

Article

From Formal References to Architectural Form and Meaning: A Transformation-Based Framework for Analysing Reference-Driven Design

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Abstract

This study investigates how formal references are transformed into architectural form and meaning. While previous studies have acknowledged the diversity of source domains in architecture, they often remain fragmented and lack a systematic framework that explains how such references are operated upon during design. This gap limits the ability to distinguish between the literal replication of recognizable forms and the deeper transformation of their conceptual, structural, and symbolic properties. In response, this research develops a Transformation-Based Formal Reference Framework (TFRF) that traces formal reference through six stages—source, interpretation, abstraction, transformation, architectural expression, and meaning production—with a feedback loop from received meaning back to interpretation. The contribution is therefore not a new classification of sources; classification by source domain (living organisms, cosmos and geographical formations, language, belief systems, precedent architecture, and human-made products) is retained only as the entry point of the process. Thirty-one architectural cases, selected through purposive sampling and independently double-coded ($\kappa = 0.75$ for abstraction and $\kappa = 0.86$ for transfer), are positioned within a two-dimensional matrix that crosses degree of abstraction (direct, analogy, abstraction) with type of transfer (form, structure, performance, symbol, space). The analysis suggests that source domain and transformation mechanism function as analytically distinct dimensions: one source can yield opposite mechanisms and distant sources can converge on the same one. The framework thereby reframes formal reference from a catalogue of inspirations into a navigable two-axis design space, offering a transferable analytical framework for understanding how architectural references become form and meaning.

Keywords: formal references; architectural form; architectural expression; design process; design inspiration; architectural thought



Academic Editor: Li Yang

Received: 20 June 2026

Revised: 23 July 2026

Accepted: 3 August 2026

Published: 7 August 2026

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1. Introduction

Architecture has long been recognized not only as the production of physical environments but also as a cultural and intellectual practice through which meanings are generated, negotiated, and communicated. Within this broader perspective, architectural form cannot be understood solely as a visual or technical outcome; rather, it emerges through a process of interpretation in which designers draw upon diverse sources of inspiration and transform them into spatial, formal, and symbolic expressions. These sources, referred to

in this study as *formal references*, may originate from natural phenomena, living organisms, cultural narratives, religious beliefs, historical precedents, linguistic structures, or technological artefacts.

The relationship between form and meaning has occupied a central position in architectural theory for decades. Charles Jencks emphasized the communicative and symbolic dimensions of architecture, arguing that buildings operate through multiple layers of meaning and interpretation [1]. Kenneth Frampton highlighted the importance of contextual and cultural references in shaping architectural expression through critical regionalism [2]. Similarly, Aldo Rossi viewed architecture as a repository of collective memory structured through historical and typological references [3], while Christian Norberg-Schulz interpreted architectural form as a manifestation of *genius loci*, linking built environments to existential and experiential meanings [4].

Despite these influential contributions, scholarship addressing formal references remains fragmented. Existing studies generally focus on identifying and categorizing sources of inspiration, emphasizing their diversity and cultural significance [1,2]. Other studies examine specific categories of references or particular historical contexts, providing valuable but isolated insights into architectural inspiration [5,6]. Consequently, the literature offers extensive knowledge regarding what architects refer to, yet provides limited explanation of how these references are interpreted, transformed, and ultimately translated into architectural form and meaning.

Recent developments in design cognition, computational design, and biomimetic research have partially addressed this issue by introducing more explicit procedural models. Design cognition studies have explored how designers select and manipulate references during conceptual design processes [7,8]. Biomimetic design research has formalized mechanisms through which biological principles are abstracted and transferred into architectural solutions [9]. Similarly, computational morphogenesis, generative design, and artificial intelligence have expanded discussions on form generation by modelling design as a rule-based, performance-driven, or data-informed process [10–13]. However, even within these emerging approaches, the source of a reference and the mechanism through which it is transformed are frequently treated as a single phenomenon rather than as analytically distinct dimensions.

Taken together, these bodies of work reveal a consistent limitation. Source-oriented surveys such as those of Jencks and Frampton [1,2] and the historical accounts of Kostof and Curtis [5,6] provide rich catalogues of what architects draw upon, yet they treat reference primarily as a matter of classification and leave the operations that convert a reference into built form implicit. Procedural strands, by contrast, make some of these operations explicit: design-cognition studies model how designers retrieve and manipulate references [7,8], biomimetic research formalises the abstraction and transfer of biological principles [9], and computational and generative approaches describe form generation as a rule-based or performance-driven process [10–13]. Their strength is procedural precision, but many remain focused on a particular source family, cognitive process, or computational apparatus, and the reviewed approaches generally do not explicitly separate the source domain from the mechanism through which it is transformed. What remains unresolved, therefore, is a framework that (i) applies across heterogeneous source domains rather than a single one, and (ii) treats source and transformation as two analytically distinct dimensions rather than a single fused phenomenon. Table 1 summarises the major research approaches reviewed above, their principal contributions, and the specific limitation each leaves open.

Table 1. Comparative analysis of the major research approaches addressing formal references, their principal contributions, and the specific limitation each leaves unresolved.

Previous Studies	Contribution	Remaining Gap
Source-oriented surveys and histories [1,2,5,6]	Identify and classify the diversity of sources architects refer to; establish the cultural and symbolic significance of reference.	Treat reference as classification; the operations that turn a source into built form remain implicit.
Design-cognition studies [7,8]	Model how designers retrieve, select, and manipulate references during conceptual design.	Focus on cognitive process in general; do not distinguish source domain from transfer mechanism across heterogeneous references.
Biomimetic design research [9]	Formalise how biological principles are abstracted and transferred into architectural solutions.	Bound to a single source domain (living organisms); not generalised to other references.
Computational and generative design [10–13]	Describe form generation as a rule-based, performance-driven, or data-informed process.	Tied to a specific computational apparatus; source and transformation are treated as one fused phenomenon.

Against this background, the present study addresses the gap identified above. It retains source classification only as an entry point and introduces a transformation-based framework that treats source and mechanism as analytically distinct dimensions, mapping any reference-driven design onto the two axes of abstraction and transfer. In this way it applies across all six source domains rather than a single family of sources and makes explicit the transformation operations that the approaches in Table 1 leave implicit.

This limitation is particularly relevant when recognizable formal resemblance is prioritized over the explicit analysis of the interpretative and transformative operations through which a reference is incorporated into design. As Eisenman argued, architectural form should be understood as the outcome of a conceptual and generative process rather than as a static visual image [14]. In such cases, architectural production may risk becoming increasingly image-driven, potentially reducing the intellectual and cultural depth embedded within the design process.

This study argues that a more systematic understanding of formal references requires distinguishing the source of inspiration from the *mechanism* through which it is transformed into architectural form. Accordingly, the research seeks to develop a Transformation-Based Formal Reference Framework (TFRF) capable of explaining the process through which references evolve from initial sources into architectural expressions and ultimately into meaning production.

To address this objective, the study is guided by the following research questions:

RQ1. How are formal references transformed into architectural form throughout the design process?

RQ2. To what extent can source domains and transformation mechanisms be treated as analytically distinct dimensions in architectural design?

RQ3. Can formal references be systematically mapped within a transformation-based framework that explains the production of architectural meaning?

Methodologically, the study adopts a qualitative comparative approach based on the analysis of thirty-one architectural cases representing diverse formal reference domains. Through cross-case examination, the research identifies recurring transformation strategies and positions each case within a two-dimensional analytical matrix defined by degree of abstraction and type of transfer.

The contribution of this study is not the proposal of a new classification of source domains. Rather, it introduces a process-oriented framework that explains how references

are interpreted, abstracted, transformed, expressed architecturally, and ultimately translated into meaning. The resulting Transformation-Based Formal Reference Framework (TFRF) links source, interpretation, abstraction, transformation, architectural expression, and meaning production within a single operational model. In doing so, the study shifts the discussion of formal references from a descriptive catalogue of inspirations toward a systematic and transferable framework for analysing, comparing, and teaching architectural form generation.

2. Materials and Methods

This study employs a qualitative, theory-driven analytical methodology designed to systematically investigate the role of formal references in architectural design. Rather than merely describing examples, the research focuses on identifying patterns, transformation mechanisms, and expressive outcomes of architectural references through a comparative case study approach.

2.1. Case Study Selection

This study employs a purposive, theory-driven sampling strategy to construct a diverse corpus of architectural cases suitable for examining the transformation of formal references into architectural form and meaning. The objective of case selection was not statistical representativeness but analytical diversity, enabling the identification and comparison of recurring transformation mechanisms across different architectural contexts.

The case corpus consists of thirty-one architectural projects selected according to five inclusion criteria:

- **Documented Formal Reference:** The project had to demonstrate a clearly identifiable formal reference supported by architect statements, project documentation, monographs, scholarly publications, or critical interpretations.
- **Source-Domain Representation:** The corpus was required to represent all six source domains investigated in this study: living organisms, cosmos and geographical formations, language, belief systems, precedent architecture, and human-made products.
- **Transformation Diversity:** Cases were selected to cover the full range of abstraction levels and transfer mechanisms, ensuring that the analytical framework would not be biased toward a particular design strategy.
- **Architectural Scale and Clarity:** Only architectural projects were included. Urban-scale proposals, planning schemes, and projects lacking sufficient design documentation were excluded to maintain analytical consistency.
- **Conceptual Richness:** Both canonical and less-studied projects were incorporated to balance visibility, theoretical significance, and diversity of design approaches.

The final corpus spans different historical periods, geographical regions, building functions, and architectural traditions. This diversity was intentionally sought in order to test whether similar transformation mechanisms could emerge from different source domains and whether different sources could generate comparable architectural outcomes.

To reduce interpretative bias, all the cases were independently coded by both authors according to the two analytical dimensions developed in this study: degree of abstraction and type of transfer. Inter-rater reliability was assessed using Cohen's kappa coefficient. Agreement reached $\kappa = 0.75$ for abstraction categories, indicating substantial agreement, and $\kappa = 0.86$ for transfer categories, indicating almost perfect agreement according to the benchmarks proposed by Landis and Koch [15].

Cases generating divergent interpretations were subjected to a secondary review process. These disagreements were concentrated in seven borderline cases where more than one classification could reasonably be justified. Final classifications were established

through joint examination of documentary evidence, including architect statements, design descriptions, and scholarly analyses. Only consensus classifications were included in the final analytical matrix.

Accordingly, the case-selection process was designed not to establish statistical generalizations but to construct a theoretically informative corpus capable of revealing transferable patterns in the transformation of formal references into architectural expression and meaning.

Purposive sampling was adopted rather than random or exhaustive sampling because the research question is explanatory rather than distributional: the aim is to reveal how references are transformed, not to estimate how frequently a given strategy occurs in the built environment. A random sample drawn without regard to source domain or transformation strategy would over-represent common tendencies and could omit the analytically critical cases needed to test whether distant sources converge and whether a single source diverges. The final number of cases, thirty-one, was determined through coverage-oriented purposive sampling. Case recruitment continued until the corpus represented all six source domains, all three abstraction levels, and all five transfer categories, while additional cases were judged analytically redundant in relation to the framework's intended comparative scope. Projects were excluded when they failed any inclusion criterion, specifically when the claimed reference could not be corroborated by at least two independent documentary sources, when the work operated at urban or planning scale rather than building scale, or when available documentation was insufficient to code both analytical dimensions with confidence. The inclusion and exclusion criteria, together with their rationale, are summarised in Table 2.

Table 2. Case-selection criteria: inclusion requirements, corresponding exclusion conditions, and the analytical rationale underpinning the purposive sampling strategy.

Criterion	Inclusion Requirement	Exclusion Condition	Rationale
Documented formal reference	A clearly identifiable reference supported by architect statements, monographs, or scholarly analysis.	Reference not corroborated by at least two independent sources.	Ensures the coded reference reflects intent, not post hoc interpretation.
Source-domain representation	Case belongs to one of the six source domains under study.	Reference falls outside the six domains.	Guarantees coverage of the full entry-point taxonomy.
Transformation diversity	Corpus collectively spans all abstraction levels and transfer types.	Adding the case would skew the corpus toward one strategy.	Prevents bias toward a single design mechanism.
Architectural scale and clarity	Building-scale project with sufficient design documentation.	Urban-scale or planning scheme, or documentation too sparse to code.	Maintains analytical consistency and codability.
Conceptual richness	Canonical or less-studied project with interpretable design logic.	No discernible conceptual relationship between source and form.	Balances visibility, significance, and diversity of approaches.

2.2. Analytical Framework

The analytical framework developed in this study is based on the premise that architectural references should be understood not merely as sources of inspiration but as components of a transformation process through which architectural form and meaning are generated. While previous studies have largely focused on identifying and categorizing sources of inspiration, they provide limited explanation of how references are interpreted, transformed, and ultimately materialized as architectural outcomes. To address this gap, the present study develops the Transformation-Based Formal Reference Framework (TFRF) as a process-oriented analytical model.

Rather than treating formal references as static categories, the TFRF conceptualizes them as dynamic elements within a sequence of interconnected cognitive and design operations. The framework traces the progression of a reference from its original source to its architectural manifestation and subsequent meaning production. The overall structure of the framework is presented in Figure 1.

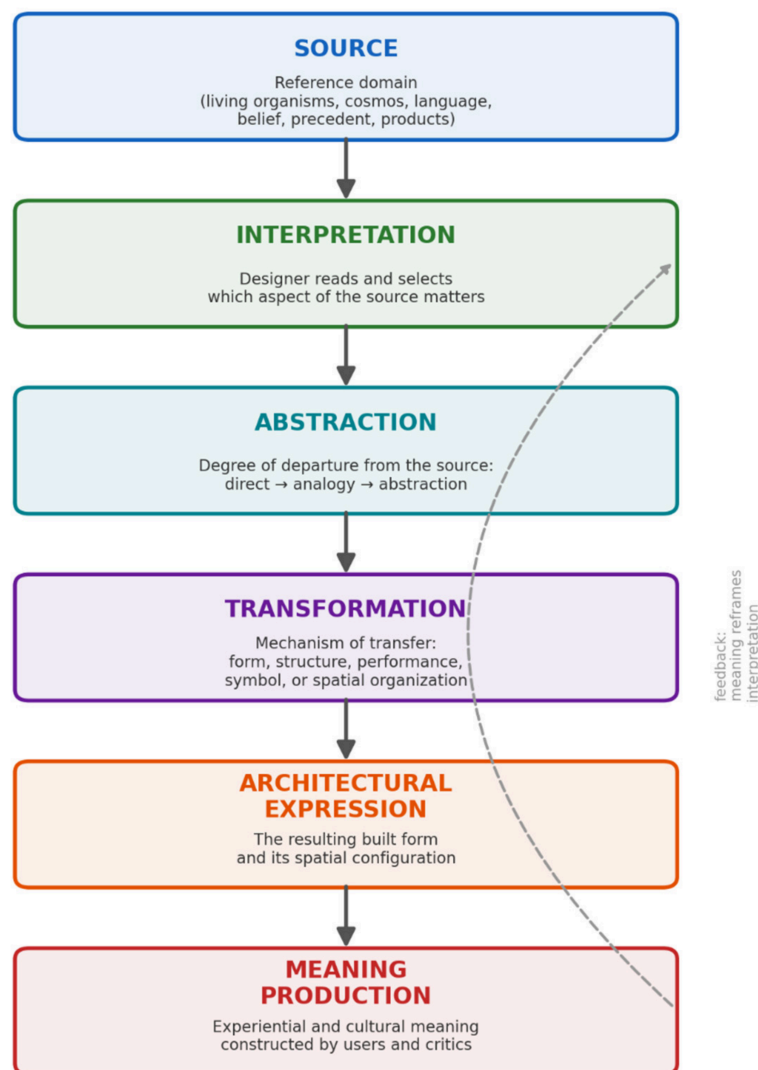


Figure 1. Transformation-Based Formal Reference Framework (TFRF): the six-stage model (source: prepared by the authors).

As illustrated in Figure 1, the framework consists of six interconnected stages.

Source refers to the original domain from which inspiration is derived. In this study, source domains include living organisms, cosmos and geographical formations, language, belief systems, precedent architecture, and human-made products.

