in historic settings. Instead, it shows what becomes analytically visible when a realized contemporary intervention is treated as an interface rather than as an isolated object. The documented geometry links support placement, spatial permeability, programmatic layering, canopy coverage, and modular construction, but these relations include qualifications and cannot be converted into general claims of environmental, social, or conservation success.

Relative to HBIM scholarship, the framework changes the unit of analysis. HBIM research has made major advances in the documentation, semantic enrichment, structural diagnosis, restoration planning, and management of historic assets (Simeone et al., 2019; Moyano et al., 2022; Liu et al., 2023; De Falco et al., 2024; Cui & Wu, 2025; Banfi & Liu, 2026). The present study instead focuses on relations generated by a contemporary addition around and above archaeological fabric. This is a complementary analytical extension, not an alternative to HBIM and not a claim that HBIM is incapable of representing such relations.

Relative to performance-led parametric research, the evidentiary distinction is equally important. Studies that report optimized shading, daylight, energy, or thermal comfort use explicit models, objective functions, simulation, and verification (Chi et al., 2021; Zhang et al., 2021; Palomo Amores et al., 2023; Şenalp et al., 2025). Reviews of city-square thermal comfort confirm the central role of measurement, simulation, indices, and user data (Mandić et al., 2024). Metropol Parasol's canopy therefore supports an interpretation of shading affordance, but this study cannot infer temperature reduction, airflow improvement, visual comfort, or thermal comfort from form alone.

The same boundary applies to public interaction and accessibility. Public-space research uses observation, surveys, space syntax, and multi-source data to connect spatial configuration with perception, activity, or vitality (Birer & Çalışır Adem, 2022; Zencirkiran & Suta, 2025; Long et al., 2025). Accessibility in Spanish heritage environments is itself a specialized and still developing field (del Bosque et al., 2025). Consequently, documented circulation and programmatic layering identify spatial provision, not actual social vitality, universal access, or ease of use.

A balanced heritage interpretation must also address visual dominance, authenticity, and contextual compatibility. Contemporary additions need not imitate historic fabric, but their success cannot be inferred from technological sophistication or archaeological accommodation alone; scale, silhouette, material expression, and public perception remain consequential (García-Esparza, 2022; Kurnaz & Anıktar, 2024; Tang & Figliola, 2025). At approximately 150 m long and up to 28 m high, Metropol Parasol establishes an unmistakably dominant contemporary presence (Koppitz et al., 2011). The evidence permits identification of this tension, but without perception or stakeholder data it cannot adjudicate whether the contrast is acceptable, disruptive, or culturally productive.

The revised evidence coding also reduces confirmation bias. Criteria derived from literature are not treated as assumed benefits: a relationship must be supported by traceable evidence, conflicting evidence produces a qualified status, and outcomes absent from the dataset remain not established. For the same reason, the earlier speculative comparison with a conventional non-parametric canopy has been removed. Without a matched case, structural model, or counterfactual design, claims of lower material use, fewer supports, or superior permeability would be untestable.

The framework's specific contribution consists of four linked elements: an interface-centred unit of analysis; an explicit mechanism connecting constraints, rule-based geometric decisions, and observable cross-domain relations; a 12-criterion audit trail that separates affordances from verified outcomes; and proposition-level reporting that retains trade-offs and rival interpretations. These elements advance an integrative mode of qualitative analysis, but a single application cannot validate the framework.

Transferability is therefore methodological and conditional. Comparable research may reuse the questions, criteria, evidence statuses, and claim-boundary logic, but each case must re-establish local heritage values, climate, accessibility, governance, structural documentation, procurement, maintenance, and community perspectives. Validation should involve multiple contrasting cases, independent coders and inter-rater testing, and—where outcomes are claimed—environmental simulation and measurement, structural analysis, behavioural observation, user surveys, and accessibility audits.

7. Conclusion

This study examined Metropol Parasol as a parametric architectural interface within a historically layered semi-open public space. Using a critical single-case design and a 12-criterion documentary framework, it traced how rule-based geometry relates to spatial mediation, environmental affordances, and structural-geometric organization. The evidence supports links among variable geometry, support placement, ground-level permeability, programmatic layering, shading affordance, modular coordination, and documented constructability. Contextual continuity, access provision, daylight mediation, ventilation affordance, and structural organization remain qualified, while thermal-comfort outcomes are not established.

The academic contribution is not a new parametric model or proof that parametric intervention improves heritage environments. It is an interface-centred analytical framework that connects research streams commonly treated separately, specifies observable mediation mechanisms, and records whether evidence supports, qualifies, contradicts, or cannot establish each claim. This approach also makes visual dominance and contextual contestation part of heritage mediation rather than treating archaeological accommodation as sufficient evidence of compatibility.

The findings do not verify social vitality, universal accessibility, airflow, daylight quality, thermal comfort, structural efficiency, material optimality, visual acceptance, authenticity, or conservation performance. They also do not justify comparison with a hypothetical conventional canopy. These boundaries are substantive results of the analysis, not merely procedural caveats.