The six source domains were not chosen arbitrarily but derive from recurrent categories in architectural theory that together span the natural, cultural, and technological registers from which designers habitually draw. Living organisms and the cosmos capture reference to the natural world and have long anchored organic and structural traditions in architecture [16–18]; language and belief systems capture the cultural and symbolic register central to semiotic and phenomenological readings of form [1,4]; precedent architecture captures the discipline’s internal, typological memory [3]; and human-made products capture reference to technology and industrial artefacts [19]. Collectively, these six domains

encompass the principal categories of formal references identified in the architectural literature and provide sufficient conceptual coverage for the analytical purposes of the present framework, which is why they are retained as the entry point of the framework. Table 3 states, for each domain, a representative scholarly source and the reason for its inclusion.

Table 3. The six source domains used as the entry point of the framework, with a representative scholarly reference and the rationale for including each domain.

Source Domain	Representative Reference	Reason for Inclusion
Living organisms	Otto [16]; Wright [17]	Foundational to organic and biomimetic traditions; supplies form, structure, and organizing principles drawn from nature.
Cosmos and geographical formations	Sullivan [18]	Captures reference to natural landforms and cosmological order, a persistent source of monumental and site-responsive form.
Language	Jencks [1]	Central to the semiotic reading of architecture as a system of signs and communicable meaning.
Belief systems	Norberg-Schulz [4]	Grounds the symbolic and phenomenological register through which religious and existential meaning enters form.
Precedent architecture	Rossi [3]	Represents the discipline’s internal, typological memory in which buildings reference earlier buildings.
Human-made products	Kurokawa [19]	Captures reference to technology and industrial artefacts, characteristic of metabolist and high-tech thought.

Interpretation describes the designer’s selective reading of the source, through which particular characteristics, relationships, symbolic associations, or performance principles are identified as relevant to the design problem.

Abstraction represents the extraction and reformulation of selected source attributes. This stage determines the degree to which the resulting architectural expression departs from its original reference.

Transformation refers to the process through which abstracted ideas are translated into architectural strategies and design decisions.

Architectural Expression represents the material and spatial manifestation of the transformed reference within the built environment through form, structure, organization, materiality, or experience.

Meaning Production refers to the symbolic, cultural, experiential, and interpretative meanings generated through architectural expression and subsequently perceived by users, critics, and society.

A distinctive feature of the framework is the feedback relationship between meaning production and interpretation. Architectural meanings generated through completed projects may subsequently influence how references are understood and employed in future design processes, emphasizing the iterative nature of architectural knowledge production.

Accordingly, the TFRF functions not as a taxonomy of inspirational sources but as an operational analytical model capable of explaining how references are transformed into architectural form and meaning. The analytical application of the framework, including coding procedures and comparative mapping strategies, is presented in the following sections.

2.3. Data Collection and Interpretation

Data were collected from multiple documentary sources to establish a comprehensive and reliable understanding of the relationship between formal references and architectural outcomes. The documentary corpus included architectural drawings, project reports, architect statements, monographs, scholarly publications, design documentation, and critical reviews. Whenever available, primary sources produced by architects or design teams were prioritized to ensure a direct connection between the intended reference and the resulting architectural expression.

To enhance analytical reliability, a process of data triangulation was employed. Information concerning each case was cross-checked across multiple documentary sources in order to verify the identified reference, clarify its intended meaning, and confirm its translation into architectural form. This procedure reduced dependence on single-source interpretations and strengthened the validity of the analytical classifications. For each case, the claimed source was first verified against at least two independent documentary sources. The first source was used to establish the presence or intentionality of the reference, while the second was used to verify its architectural manifestation. Where architect-authored documentation conflicted with later critical interpretation, the primary source was used to establish design intention, whereas secondary sources were used only to contextualize meaning. Cases for which the source–form relationship could not be corroborated were excluded.

Each case was subsequently examined through the Transformation-Based Formal Reference Framework (TFRF). The analysis focused on identifying the source domain, documenting the processes of interpretation and abstraction, examining the dominant transformation mechanism, and evaluating how these processes were manifested in architectural expression and meaning production. Particular attention was given to the documented relationship between design intentions and built outcomes.

The interpretative approach adopted in this study does not assume that formal references possess fixed or universally accepted meanings. Rather, references are understood as culturally and contextually mediated constructs whose significance emerges through design decisions, architectural representation, and subsequent reception. Accordingly, the analysis sought not only to identify visual similarities between references and architectural forms but also to examine the conceptual relationships connecting source, transformation, expression, and meaning.

By combining multiple documentary sources, triangulation procedures, and a structured interpretative framework, the study establishes a consistent basis for comparing diverse architectural cases while minimizing subjective bias and enhancing analytical transparency.

2.4. Synthesis and Comparative Mapping

Following the individual case analyses, the findings were synthesized through a comparative mapping procedure designed to identify recurring transformation patterns across the case corpus. The objective of this stage was not to develop a new taxonomy of formal references but to examine how different reference domains are transformed through comparable design mechanisms and how similar architectural outcomes may emerge from distinct sources of inspiration.

To operationalize the Transformation-Based Formal Reference Framework (TFRF), each case was evaluated through two analytically distinct dimensions embedded within the framework: degree of abstraction and type of transfer. The operational structure of this procedure is illustrated in Figure 2.

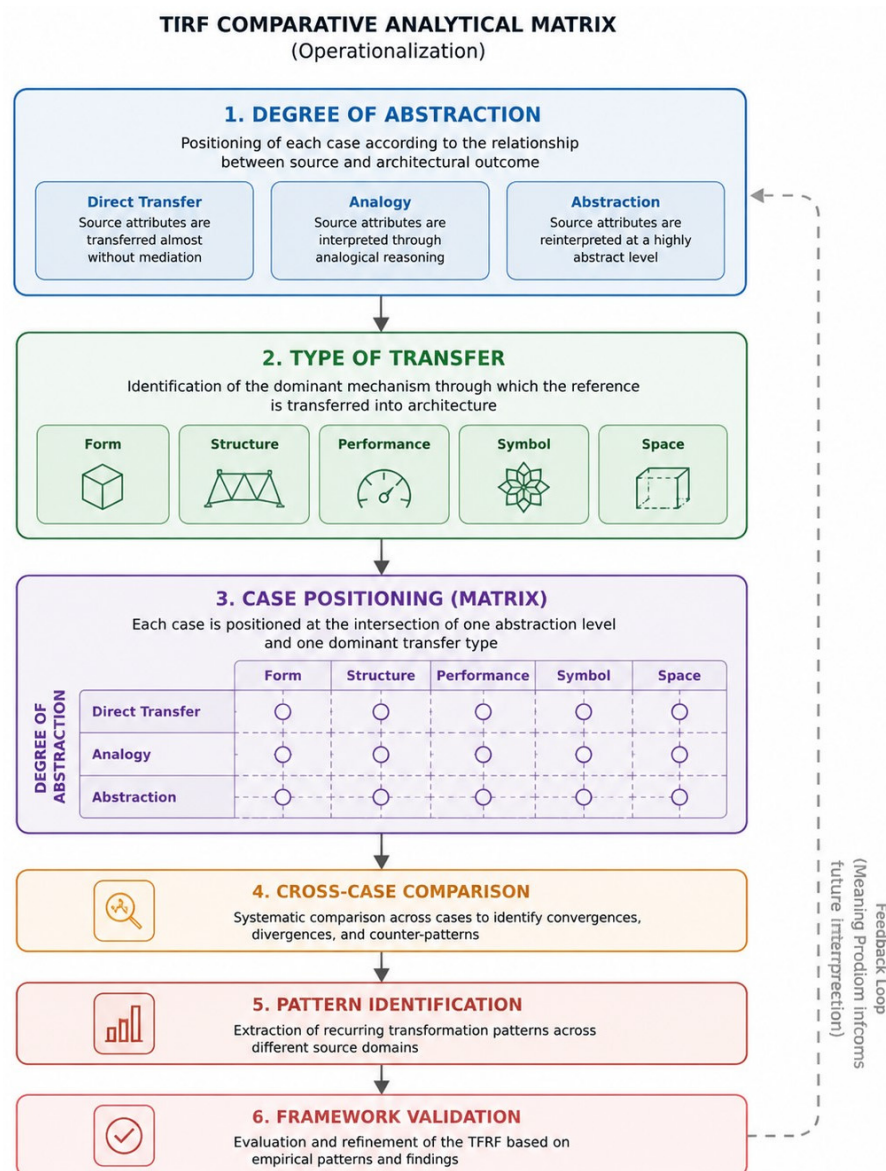


Figure 2. Operationalization of the TFRF: the abstraction $\times$ transfer mapping matrix (source: prepared by the authors).

As shown in Figure 2, the comparative mapping procedure begins with the identification of the degree of abstraction, which evaluates the relationship between the original reference and the resulting architectural expression. Cases were classified as Direct Transfer when source characteristics remained largely recognizable in the architectural outcome, Analogy when selected attributes were translated through interpretative correspondence, and Abstraction when the source was reformulated into conceptual principles with limited visual resemblance.

The second analytical dimension concerns the type of transfer, which identifies the dominant mechanism through which the reference enters the design process. Five transfer categories were employed: Form, Structure, Performance, Symbol, and Space. These categories capture whether the reference primarily influences visual composition, structural organization, environmental behaviour, symbolic meaning, or spatial configuration.

Following the coding process, each case was positioned within the comparative matrix at the intersection of one abstraction level and one dominant transfer type. This procedure enabled projects originating from different source domains to be analysed according to their transformation characteristics rather than their thematic content.

The resulting matrix formed the basis for systematic cross-case comparison, allowing the identification of convergences, divergences, and counter-patterns across the case corpus. Particular attention was given to situations in which different source domains generated similar transformation mechanisms and to cases where a single source domain produced multiple transfer strategies.

The final stage involved pattern identification and framework evaluation. Rather than functioning as isolated examples, the thirty-one architectural cases collectively contributed to evaluating the explanatory capacity of the TFRF and refining the relationships between reference, abstraction, transformation, architectural expression, and meaning production.

By treating source domain and transformation mechanism as analytically distinct dimensions, the comparative mapping procedure shifts the focus from what architects reference to how references are transformed into architecture. Consequently, the matrix serves not only as a classification tool but also as an evaluative mechanism capable of revealing transferable design tendencies across diverse architectural contexts.

2.5. Coding Procedure and Decision Rules

To ensure analytical consistency, all the cases were coded according to two analytically distinct dimensions embedded within the Transformation-Based Formal Reference Framework (TFRF): degree of abstraction and type of transfer.

The first dimension, degree of abstraction, evaluates the relationship between the source domain and the resulting architectural expression. Cases were classified as Direct Transfer when source characteristics remained clearly recognizable, Analogy when selected attributes were translated through interpretative correspondence, and Abstraction when the source was reformulated into conceptual principles with limited visual resemblance.

The second dimension, type of transfer, identifies the dominant mechanism through which the reference enters the design process. Five transfer categories were employed: Form, Structure, Performance, Symbol, and Space.

Each case received one primary classification for abstraction level and one primary classification for transfer type. Coding decisions were based on documentary evidence, including architect statements, project documentation, scholarly publications, drawings, and critical reviews. To reduce subjectivity, classifications were accepted only when supported by at least two independent sources.

Cases presenting multiple plausible interpretations were subjected to secondary review. When disagreement persisted, the classification most strongly supported by documented design intentions was adopted. This procedure ensured transparency, consistency, and comparability across the case corpus.

The resulting coding structure formed the basis for comparative matrix positioning, cross-case analysis, and framework evaluation presented in the following sections.

2.6. Limitations

Several limitations should be acknowledged when interpreting the findings of this study. First, the research adopts a qualitative and interpretative approach; therefore, the identification and classification of formal references inevitably involve a degree of researcher judgment. Although inter-rater coding, documentary triangulation, and explicit decision rules were employed to enhance reliability, alternative interpretations may remain possible in certain cases.

Second, the analysis is based on documentary evidence, including architect statements, project documentation, scholarly publications, and critical reviews. While these sources provide valuable insight into design intentions and architectural outcomes, they

may not fully capture the complete design process or the multiple interpretations that emerge after construction.

Third, the study examines a purposively selected corpus of thirty-one architectural cases. Because the corpus is purposive rather than probabilistic, the scope of generalization is analytical rather than statistical: the findings generalize to the theoretical propositions of the framework, not to a defined population of buildings. In Yin's terms, the cases support analytical generalization, in which results are generalized to theory, and not statistical generalization, in which results are inferred to a population. Consequently, the recurrence of a transformation pattern across the corpus should be read as evidence for the explanatory reach of the framework, not as an estimate of how frequently that pattern occurs in contemporary practice; the findings are transferable conceptual propositions rather than statistically generalizable regularities applicable to all architectural projects.

Finally, the proposed Transformation-Based Formal Reference Framework (TFRF) has been evaluated through qualitative comparative analysis. Future research may further test and refine the framework through larger datasets, computational methods, machine-learning-assisted classification, or quantitative design-analysis techniques.

Despite these limitations, the study provides a systematic and transparent framework for examining how formal references are transformed into architectural form and meaning across diverse design contexts.

3. Source Domains and Illustrative Architectural Cases

The following sections introduce the six source domains through both coded cases and contextual illustrative examples. Only the thirty-one cases listed in the case coding matrix presented in Section 4 form the analytical corpus used in the frequency and cross-case analyses; where a discussed case is part of this corpus, its position is recorded in that matrix and visualized in the corresponding visualization, and it can be cross-referenced with its row in that table. Other examples are included for contextual illustration only and are not part of the coded corpus.

3.1. Living Organisms

Living organisms are among the most abundant reference domains, supplying not only visible forms but also structural systems and organizing principles. The cases below are grouped by sub-source: human, animal, biological, and plant.

3.1.1. Human

Throughout history, humanity has served as a significant source of formal references in building. It can be categorized into various facets, particularly:

a. The Human Form (Overall Shape): in the columns of the Erechtheion Temple (420–393 BC), the caryatids take the form of female figures bearing the roof in place of conventional columns—a direct figural reference carrying, by tradition, a commemorative narrative of the city of Caryae [20] (Figure 3).

The dependence on humans as a source of formal references was not confined to ancient buildings but also encompassed current architecture. A notable instance is the Turning Torso skyscraper (2001–2005) by Santiago Calatrava, whose analytical drawings demonstrate that the architectural concept is inspired by the twisting human torso (Figure 4). The structure was consequently designed as a composition of a sequence of rotated cubes, mirroring this physical motion [21].

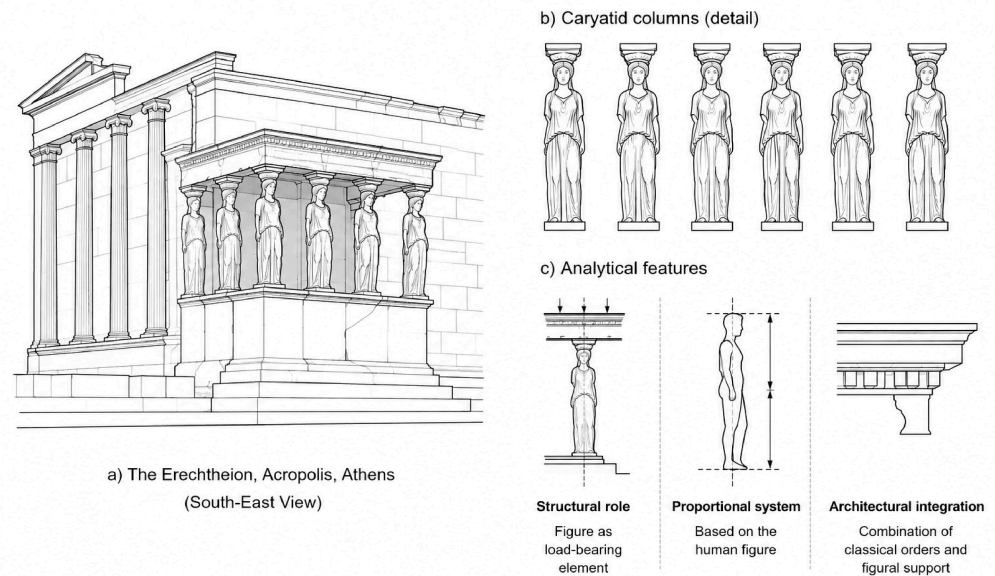


Figure 3. The Erechtheion, Acropolis, Athens: (a) south-east view; (b) Caryatid columns; and (c) analytical interpretation of their structural role, proportional system, and architectural integration. Source: prepared by the authors based on historical architectural documentation.

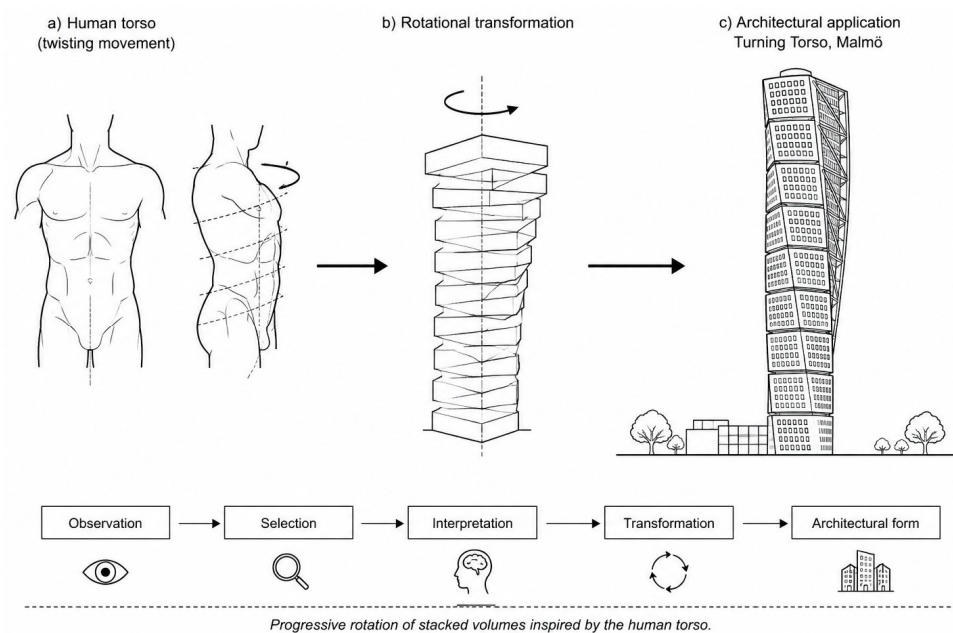


Figure 4. Transformation of the human torso's twisting movement into the progressive rotation of stacked volumes in the Turning Torso, Malmö: (a) human torso and twisting movement; (b) rotational transformation through stacked volumes; and (c) architectural application. Source: prepared by the authors based on published architectural documentation.

b. Human Organs: Human body organs are regarded as significant sources of formal references in architecture. Architectural drawings demonstrate the efforts of certain architects to examine these structures and extract the values and principles they represent, rendering them appropriate as formal design references. An illustration of this is the Science Museum in Valencia, where the eye is used as a formal reference in the compositional design (Figure 5).

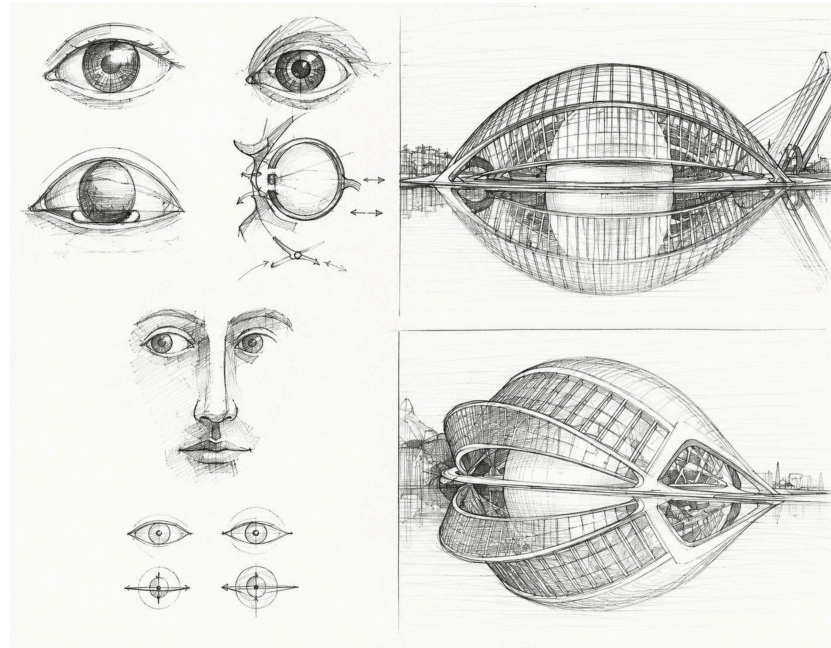


Figure 5. Analytical drawings of the human eye and its architectural translation in the Museu de les Ciències Príncep Felipe, Santiago Calatrava, Valencia: (a) eye anatomy and cross-sectional structure; (b) iris dilation and contraction mechanism; and (c) exterior views of the building's eye-shaped form. Source: prepared by the authors based on published architectural documentation.

Numerous architects have drawn inspiration from human anatomy in their designs, shown by the Brant House in Colorado, which resembles a human visage, and the Nirvana House in Japan by Aida, where the references manifest in an ambiguous or twisted fashion [22].

Conversely, a distinct and overt use of this reference is seen in Kazumasa Yamashita's Face House in Tokyo, where the primary façade exhibits a direct dependence on the human visage, to the extent that no other form is discernible [23].

Additionally, Jencks observes the inclusion of a facial form in the Tokyo Office Building designed by the same architect, where the visage is integrated into the horizontal configuration of the fifth-floor balcony. The designer employed the side profile of the firm president's head as a representation of his primary authority within the corporation [24] (Figure 6).

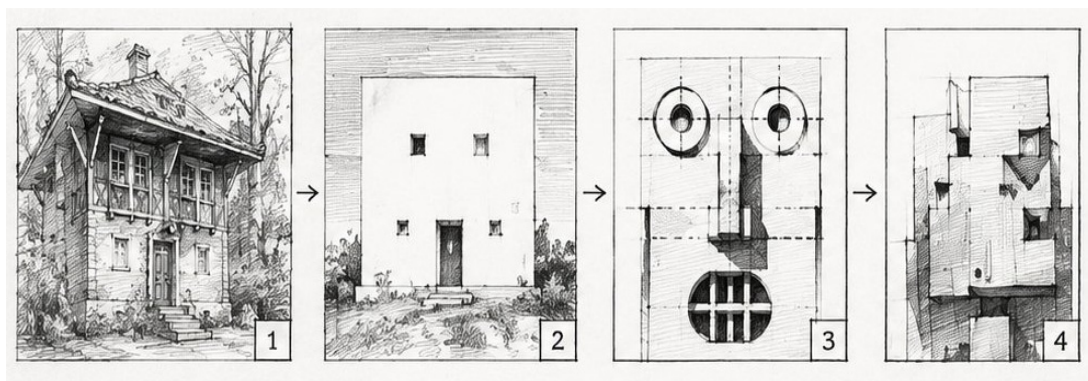


Figure 6. Brant House (1), Nirvana House (2), Face House (3), and Face Building (4). Source: prepared by the authors based on published architectural documentation.

3.1.2. Animal Life

The animal kingdom offers formal sources at two tiers: overall morphology and habitat or behaviour.

a. Animal Morphology (General Configuration): This level is characterized by deriving influence from the overall shapes of animals, encompassing their diverse dynamic postures. A notable instance is the TWA Terminal in New York, whose architecture mimics a bird in the process of landing, symbolizing the concept of flight [25]. Kansai International Airport in Japan exemplifies this, as architect Renzo Piano derived inspiration from a dinosaur's skeleton structure to create the steel pieces that support the roof, thus influencing the building's spatial composition [26] (Figure 7).

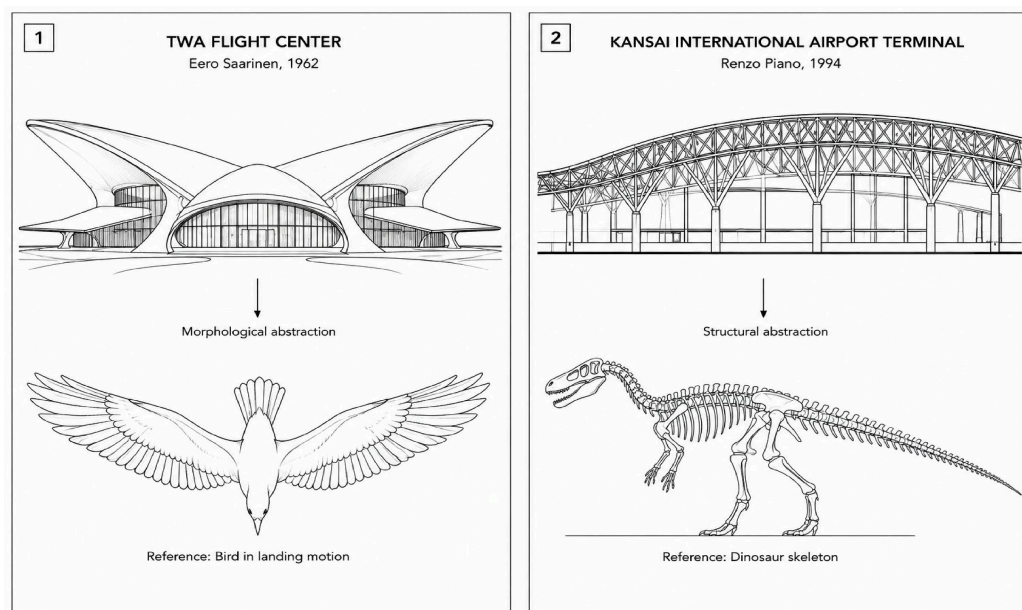


Figure 7. TWA Flight Center, Eero Saarinen, New York (1) and Kansai International Airport Terminal, Renzo Piano, Osaka (2). Source: prepared by the authors based on published architectural documentation.

b. Animal Habitats and Behaviour: Numerous organisms experience environmental conditions akin to those faced by humans, functioning within the constraints of ecological capacity and the availability of resources and energy. Over millions of years, these species have evolved and developed adaptive ways to respond to ongoing changes, offering a substantial repository of models for designers to utilize in addressing design difficulties.

A notable instance is the Beijing National Stadium (Bird's Nest) in China, which derives its structural concept from the shape of a bird's nest. The stadium's roof was engineered as a lattice steel framework featuring hollow segments [26,27]. The Munich Olympic Stadium complex, designed by Frei Otto, exemplifies the notion of lightweight and adaptable constructions inspired by spider webs, facilitating the construction of flexible edifices utilizing few resources and allowing for easy disassembly [16] (Figure 8).

3.1.3. Biology

Formal references in this field encompass tiny biological entities, including cells and DNA, by elucidating the fundamental principles that might inform architectural structures. This methodology is distinctly evident in the principles of the Metabolist movement, whose founders championed that architectural creation should encapsulate the potential for expansion, evolution, and the substitution of its elements. This viewpoint perceives

architecture as an extension of natural life cycles, wherein human civilization constitutes a segment of the universe's continuity [19,28].

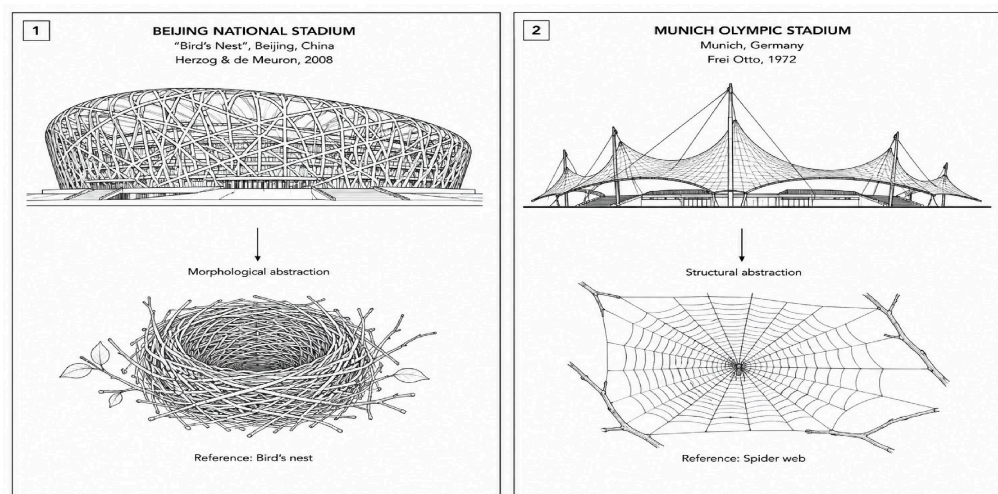


Figure 8. Beijing National Stadium (Bird's Nest), Herzog & de Meuron (1) and spider-web structures (2). Source: prepared by the authors based on published architectural documentation.

The Nakagin Capsule Tower in Tokyo, designed by Kisho Kurokawa, exemplifies inspiration drawn from the cellular life cycle, emphasizing division and regeneration. The structure has two towers linked to interchangeable modular residential capsules, embodying the principles of development and renewal in architecture [19,21].

Additionally, certain architects have utilized DNA as a formal reference, exemplified by James Law's proposal for DNA Towers in Abu Dhabi, where the towers' external form is derived from the helical structure of DNA, representing the city's future growth and urban development [29] (Figure 9).

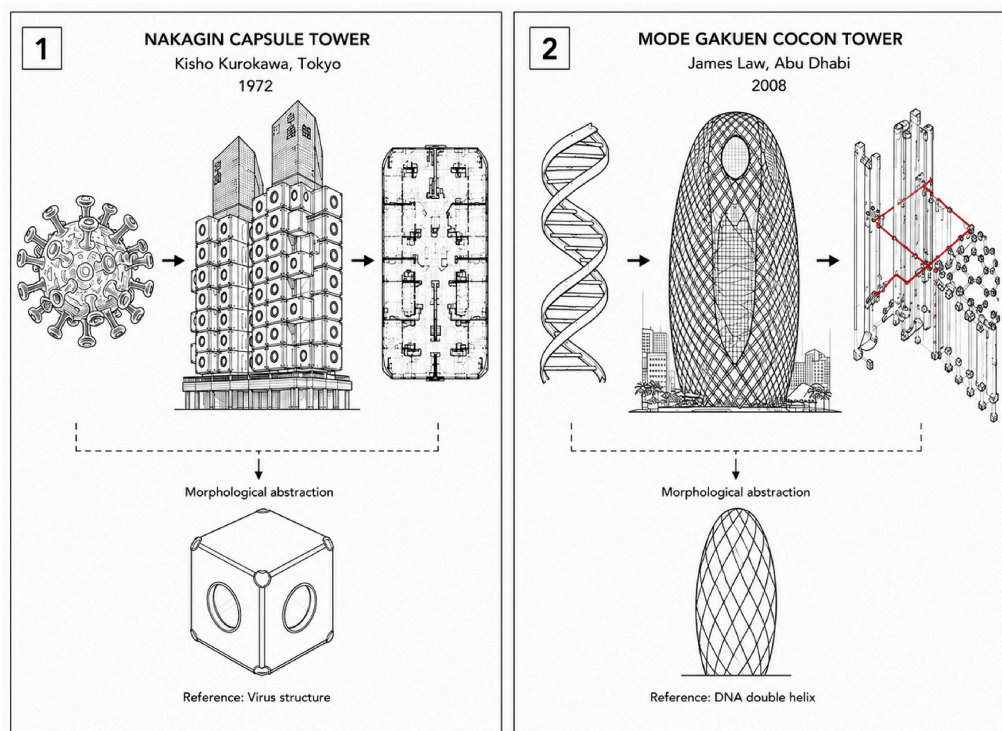


Figure 9. Nakagin Capsule Tower, Kisho Kurokawa, Tokyo (1) and DNA Towers, James Law, Abu Dhabi (2). Source: prepared by the authors based on published architectural documentation.

3.1.4. Plants

The plant world offers formal sources that extend beyond appearance to structural and organizational principles—a point stressed by Wright, who held that nature yields principles to be extracted rather than ready-made solutions [17].