Because the framework is demonstrated on one iconic case using secondary evidence and without independent coders, its transferability is limited to a conditional method of inquiry. Future research should test it across contrasting historic contexts, establish inter-rater reliability, and combine documentary analysis with project files, simulation, environmental and structural measurement, accessibility audits, behavioural observation, and stakeholder or user evidence. Such work can determine which proposed interface relations translate into verified outcomes and under what contextual conditions.

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Conflicts of Interest

The author(s) report no conflicts of interest.

Data Availability Statement

The data supporting the findings of this study are derived from publicly available architectural drawings, published project documentation, visual materials, and academic literature cited throughout the manuscript. No proprietary datasets were used.

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References

Alshawabkeh, Y. (2024). HBIM for conservation of built heritage. *ISPRS International Journal of Geo-Information, 13*(7), Article 231. https://doi.org/10.3390/ijgi13070231

Banerjee, T. (2001). The future of public space: Beyond invented streets and reinvented places. *Journal of the American Planning Association, 67*(1), 9-24. https://doi.org/10.1080/01944360108976352

Banfi, F. (2016). BIM and parametric components: The challenges of historical buildings. *Applied Geomatics, 8*(3), 199-212.

Banfi, F., & Liu, W. (2026). The state of HBIM in digital heritage: A critical and bibliometric assessment of six emerging frontiers (2015-2025). *Applied Sciences, 16*(2), 906. https://doi.org/10.3390/app16020906

Birer, E., & Çalışır Adem, P. (2022). Role of public space design on the perception of historical environment: A pilot study in Amasya. *Frontiers of Architectural Research, 11*(1), 13-30. https://doi.org/10.1016/j.foar.2021.09.003

Caetano, I., Santos, L., & Leitão, A. (2020). Computational design in architecture: Defining parametric, generative, and algorithmic design. *Frontiers of Architectural Research, 9*(2), 287-300. https://doi.org/10.1016/j.foar.2019.12.008

Carmona, M. (2021). *Public places, urban spaces: The dimensions of urban design* (3rd ed.). Routledge. https://doi.org/10.4324/9781315158457

Chi, D. A., González M., E., Valdivia, R., & Gutiérrez J., E. (2021). Parametric design and comfort optimization of dynamic shading structures. *Sustainability, 13*(14), 7670. https://doi.org/10.3390/su13147670

Croce, P., Landi, F., Puccini, B., Martino, M., & Maneo, A. (2022). Parametric HBIM procedure for the structural evaluation of heritage masonry buildings. *Buildings, 12*(2), 194. https://doi.org/10.3390/buildings12020194

Cui, H., & Wu, J. (2025). How architectural heritage is moving to smart: A systematic review of HBIM. *Buildings, 15*(15), 2664. https://doi.org/10.3390/buildings15152664

De Falco, A., Gaglio, F., Giuliani, F., Martino, M., & Messina, V. (2024). An HBIM approach for structural diagnosis and intervention design in heritage constructions: The case of the Certosa di Pisa. *Heritage, 7*(4), 1850-1869. https://doi.org/10.3390/heritage7040088

del Bosque, A., Fernández-Arias, P., Castro-López, P., Nieto-Sobrino, M., & Vergara, D. (2025). Universal accessibility to cultural heritage in Spain: A bibliometric review. *Buildings, 15*(9), 1563. https://doi.org/10.3390/buildings15091563

Fernández-Baca Casares, R., Fernández Cacho, S., & Salmerón Escobar, P. (Dirs.). (2017). *Guía del Paisaje Histórico Urbano de Sevilla: Volumen 1. Caracterización*. Instituto Andaluz del Patrimonio Histórico, Junta de Andalucía.

García-Esparza, J. A. (2022). Urban scene protection and unconventional practices-Contemporary landscapes in World Heritage cities of Spain. *Land, 11*(3), 324. https://doi.org/10.3390/land11030324

García-Hernández, M., de la Calle-Vaquero, M., & Yubero, C. (2017). Cultural heritage and urban tourism: Historic city centres under pressure. *Sustainability, 9*(8), 1346. https://doi.org/10.3390/su9081346

Koppitz, J.-P., Quinn, G., Schmid, V., & Thurik, A. (2011). Metropol Parasol-Digital timber design. In C. Gengnagel, A. Kilian, N. Palz, & F. Scheurer (Eds.), *Computational design modelling* (pp. 249-257). Springer. https://doi.org/10.1007/978-3-642-23435-4_28

Kurnaz, A., & Anıktar, S. (2024). Visual perception and contextual relationship of contemporary extensions and historical buildings. *Journal of Architectural Conservation, 30*(1), 35-55. https://doi.org/10.1080/13556207.2024.2318923

Liberotti, R., & Gusella, V. (2023). Parametric modeling and heritage: A design process sustainable for restoration. *Sustainability, 15*(2), 1371. https://doi.org/10.3390/su15021371

Liu, J., Azhar, S., Willkens, D., & Li, B. (2023). Static terrestrial laser scanning (TLS) for heritage building information modeling (HBIM): A systematic review. *Virtual Worlds, 2*(2), 90-114. https://doi.org/10.3390/virtualworlds2020006

Long, Y., Jiao, S., Yu, Y., & Xiao, K. (2025). An analysis of spatial vitality distribution and formation mechanisms in historical urban areas based on multi-source big data: A case study of Changsha. *Frontiers of Architectural Research, 14*(6), 1727-1749. https://doi.org/10.1016/j.foar.2025.03.005

Mandić, L., Đjukić, A., Marić, J., & Mitrović, B. (2024). A systematic review of outdoor thermal comfort studies for the urban (re)design of city squares. *Sustainability, 16*(12), 4920. https://doi.org/10.3390/su16124920

Mayer, J. H. (2012). *Metropol Parasol: Retooling the Plaza de la Encarnación*. Hatje Cantz.