Similarly, Louis Sullivan called for a return to nature to learn from its inherent logic, admiring its coherence, integration, and the harmony among its parts. He regarded the study of natural principles as a fundamental source of inspiration in architectural design [18]. Accordingly, many architects have relied on plants as a source for their designs, both at the level of formal composition and urban planning.

a. From a Formal Perspective: This approach is exemplified in the Lotus Temple (Baha'i House of Worship) in India, whose design was inspired by the lotus flower due to its strong symbolic significance in Indian culture, representing purity, peace, and immortality. The temple is surrounded by water pools, enhancing the perception of the structure as if it were floating like a lotus flower [21,30] (Figure 10).

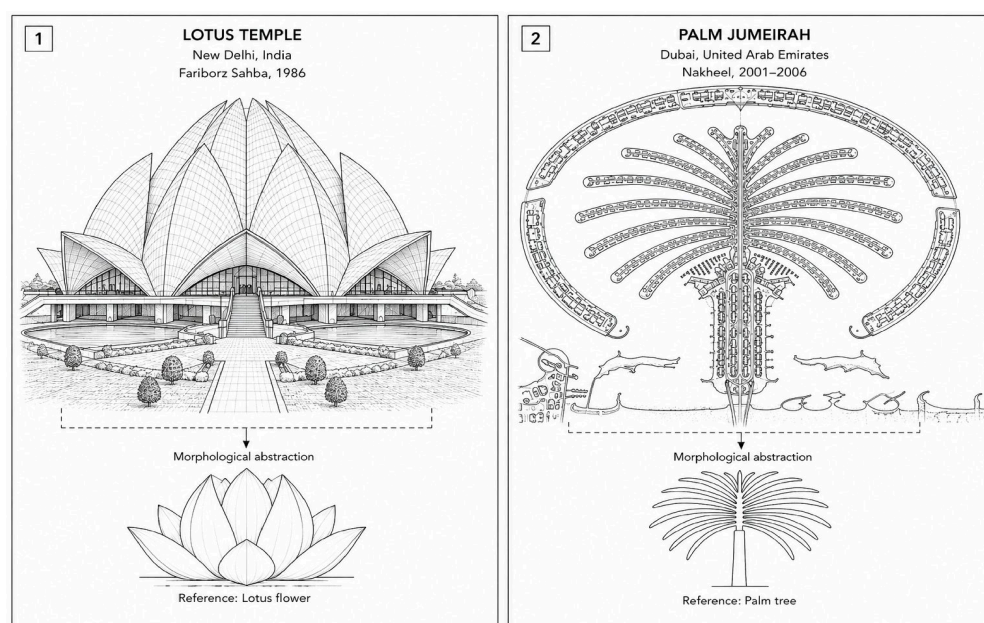


Figure 10. Lotus Temple (Baha'i House of Worship), Fariborz Sahba, New Delhi (1) and Palm Jumeirah, Dubai, United Arab Emirates (2). Source: prepared by the authors based on published architectural documentation.

b. From an Intellectual Standpoint (Adaptation and Problem-Solving Methodology): This level draws influence from the conceptual ideas of plants, specifically their capacity to adapt to ambient conditions and respond to surrounding difficulties. An illustration of this is the Qizhong Arena in Shanghai, whose roof comprises eight components that resemble the petals of a white magnolia blossom. The roof features a foldable steel system, with each petal articulating and rotating around a pivot supported by three rods, mimicking the blooming motion of a flower in reaction to climatic conditions, and symbolically representing the city's growth and urban prosperity [31,32] (Figure 11).

3.2. Cosmos and Geographical Formations

This source can be categorized into numerous primary classifications, most notably:

a. The Universe, Celestial Sphere, Stars, and Natural Occurrences: This level is characterized by borrowing influence from celestial shapes and natural occurrences. An exemplary instance is the London City Hall by Norman Foster, wherein the inner space is conceived

as a spiralling (helical) structure, grounded on elliptical geometries and dynamic patterns influenced by natural phenomena such as the cosmos and storms [24,33] (Figure 12).

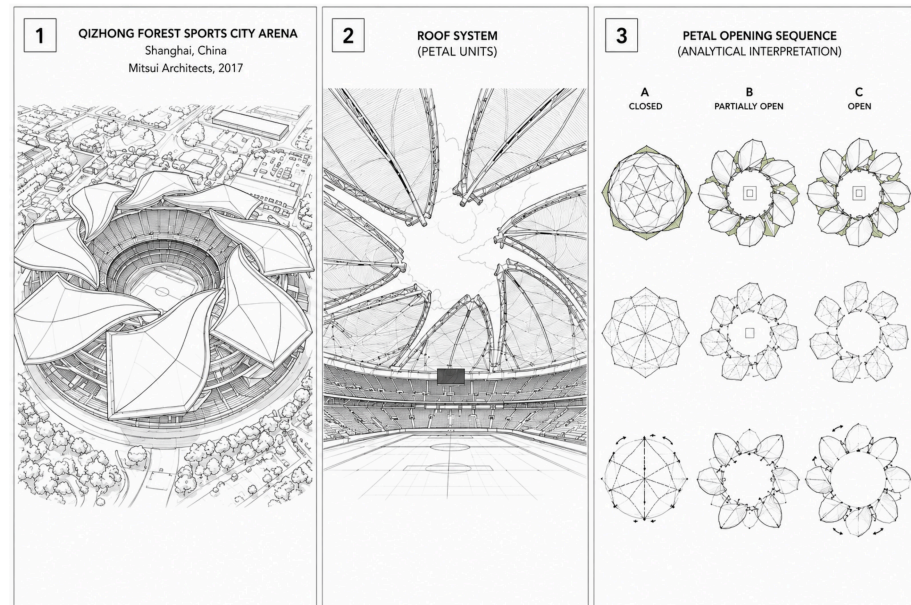


Figure 11. Qizhong Forest Sports City Arena, Shanghai, Mitsui Architects (1), its magnolia-petal roof system (2), and the petal-opening sequence (3). Source: prepared by the authors based on published architectural documentation.

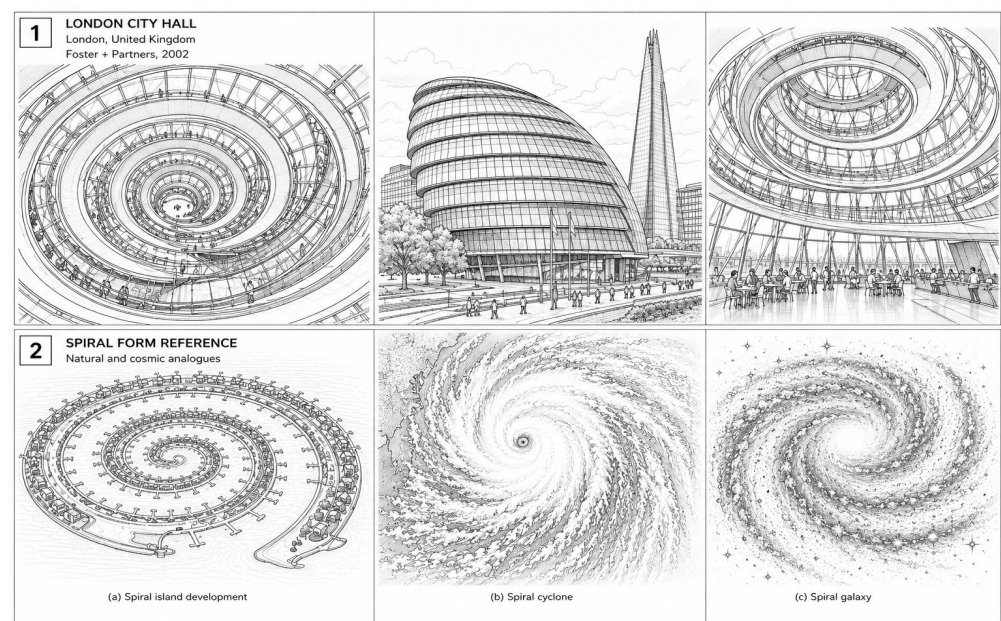


Figure 12. London City Hall, Norman Foster, London (1) and spiral form references in nature and the cosmos: spiral island development, spiral cyclone, and spiral galaxy (2). Source: prepared by the authors based on published architectural documentation.

b. Earth and Topography: The earth, with its mountains, valleys, and diverse landforms, represents an important source of formal references in architecture, offering rich models that can be utilized in architectural composition. A notable example is the Aqua Tower in Chicago by Jeanne Gang, which is distinguished by its sculptural form inspired by the rock formations of the Great Lakes region.

The projections of the balconies vary along the height of the tower, creating undulating forms that reflect the geological characteristics of limestone in the area, giving the building a dynamic appearance that evokes natural landforms [34,35] (Figure 13).

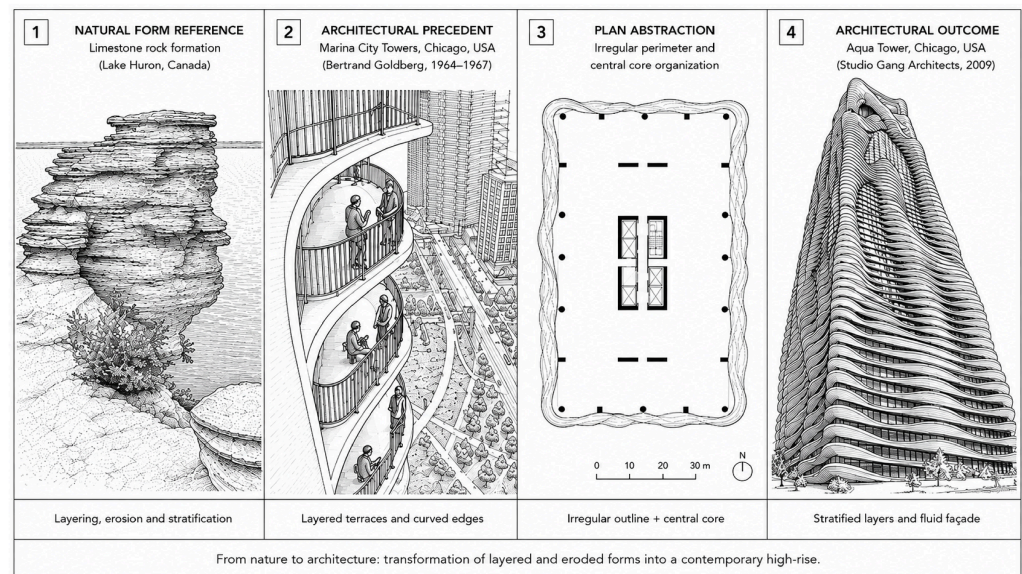


Figure 13. Natural form reference: limestone rock formation, Lake Huron (1); architectural precedent: Marina City Towers, Bertrand Goldberg, Chicago (2); plan abstraction (3); and architectural outcome: Aqua Tower, Studio Gang, Chicago (4). Source: prepared by the authors based on published architectural documentation.

c. Water: Water elements—such as droplets, waves, and their various states like ice—are considered important sources of formal references in architecture due to their dynamic properties and diverse geometric formations. A notable example is the floating house in Portland designed by Robert Oshatz, whose fluid form reflects the curves of the Columbia River, directly emulating the movement of water [36] (Figure 14).

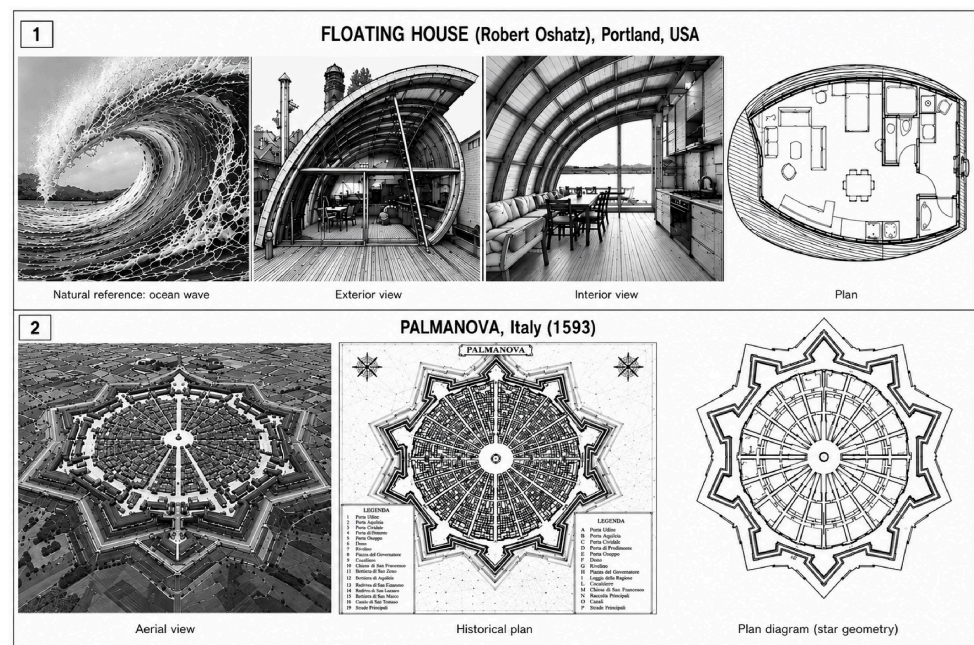


Figure 14. Floating House, Robert Oshatz, Portland (1) and Palmanova, Italy, 1593 (2). Source: prepared by the authors based on published architectural documentation.

3.3. Language

Language supplies formal references through three channels—the shapes of letters and words, narrative stories, and myths—each translated into architecture in a different way.

a. Letters and Words: The forms of alphabetic letters can be utilized to address site-related challenges, organize functional elements, and guide architectural massing. An example of this is the Walter Towers in Toronto, Canada, where the design was based on the shape of the letter (W) as a direct reference to the project's name [24].

Some letters also embody geometric relationships that align with structural requirements. This is evident in the Palazzetto dello Sport in Rome, where the architect employed the form of the letter (Y) in designing the structural supports that carry the roof, reflecting an integration between form and function [37,38] (Figure 15).

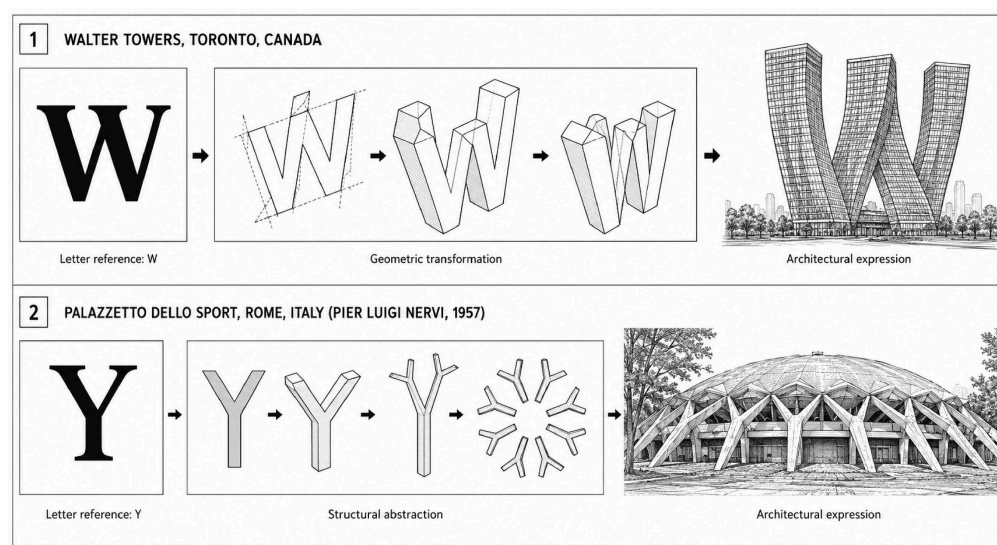


Figure 15. Walter Towers, Toronto, Canada (1) and Palazzetto dello Sport, Pier Luigi Nervi, Rome (2). Source: prepared by the authors based on published architectural documentation.

In this context, the New Basra Cultural Palace project represents a clear example of employing language as a source of formal reference in architectural design. The designer indicates that the concept was derived from two main aspects:

1- Arabic calligraphy: This is reflected in the openings distributed across the building's façades, inspired by the "dots" in Arabic letters, expressing the uniqueness of the Arabic language and its role in disseminating culture [39].

2- Books and Arab culture: This is evident in the building's internal composition, where curved spaces resemble the pages of an open book, symbolizing the historical and cultural role of the city of Basra.

Thus, the designer moved away from directly imitating traditional architecture and instead relied on the cultural context through linguistic and intellectual elements, achieving a synthesis between contemporary architectural expression and Arab cultural identity [2,39] (Figure 16).

b. Stories: Narratives and stories represent significant sources of formal references in architecture due to their symbolic richness and their ability to translate meanings into expressive architectural forms. A prominent example is the Romeo and Juliet project by Peter Eisenman, where the design concept was closely linked to Shakespeare's Romeo and Juliet, taking the original setting as a reference framework.

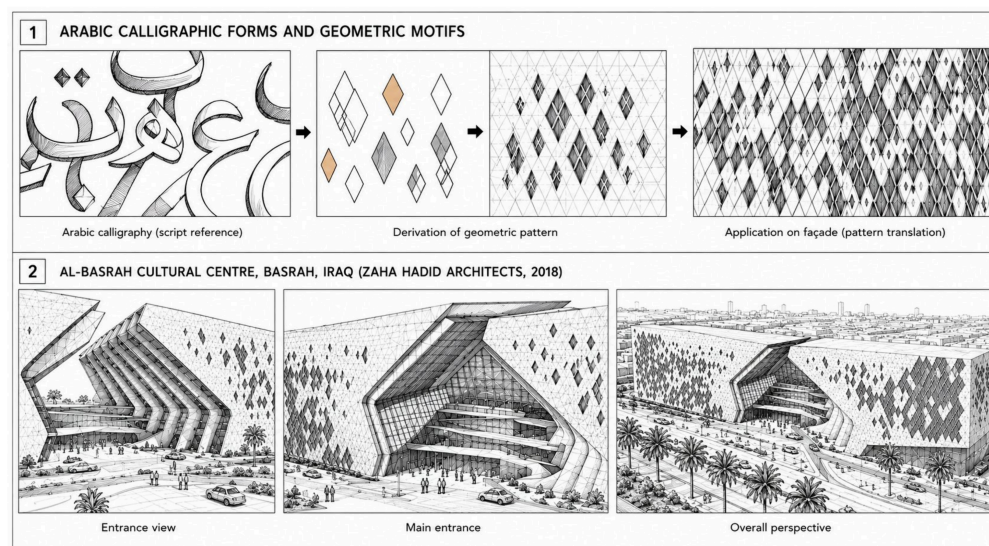


Figure 16. Arabic calligraphic forms (1) and the Al-Basrah Cultural Centre, Basra (2). Source: prepared by the authors based on published architectural documentation.

Through this project, Eisenman sought to express the city of Verona and his own interpretation of it by drawing on the structure and events of the play. Consequently, the architectural forms were transformed into signs and symbols that reflect the sequence of the narrative and convey its underlying meanings [14,24] (Table 4).

Table 4. Narrative references and their architectural representations in Eisenman’s Romeo and Juliet project (Source: prepared by the authors based on [14]).

Architectural Form	Narrative Source	Represented Concept	Role in the Narrative Structure
Church	Romeo and Juliet	Union	Spatial representation of the protagonists’ marriage.
Juliet’s House	Romeo and Juliet	Separation	Symbolic point of departure and social division.
Juliet’s Tomb	Romeo and Juliet	Dialogue	Setting of the final encounter and narrative resolution.

The components of the narrative text consist of the old city of Verona, Romeo’s palace, Juliet’s palace, as well as the church and the cemetery. Eisenman reinterpreted this narrative by relocating it from its original context in Verona to the new project site in the city of Montague, while preserving its symbolic structure and narrative meanings [14].

The story revolves around three main themes: encounter, separation, and dialogue, which are reflected in a clear spatial and architectural sequence within the project, as follows:

1. The Adige River, which divides the city into two parts, symbolizes the separation between the families of Romeo and Juliet.
2. The placement of Romeo’s palace outside the boundaries of Juliet’s palace reflects the concept of exclusion and separation.
3. The integration of the urban fabric on both sides of the river expresses the idea of union.
4. The palace towers symbolically represent the houses of Romeo and Juliet in Verona.
5. The main axis of the city embodies the concept of union, with the church located along it.
6. The cemetery includes a symbolic reference to Juliet’s house (her tomb).

The project also incorporates a set of internally unresolved architectural configurations, reflecting tension and dialogue between the narrative's characters, thus translating the dramatic structure of the story into architectural form [14,40] (Figure 17).

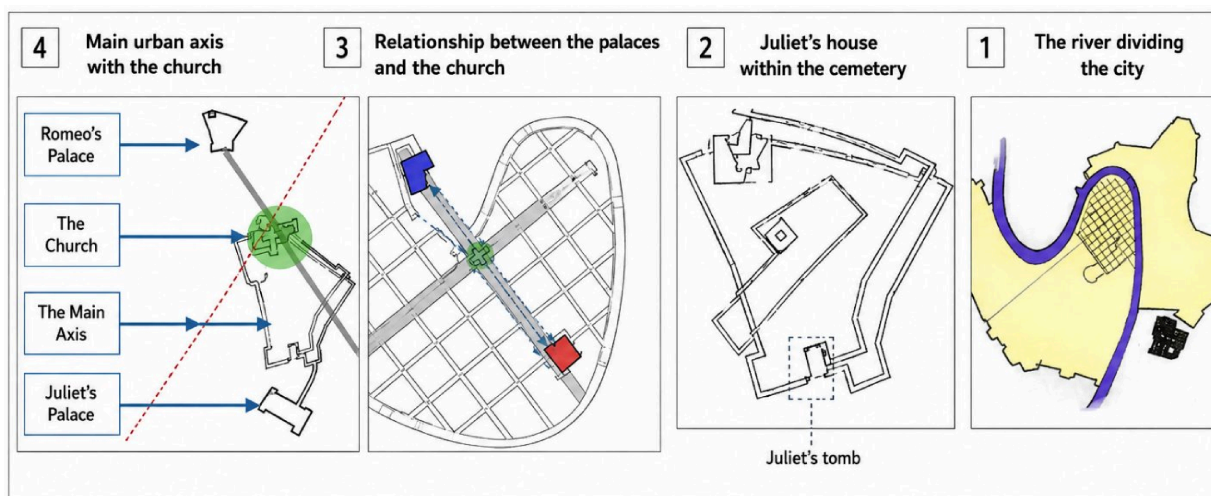


Figure 17. Peter Eisenman's Romeo and Juliet project, Verona: the dividing river (1), Juliet's tomb (2), the palaces and church (3), and the main urban axis (4). Source: prepared by the authors based on published architectural documentation.

c. Myths: Myths offer layered symbolic references, read first by the designer and then by the recipient, and have long prompted architects to reinterpret them in expressive form.

Among the architects who relied on myths as a source of reference is Mies van der Rohe, who was deeply influenced by Greek architecture. He acknowledged in his writings that myths constitute one of the fundamental drivers in shaping his architectural language. This influence is evident in the German Pavilion in Barcelona, which reflects inspiration from the Greek myth of the Labyrinth. The myth narrates the victory of the hero Theseus over the monster within the maze, guided by the thread of Ariadne, which led him out toward the light [2,41].

This concept is translated architecturally through the project's spatial composition, characterized by interconnected sequences and layered pathways that guide movement through the space toward open and illuminated areas [2,41] (Figure 18).

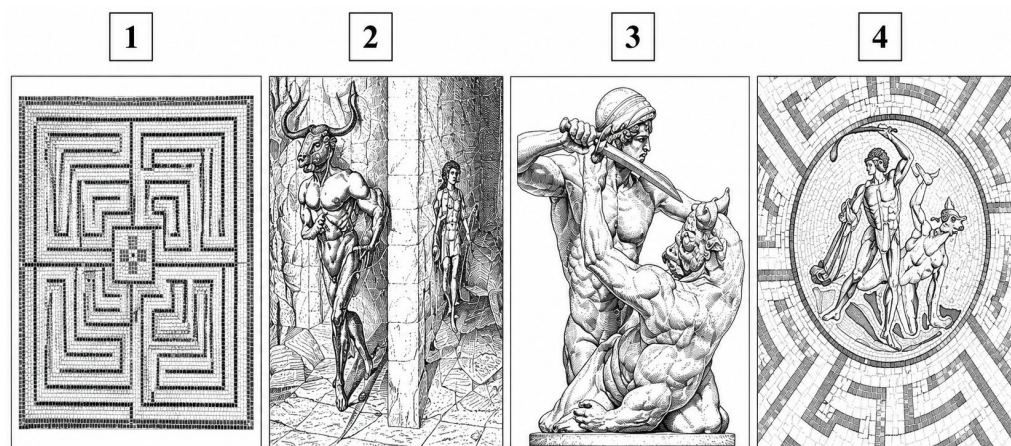


Figure 18. The Theseus and Minotaur narrative: the Cretan labyrinth (1), the encounter (2), the battle (3), and the hero's victory (4). Source: prepared by the authors based on published architectural documentation.

The critic also highlights the architect's influence from Greek palatial architecture, particularly its composition of interconnected elements such as rooms, courtyards, water features, and subterranean labyrinths. Mies was notably inspired by the Palace of Knossos, reflected in the pavilion's elevated platform. The spatial organization of the pavilion exhibits labyrinth-like qualities, including horizontal extension, fluidity, dim lighting, and asymmetry, all of which evoke the movement patterns within a maze. Through this approach, the design successfully reinterprets the spirit of Greek architecture using simple elements and modern materials, reviving the memory of Knossos in a contemporary architectural language [2,42] (Figure 19).

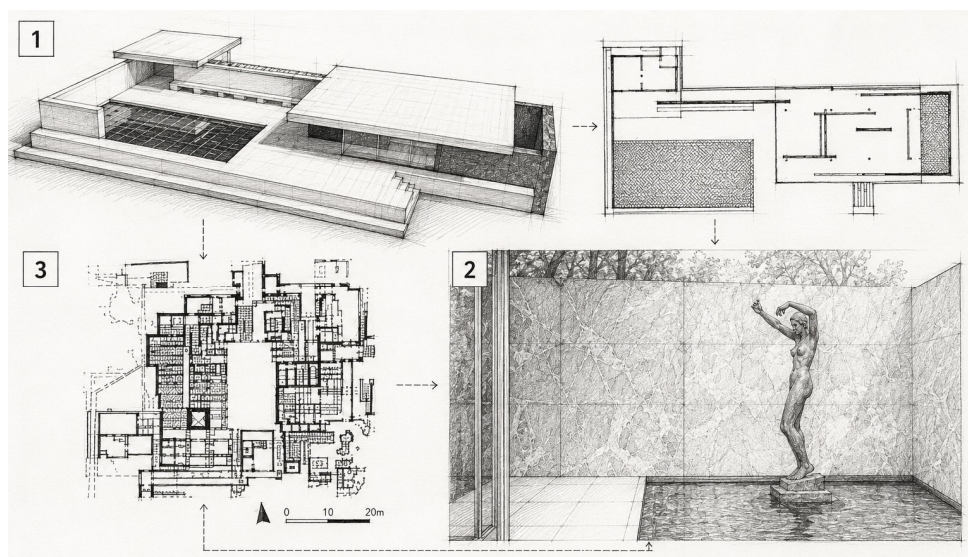


Figure 19. German Pavilion, Mies van der Rohe, Barcelona (1), the symbolic spatial core (2), and the Palace of Knossos (3). Source: prepared by the authors based on published architectural documentation.

3.4. Belief Systems (Religion and Ideologies)

Belief systems are a key source of formal references in architecture, shaping its symbolic expressions and design concepts. This source can be classified into several main categories based on its influence on architectural form.

a. Religious Symbols: Religious symbols are among the most important sources of formal references in architecture, as they are reflected in the organization of architectural plans in ways that express doctrinal meanings. A prominent example is Christian church architecture, where the layout often takes the form of a cross as a symbolic representation of the faith, despite variations among denominations. This is clearly illustrated in St. Peter's Basilica in the Vatican, whose plan embodies this symbolism in an abstract manner [5,43] (Figure 20).

Religious symbols in Islamic architecture are manifested through architectural elements that carry clear symbolic meanings. Among these are mosque balconies known as “arā’is,” which express the unity and cohesion of worshippers, resembling a solid, inter-linked structure [5]. This symbolism is evident in many contemporary examples, including the Sheikh Zayed Mosque in Abu Dhabi.

The use of religious symbolism is also reflected in the Conceptual Mosque project by Manço Architects, proposed for a competition held in Türkiye in 2010, where it won the WA Award (Cycle 8). The design was inspired by the Kaaba and expressed as a simple cube symbolizing humility. The cube was tilted toward the qibla to represent the movements of prayer, particularly prostration, offering a direct symbolic expression [44,45] (Figure 21).

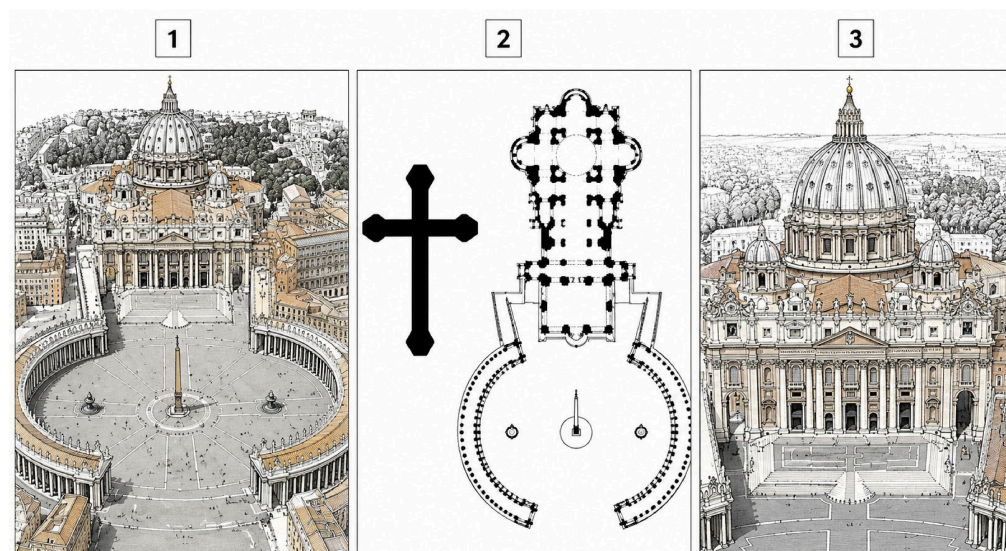


Figure 20. St. Peter's Square and Basilica, Vatican City (1), the cross-plan correspondence (2), and St. Peter's Basilica (3). Source: prepared by the authors based on published architectural documentation.

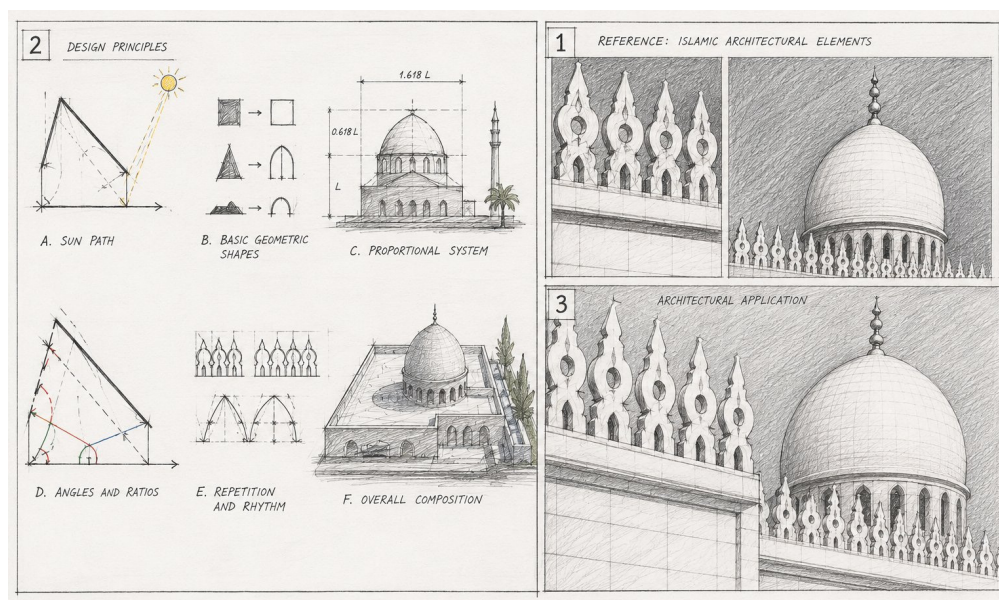


Figure 21. Reference: Islamic architectural elements (1); design principles (2); and architectural application (3), illustrated through a mosque design inspired by Islamic geometric and formal traditions. Source: prepared by the authors based on published architectural documentation.

b. Religious Beliefs: Religious beliefs are influential sources in shaping architecture, as their doctrinal concepts are reflected symbolically in architectural compositions. A prominent example is the Jubilee Church in Rome, designed by Richard Meier, which was inspired by the Christian doctrine of the Trinity (Father, Son, and Holy Spirit). This belief is expressed architecturally through three primary elements represented by the white sails.