Menges, A., Schwinn, T., & Krieg, O. D. (Eds.). (2021). *Integrative computational design and robotic fabrication: Architecture without architects?* Architectural Design, 91(2). Wiley.

Moropoulou, A., Labropoulos, K. C., Delegou, E. T., Karoglou, M., & Bakolas, A. (2013). Non-destructive techniques as a tool for the protection of built cultural heritage. *Construction and Building Materials, 48*, 1222-1239. https://doi.org/10.1016/j.conbuildmat.2013.03.044

Moyano, J., Carreño, E., Nieto-Julián, J. E., Gil-Arizón, I., & Bruno, S. (2022). Systematic approach to generate Historical Building Information Modelling (HBIM) in architectural restoration project. *Automation in Construction, 143*, 104551. https://doi.org/10.1016/j.autcon.2022.104551

Oxman, R. (2006). Theory and design in the first digital age. *Design Studies, 27*(3), 229-265. https://doi.org/10.1016/j.destud.2005.11.002

Palomo Amores, T. R., Sánchez Ramos, J., Guerrero Delgado, M. C., Castro Medina, D., Cerezo-Narváez, A., & Álvarez Domínguez, S. (2023). Effect of green infrastructures supported by adaptive solar shading systems on livability in open spaces. *Urban Forestry & Urban Greening, 82*, 127886. https://doi.org/10.1016/j.ufug.2023.127886

Penjor, T., Banihashemi, S., Hajirasouli, A., & Golzad, H. (2024). Heritage building information modeling (HBIM) for heritage conservation: Framework of challenges, gaps, and existing limitations of HBIM. *Digital Applications in Archaeology and Cultural Heritage, 35*, e00366. https://doi.org/10.1016/j.daach.2024.e00366

Schling, E., Wan, Z., Wang, H., & D'Acunto, P. (2023). Asymptotic geodesic hybrid timber gridshell. In *Advances in Architectural Geometry 2023* (pp. 97-110). De Gruyter. https://doi.org/10.1515/9783111162683-008

Şenalp, M., Köymen, E., Yaşa, E., & Başar, M. E. (2025). Parametric exploration of natural lighting and visual comfort in contemporary additions to historic buildings. *Journal of Daylighting, 12*(2), 506-519. https://doi.org/10.15627/jd.2025.30

Shehata, A. O., Hassan, A. M., Shahda, M. M., & Megahed, N. A. (2024). Green retrofitting of heritage buildings based on (3Ts) framework: An applied case study. *Frontiers of Architectural Research, 13*(4), 776-798. https://doi.org/10.1016/j.foar.2024.02.015

Simeone, D., Cursi, S., & Acierno, M. (2019). BIM semantic enrichment for built heritage representation. *Automation in Construction, 97*, 122-137. https://doi.org/10.1016/j.autcon.2018.11.004

Speranza, P. (2016). Social interaction and cohesion tool: Integrating socio-computational design in urban ecology for Barcelona's Superilles. In *Proceedings of the Association of Collegiate Schools of Architecture Annual Meeting 2016*. ACSA.

Taleghani, M. (2018). Outdoor thermal comfort by different heat mitigation strategies: A review. *Renewable and Sustainable Energy Reviews, 81*, 2011-2018. https://doi.org/10.1016/j.rser.2017.06.010

Tang, K., & Figliola, A. (2025). Balancing heritage and modernity: A hierarchical adaptive approach in Rome's cultural sports urban renewal. *Buildings, 15*(24), 4570. https://doi.org/10.3390/buildings15244570

Wang, Y., Jin, C., Xu, D., Wang, T., & Wang, B. (2024). Analysis of multi-dimensional layers in historic districts based on theory of the Historic Urban Landscape: Taking Shenyang Fangcheng as an example. *Land, 13*(11), 1736. https://doi.org/10.3390/land13111736

Woodbury, R. (2010). *Elements of parametric design*. Routledge.

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). SAGE Publications.

Zencirkiran, A., & Suta, O. (2025). Spatial organization and user experience in a university campus: A mixed-method space syntax analysis of Trakya University Balkan Campus. *Sustainability, 17*(24), 11221. https://doi.org/10.3390/su172411221

Zhang, J., Liu, N., & Wang, S. (2021). Generative design and performance optimization of residential buildings based on parametric algorithm. *Energy and Buildings, 244*, Article 111033. https://doi.org/10.1016/j.enbuild.2021.111033