The architect intentionally avoided making these elements equal in size; instead, they vary in height and width, reflecting the hierarchical order of the Trinity. The largest sail covers the main nave, symbolizing the dominance of God the Creator (the first hypostasis). The middle sail covers the daily chapel and confession rooms, representing the role of Christ (the second hypostasis) in granting repentance and forgiveness. The smallest sail covers the baptismal area, symbolizing the blessing of the Holy Spirit (the third hypostasis) in the rite of baptism [1,2] (Figure 22).

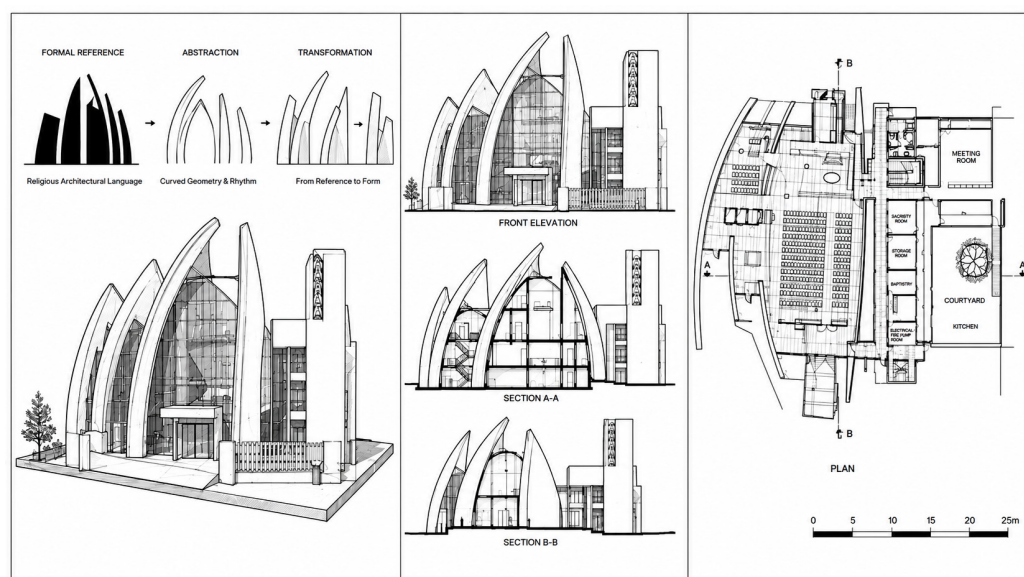


Figure 22. Jubilee Church, Richard Meier, Rome: formal reference, abstraction, and transformation (**top left**); exterior view (**bottom left**); front elevation and sections A–A and B–B (**centre**); and floor plan (**right**). Source: prepared by the authors based on published architectural documentation.

c. Sacred Religious Texts: Sacred religious texts represent an important source of formal references in architecture, as their meanings and spiritual connotations are translated into architectural forms that express their underlying messages. An example of this is the proposed Dar Al-Qur’an building in Medina, where the design concept was inspired by the Qur’anic verse: “Had We sent down this Qur’an upon a mountain, you would have seen it humbled and split asunder from fear of Allah” (Surah Al-Hashr: 21).

This meaning is reflected in the architectural composition, where the building is designed to resemble a fractured rock mass, symbolically evoking the image of the mountain. These fissures are also utilized to create visual contrast between solid and void, as well as to introduce natural light into the interior spaces, enhancing both the expressive and functional aspects of the design [2] (Figure 23).

d. Religious Narratives: Religious narratives represent rich sources that contribute to shaping formal references in architecture due to their deep symbolic meanings and their potential for architectural expression. An example of this is the Guggenheim Museum in Bilbao, designed by Frank Gehry, where critic Hugh Pearman suggests that the design may have been influenced by the story of the Flood. This narrative recounts how the Prophet Noah and selected living creatures were saved aboard the Ark, which eventually came to rest, marking the beginning of a new era.

From this perspective, the museum can be interpreted as a contemporary representation of Noah’s Ark, with its curved forms resembling the hull of a ship, symbolizing salvation and transition toward safety. Pearman argues that Gehry intended the museum to function as a “vessel” that carries visitors through an architectural experience toward a place of refuge and inspiration [1,46].

This interpretation is further reinforced by the museum’s location in the city of Bilbao, historically known for its shipbuilding industry, which adds a contextual dimension to the design concept [47] (Figure 24).

Pearman extends the reading to the museum’s outdoor sculptures—animal figures interpreted as the “gathering” before the Flood (Figure 25).

Some critics who support this interpretation suggest that Frank Gehry abstracted the rainbow that appeared in the sky after the Flood and transformed it into an architectural

element in the form of a pedestrian bridge that wraps around the museum, symbolizing the beginning of a new era [1,46].

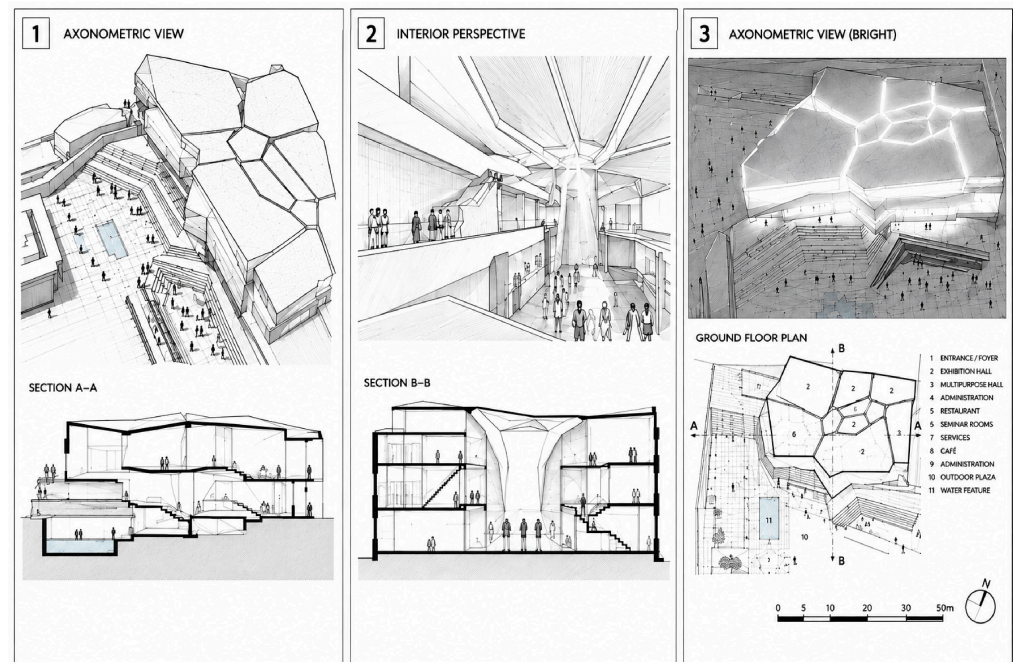


Figure 23. Proposed Dar Al-Qur'an Headquarters, Al-Madinah Al-Munawwarah (1–3). Source: prepared by the authors based on published architectural documentation.

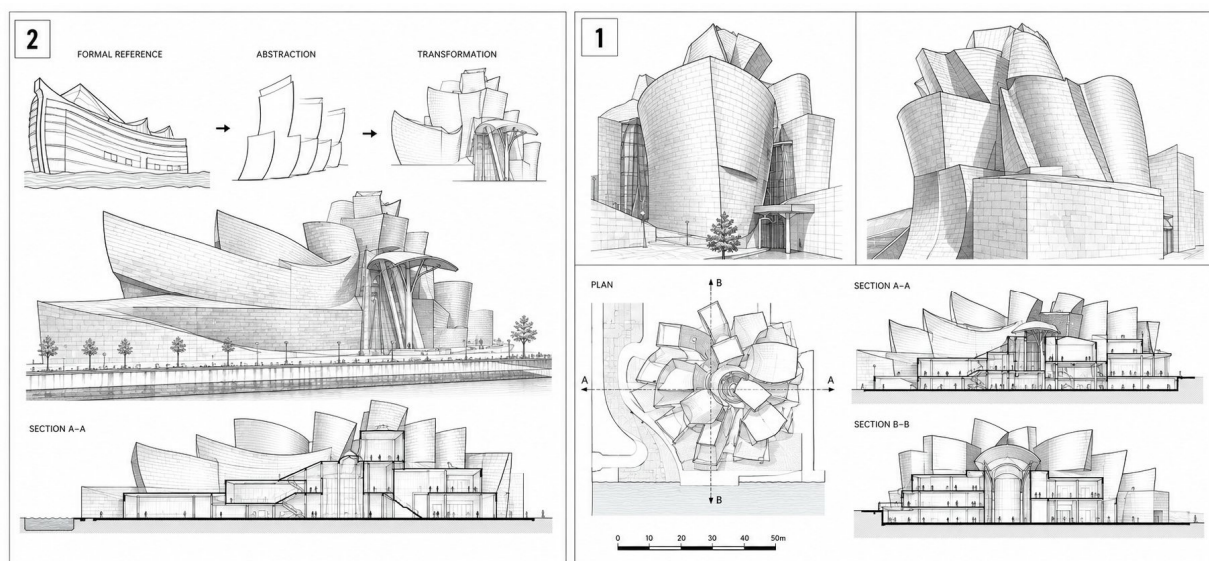


Figure 24. Guggenheim Museum Bilbao, Frank Gehry, Bilbao (1) and the interpretation of Noah's Ark (2). Source: prepared by the authors based on published architectural documentation.

3.5. Precedent Architecture

Precedent architecture—both traditional and contemporary—along with its architectural principles, is considered an important source of formal references in architecture. Architects draw upon their accumulated formal and structural values to reinterpret them within modern contexts.

An example of this is the Sana'a Commercial Center in Sana'a, where elements of local architectural heritage were incorporated, such as windows topped with semi-circular qa-

mariyyah, horizontal and vertical decorative patterns, arches, muqarnas, and articulated mass endings, reflecting a direct inspiration from traditional architecture [48].

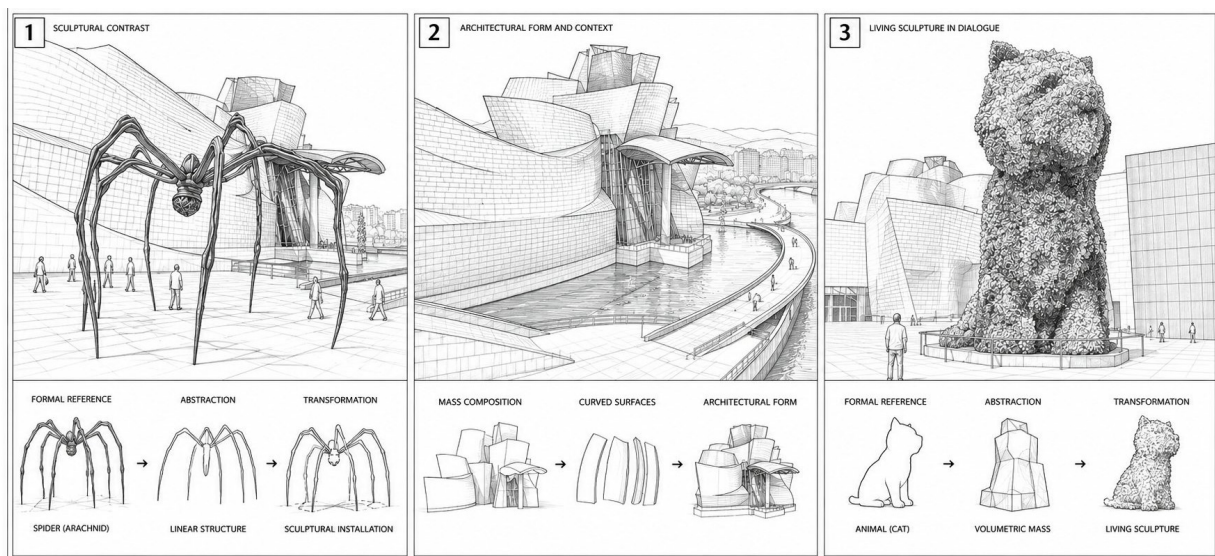


Figure 25. Outdoor installations at the Guggenheim Museum Bilbao: Maman (1), the museum and its landscape (2), and Puppy (3). Source: prepared by the authors based on published architectural documentation.

This approach is also evident in the design of the new headquarters of the Supreme Constitutional Court in Cairo by architect Ahmed Mito, which draws on elements of ancient Egyptian architecture, reinterpreted within a contemporary architectural framework [2,49] (Figure 26).

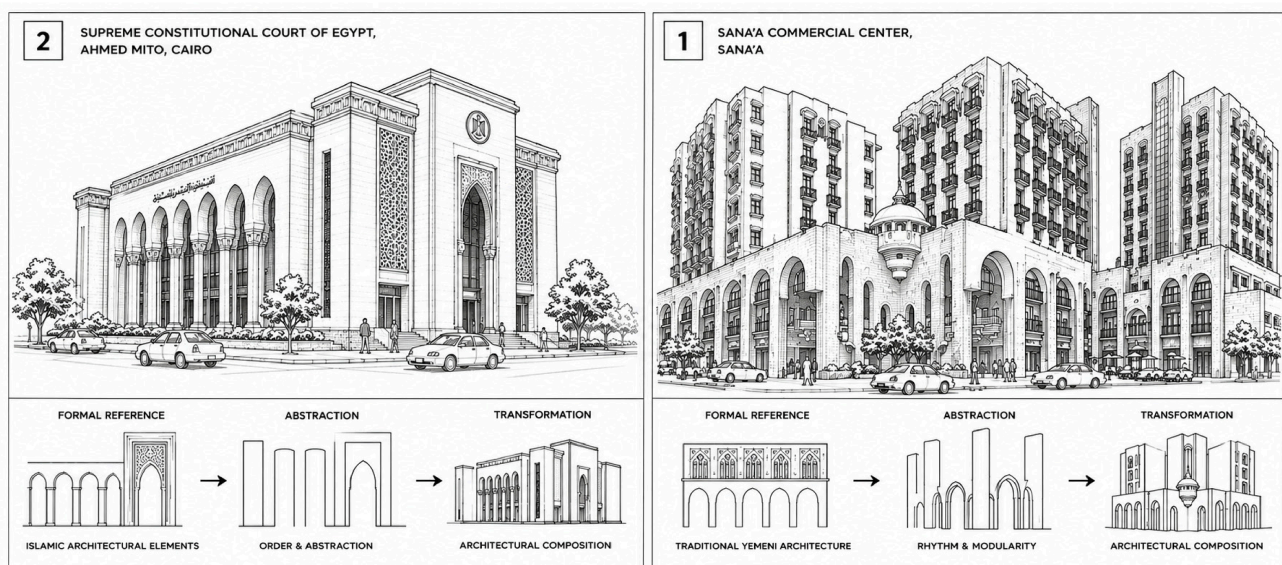


Figure 26. Sana'a Commercial Center, Sana'a (1) and the Supreme Constitutional Court of Egypt, Ahmed Mito, Cairo (2) (Source: adapted by the authors from [49]).

3.6. Human-Made Products

Human-made products are considered important sources of formal references in architecture, as architects draw inspiration from their forms and functional mechanisms to develop contemporary design solutions. This source can be classified into several categories:

3.6.1. Machines and Their Products

Some designers have relied on machine forms as a source of inspiration, as seen in the United Overseas Bank building in Bangkok, which was inspired by the image of a robot to express the speed and precision of banking operations [1]. Others have drawn inspiration from the functioning of machines themselves, as in dynamic architecture, such as rotating residential buildings that reflect movement and continuous transformation [50].

The Dynamic Tower in Dubai illustrates this principle most explicitly. Each of its floors is mounted on an independent mechanism that allows it to rotate a full turn around a fixed central core, and because the floors turn separately and at different speeds, the overall silhouette of the building is never fixed: its massing continuously shifts, twisting and re-forming as the individual levels move out of alignment with one another. The reference here is therefore not to the appearance of a machine but to its operation. By translating the mechanical logic of continuous motion into the building's very form, the design makes movement and transformation themselves the architectural idea, so that the tower is experienced as an object in perpetual change rather than a static mass [50].

3.6.2. Tools and Inanimate Objects

Designs have also been inspired by tools and inanimate objects. A prominent example is the Burj Al Arab in Dubai, whose location on an artificial island in the sea inspired its sail-like form, symbolizing maritime navigation—one of the city's most significant historical activities [1,6] (Figure 27).

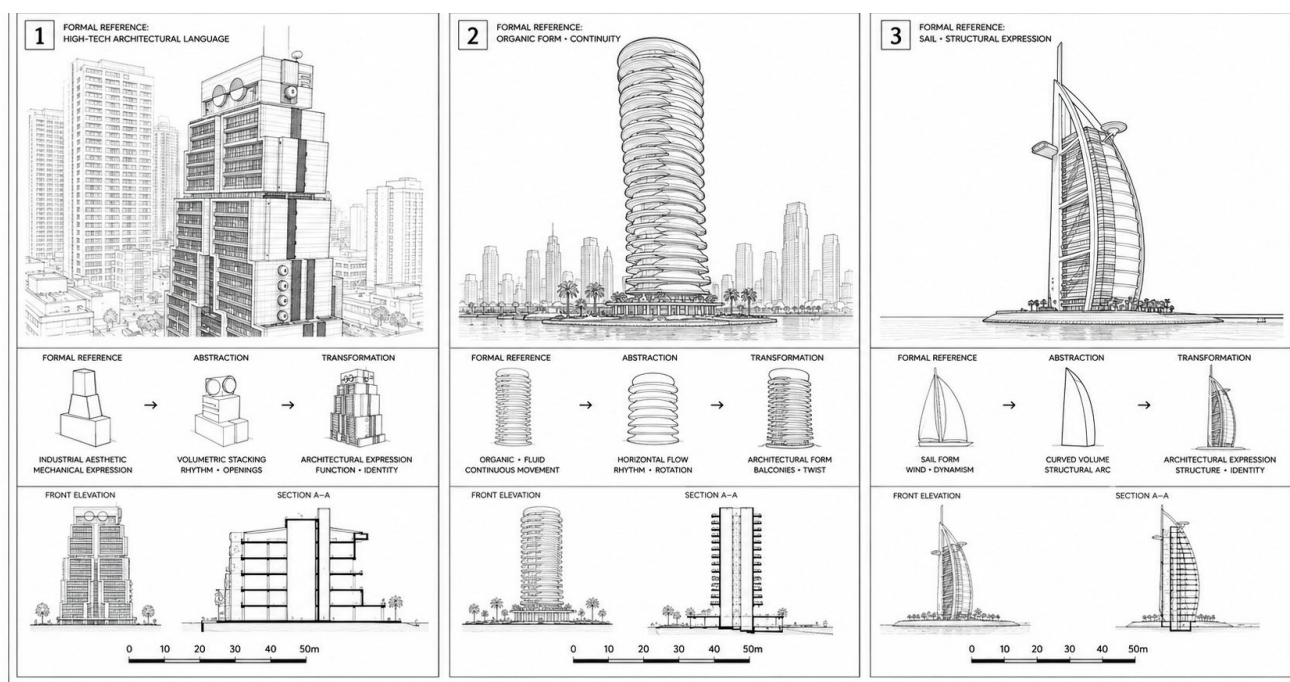


Figure 27. Robot Building, Bangkok (1), Dynamic Tower proposal, Dubai (2), and Burj Al Arab, Dubai (3). Source: prepared by the authors based on published architectural documentation.

3.6.3. Arts

Arts are considered important sources of formal references in architecture and can be classified into several categories, including:

a. Painting: Some architects show clear influence from artistic works, as seen in Peter Eisenman's inspiration from *The Creation of Adam* by Michelangelo, which depicts the moment of giving life to Adam by the Creator. Eisenman was particularly intrigued by the small gap between the hand of God and that of Adam, which symbolically represents the distinction between divine power and human fragility.

Based on this idea, Eisenman translated the concept of “non-contact” into the design of interior spaces, deliberately separating certain non-load-bearing structural elements from other spatial components. This reflects a symbolic interpretation of the separation between the divine and the human, expressing a philosophical dimension beyond mere form [1] (Figure 28).

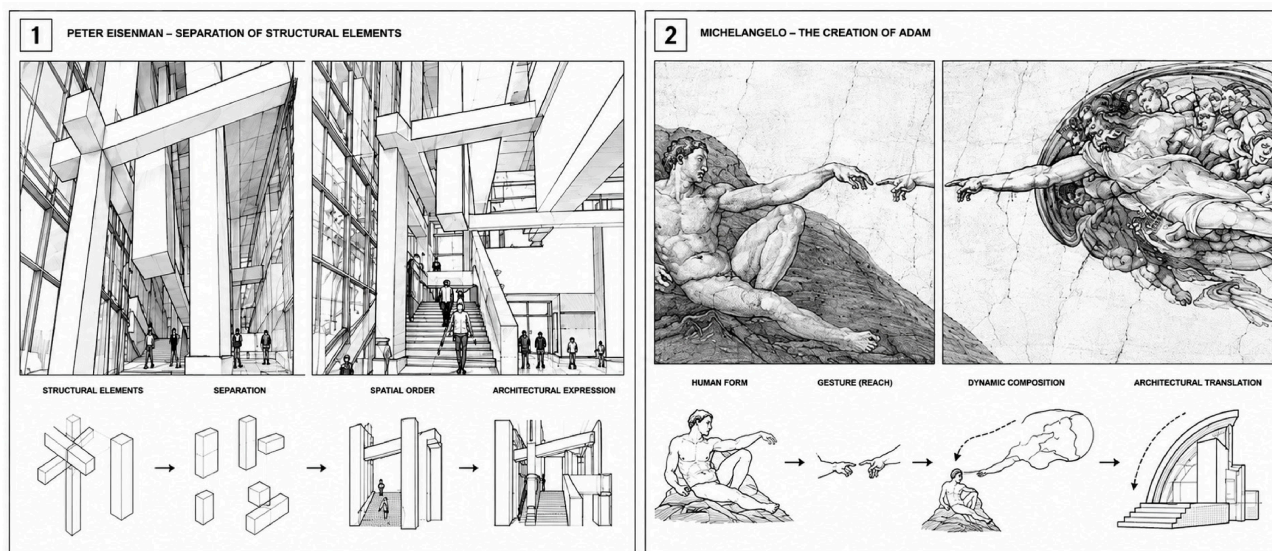


Figure 28. Peter Eisenman's spatial interpretation (1) and Michelangelo's *The Creation of Adam* as a formal reference (2). Source: prepared by the authors based on published architectural documentation.

The activities of the De Stijl movement can also be highlighted, as it relied on drawing inspiration from two-dimensional artworks. The works of Mondrian and Doesburg enabled the translation of their formal characteristics into architecture, allowing walls, ceilings, and windows to acquire qualities similar to those found in paintings. This is evident in the Schröder House by Rietveld, where horizontal and vertical planes are advanced and recessed to create an interplay of light and shadow, while the use of colour achieves a dynamic balance among different elements and layers.

It can also be noted that Le Corbusier was influenced by visual arts, which is reflected in his architectural works, whether in entire buildings or in specific elements such as walls and doors. He employed colours explicitly, particularly primary colours (blue, yellow, and red), as seen in some of his projects, such as the *Unité d'Habitation* in Marseille [2,6].

b. Sculpture: It can be said that many of Le Corbusier's works possess a strong sculptural quality, whether at the level of the architectural mass or the façades. This is evident in prominent projects such as the Ronchamp Chapel and the *Unité d'Habitation* in Marseille, where the treatment of forms reflects a sculptural approach. This quality is also expressed in the design of the roof garden, which takes on a sculptural character and adds an expressive dimension to the building [2,6] (Figure 29).

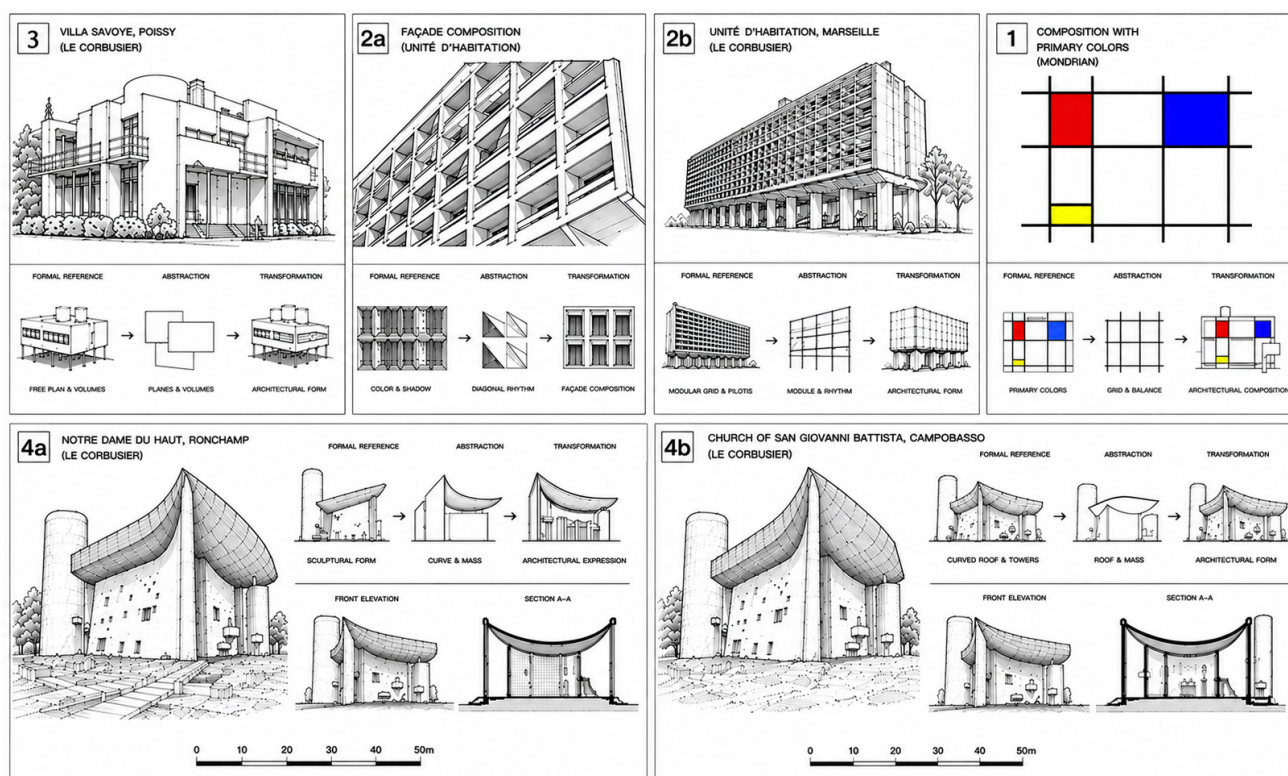


Figure 29. Piet Mondrian’s composition with primary colours (1); Villa Savoye, Poissy, France, by Le Corbusier (2a); façade composition of Unité d’Habitation, Marseille, France (2b); Unité d’Habitation, Marseille, France, by Le Corbusier (3); Notre Dame du Haut, Ronchamp, France, by Le Corbusier (4a); and the Church of San Giovanni Battista, Campobasso, Italy, by Le Corbusier (4b). Source: prepared by the authors based on published architectural documentation.

4. Results

The analysis of the selected case studies reveals that formal references operate not as static sources of inspiration but as dynamic transformation processes that shape both architectural expression and meaning production. To operationalize the Transformation-Based Formal Reference Framework (TFRF), each case was coded according to two analytical dimensions: degree of abstraction (Direct Transfer, Analogy, Abstraction) and dominant type of transfer (Form, Structure, Performance, Symbol, Space).

The complete coding structure of the thirty-one architectural cases is presented in Table 5. This table constitutes the primary analytical dataset from which all the subsequent comparisons and pattern identifications were derived.

The coded cases were subsequently positioned within the abstraction $\times$ transfer matrix shown in Figure 30. This visualization enables the comparative examination of projects independently of their source domains and highlights the distribution of transformation strategies across the corpus.

The central finding emerging from the matrix is that source domain and transformation mechanism function as analytically distinct dimensions. Cases originating from different domains frequently occupy similar matrix positions, while cases sharing a common source domain may employ substantially different transformation strategies. This finding directly supports the core proposition of the TFRF, namely that architectural references are more effectively understood through transformation processes than through source categories alone.

Table 5. Case Coding Matrix according to the Transformation-Based Formal Reference Framework (TFRF): two-dimensional classification of the analysed cases based on degree of abstraction and dominant transfer type. Each case received one primary transfer classification; a secondary expression is reported where a case was also coded for a second transfer type (Source: prepared by the authors).

#	Building/Source	Source Domain	Abstraction	Primary Transfer Type	Secondary
1	Erechtheion (female figure)	Living organisms	Direct	Form	Symbol
2	Turning Torso—Calatrava (human torso)	Living organisms	Abstraction	Structure	–
3	Face House—Yamashita (human face)	Living organisms	Direct	Form	–
4	TWA Terminal—Saarinen (landing bird)	Living organisms	Analogy	Form	Performance
5	Kansai Airport—Piano (dinosaur skeleton)	Living organisms	Abstraction	Structure	–
6	Bird’s Nest Stadium, Beijing	Living organisms	Analogy	Structure	–
7	Munich Stadium—Otto (spider web)	Living organisms	Abstraction	Performance	Structure
8	Nakagin Tower—Kurokawa (living cell)	Living organisms	Abstraction	Performance	Symbol
9	DNA Towers—Law (double helix)	Living organisms	Analogy	Form	–
10	Lotus Temple, India (lotus flower)	Living organisms	Analogy	Form	Symbol
11	Qizhong Arena (magnolia flower)	Living organisms	Analogy	Performance	–
12	London City Hall—Foster (cosmic phenomena)	Cosmos & Geography	Abstraction	Structure	Space
13	Aqua Tower—Gang (rock formations)	Cosmos & Geography	Analogy	Form	–
14	Floating House—Oshatz (river curves)	Cosmos & Geography	Analogy	Form	Space
15	Walter Towers (letter W)	Language	Direct	Form	–
16	Palazzetto dello Sport (letter Y)	Language	Abstraction	Structure	–
17	Basra Cultural Palace (calligraphy/book)	Language	Abstraction	Symbol	Space
18	Romeo & Juliet—Eisenman (narrative)	Language	Abstraction	Space	Symbol
19	Barcelona Pavilion—Mies (labyrinth myth)	Language	Abstraction	Space	Symbol
20	St Peter’s Basilica (cross plan)	Belief systems	Direct	Symbol	–
21	Conceptual Mosque—Manço (the Kaaba)	Belief systems	Direct	Symbol	–
22	Jubilee Church—Meier (Trinity doctrine)	Belief systems	Abstraction	Symbol	–
23	Dar Al-Qur’an, Medina (Qur’anic verse)	Belief systems	Analogy	Form	Symbol
24	Bilbao—Gehry (Noah’s Ark)	Belief systems	Abstraction	Symbol	–
25	Sana’a Commercial Center (heritage)	Precedent architecture	Direct	Form	Symbol
26	Constitutional Court—Mito (Egyptian)	Precedent architecture	Analogy	Form	Symbol
27	Robot Building, Bangkok (robot)	Human-made products	Direct	Form	–
28	Burj Al Arab, Dubai (sail)	Human-made products	Analogy	Form	Symbol
29	Eisenman House (Creation of Adam)	Human-made products	Abstraction	Symbol	–
30	Schröder House—Rietveld (De Stijl)	Human-made products	Abstraction	Structure	–
31	Ronchamp—Le Corbusier (sculpture)	Human-made products	Abstraction	Form	–

Three paired comparisons illustrate this distinction. The Erechtheion and the Sana’a Commercial Center originate from different source domains (living organisms and precedent architecture, respectively) yet occupy similar analytical positions, demonstrating comparable transformation logic despite unrelated references. Conversely, the Nakagin Capsule Tower and the DNA Towers derive from the same biological domain but employ different abstraction levels and transfer mechanisms. A third example is provided by the Walter Towers and the Palazzetto dello Sport, which share a linguistic source yet occupy opposite ends of both analytical axes.

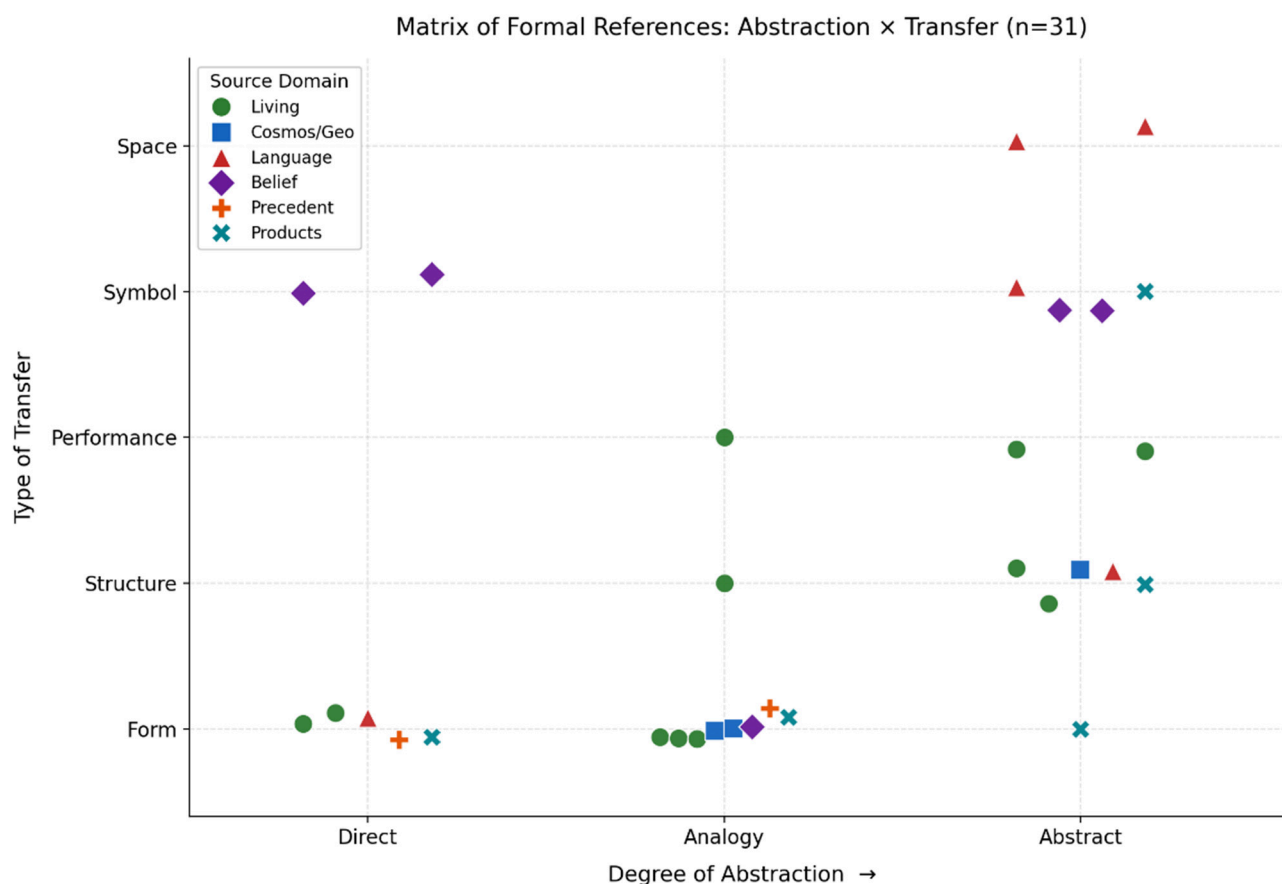


Figure 30. Distribution of the analysed cases across the abstraction × transfer matrix, colour-coded by source domain (Source: prepared by the authors).

Figure 30 also reveals domain-specific tendencies. Language and narrative references cluster predominantly toward the abstraction pole, indicating a preference for conceptual translation rather than literal representation. Precedent-based references remain confined to the direct and analogical range and do not reach full abstraction. Living-organism references span the entire matrix, suggesting the greatest degree of transformational flexibility among all source domains.

To move beyond individual case positioning and identify broader tendencies within the corpus, the matrix results were aggregated into frequency distributions, as presented in Table 6.

Within the analysed corpus, abstraction is the most frequently coded transformation mode (45%), followed by analogy (32%) and direct transfer (23%). Formal transfer represents the most frequent individual transfer channel; however, structural, symbolic, performative, and spatial transfers collectively exceed formal transfer, demonstrating that architectural references operate through a diverse range of conceptual mechanisms beyond visual resemblance alone.

Within the analysed corpus, analogy and abstraction occur more frequently than direct transfer. This distribution should not be interpreted as evidence of a population-wide tendency in contemporary architectural practice, but as a pattern within the purposively constructed case set, in which references are more frequently translated through conceptual, symbolic, structural, and performative processes than through literal reproduction.

Table 6. Cross-case frequency analysis of abstraction degree, transfer type, and source domain across the thirty-one cases (Source: prepared by the authors).

Dimension	Category	<i>n</i> (%)	Cross-Case Observation
Abstraction degree	Direct	7 (23%)	Least common; concentrated in precedent and direct-symbol cases
	Analogy	10 (32%)	Dominant in cosmos/geography and animal-morphology cases
	Abstraction	14 (45%)	Most common overall; dominant in language and belief domains
Primary transfer type	Form	14 (45%)	The single most frequent transfer mode across all domains
	Structure	6 (19%)	Typical of biological and letter-derived structural cases
	Symbol	6 (19%)	Concentrated in belief systems and narrative references
	Performance	3 (10%)	Adaptive/mechanical cases (Munich, Qizhong, Nakagin)
	Space	2 (6%)	Rarest; appears only in highly abstract narrative cases
Source domain	Living organisms	11	The most represented and most transformationally versatile
	Language/Belief systems/Human-made products	5 each	Mid-range representation across conceptual domains
	Cosmos and geographical formations	3	Concentrated in the analogical-formal region
	Precedent architecture	2	Confined to the direct/analogical, never abstract

Cross-Case Comparative Analysis

While the preceding section positioned individual cases within the analytical matrix, the explanatory value of the framework becomes clearer when relationships across source domains are examined. To identify recurring tendencies, source domains were cross-tabulated against both degree of abstraction and type of transfer. The two cross-tabulations are summarised in Tables 7 and 8 and visualised jointly in Figure 31.

Five principal patterns emerge from the comparative analysis.

Pattern 1: Source domains exhibit characteristic abstraction tendencies. Language and product-related references gravitate toward abstraction, while biological and geographical references are primarily associated with analogy. Precedent-based references remain concentrated within direct and analogical categories. Belief-system references, by contrast, do not display a single dominant abstraction tendency: they are distributed almost evenly between direct and abstract treatments, appearing as literal, recognizable religious forms in some cases and as fully reformulated conceptual principles in others. This bimodal distribution indicates that the abstraction level of belief-system references is governed less by the domain itself than by the designer's interpretive stance toward the sacred content.

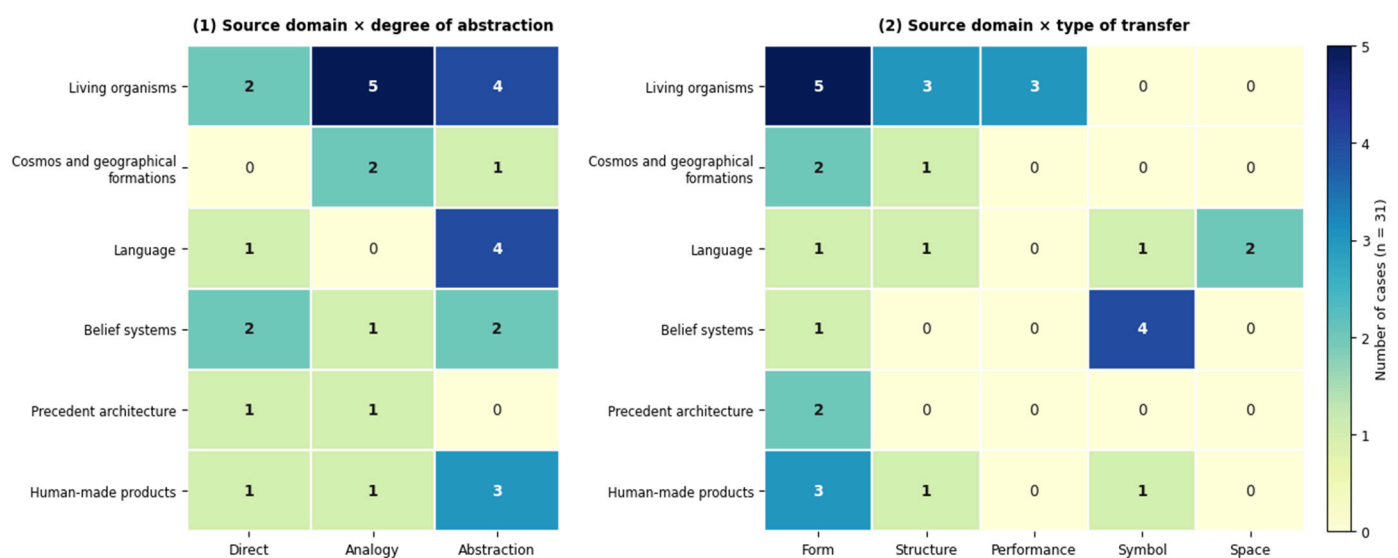
Pattern 2: Source domains display characteristic transfer preferences. Belief-system references predominantly operate through symbolic transfer, linguistic references frequently employ spatial transfer, and biological references favour formal and structural transfer mechanisms. Human-made product references, in turn, are dominated by formal transfer: in most cases the artefact or artwork enters the design as a visual and compositional model, with its outward appearance reinterpreted architecturally, and only occasionally as a structural or symbolic principle. This preference for formal transfer reflects the fact that manufactured objects are themselves already designed forms, so their most readily transferable property is their shape rather than an underlying performance or meaning.

Table 7. Cross-tabulation of source domain and degree of abstraction (Source: prepared by the authors).

Source Domain	Direct	Analogy	Abstraction	Dominant Mode
Living organisms	2	5	4	Analogy
Cosmos and geographical formations	0	2	1	Analogy
Language	1	0	4	Abstraction
Belief systems	2	1	2	Direct/Abstraction
Precedent architecture	1	1	0	Direct/Analogy
Human-made products	1	1	3	Abstraction

Table 8. Cross-tabulation of source domain and type of transfer. Row totals correspond to the number of cases per source domain, and column totals correspond to the primary transfer counts reported in Table 6; both sum to the thirty-one cases coded in Table 5 (Source: prepared by the authors).

Source domain	Form	Struct.	Perf.	Symbol	Space	Dominant
Living organisms	5	3	3	0	0	Form
Cosmos and geographical formations	2	1	0	0	0	Form
Language	1	1	0	1	2	Space
Belief systems	1	0	0	4	0	Symbol
Precedent architecture	2	0	0	0	0	Form
Human-made products	3	1	0	1	0	Form

**Figure 31.** Heat-map of the two cross-tabulations: source domain × degree of abstraction (1) and source domain × type of transfer (2) (Source: prepared by the authors).

Pattern 3: Source domain and transformation strategy are related but not identical. Certain domains demonstrate recurring tendencies; however, these tendencies do not determine architectural outcomes. Transformation mechanisms therefore remain analytically distinguishable from source categories, even though domain-specific tendencies can be observed within the analysed corpus.

Pattern 4: Conceptual transfer mechanisms collectively outweigh formal resemblance. Although formal transfer is the most frequent individual category, symbolic, structural, performative, and spatial transfers together constitute the majority of cases.

Pattern 5: Certain matrix positions act as convergence zones. Cases originating from unrelated domains frequently converge upon similar transformation mechanisms, while others display substantial internal diversity. Living-organism references occupy

the widest range of matrix positions, making them the most transformationally versatile source domain.

The comparative analysis also reveals several counter-patterns that further support the framework. The Erechtheion, despite its biological source, operates primarily through direct symbolic transfer. The Basra Cultural Palace translates a linguistic source into symbolic meaning rather than spatial sequence. Similarly, Dar Al-Qur'an departs from the symbolic tendency of belief-system references and adopts an analogical-formal strategy. These exceptions reinforce the argument that designer interpretation can override domain-specific tendencies, demonstrating that the transformation axis is analytically distinguishable from the source axis.

The comparative analysis yields five principal findings that summarize the explanatory capacity of the proposed framework and provide the basis for subsequent theoretical discussion:

Finding 1. Direct references are predominantly associated with formal or symbolic transfer and do not generate spatial or performative transformations within the analysed corpus.

Finding 2. Abstract references generate the widest range of transfer mechanisms and constitute the only category capable of producing both spatial and performative transformations.

Finding 3. Linguistic and narrative references rely more heavily on symbolic and spatial transfer than biological references, which favour formal and structural channels.

Finding 4. Symbolic transfer is not confined to a single abstraction level, appearing in both direct and highly abstract references.

Finding 5. Source domain influences but does not determine transformation strategy; counter-pattern cases demonstrate that designer interpretation can override domain-specific tendencies.

The comparative findings are synthesized in Table 9, which summarizes the dominant abstraction mode, dominant transfer channel, and characteristic transformation profile associated with each source domain.

Table 9. Summary of comparative findings: dominant abstraction degree, dominant transfer channel, and characteristic pattern per source domain (Source: prepared by the authors).

Source Domain	Dominant Abstraction	Dominant Transfer	Characteristic Pattern
Living organisms	Analogy	Form/Structure	Morphological-structural translation of biological principles
Cosmos and geographical formations	Analogy	Form	Figurative echo of natural formations and terrain
Language	Abstraction	Space/Symbol	Conceptual translation of texts into spatial sequence
Belief systems	Direct/Abstraction	Symbol	Symbolic transfer regardless of abstraction degree
Precedent architecture	Direct/Analogy	Form	Figurative citation; never reaches full abstraction
Human-made products	Abstraction	Form	Abstracted reinterpretation of artefacts and artworks

Taken together, these findings support the central proposition of the TFRF: architectural meaning is produced through the interaction between abstraction and transfer rather than through the source domain alone. The framework therefore enables formal references to be analysed as transformation processes rather than as fixed categories of inspiration.

5. Discussion

This section moves beyond restating the results to ask why the observed patterns arise, what they imply for existing theories of architectural reference, and what analytical value each carries. The discussion is organised around the three research questions and then draws out the theoretical and practical consequences of the findings.

5.1. Reference as Process: Interpreting RQ1

The first and most consequential result is that references never entered the analysed projects in a finished form. Across the analysed cases, the framework reconstructs the relationship between source and architectural outcome through the stages of interpretation, abstraction degree, and transfer. In cases coded as direct transfer, this mediating distance remains limited, whereas analogical and abstract cases involve progressively greater reformulation. This is visible in the aggregate distribution: abstraction and analogy together account for roughly three-quarters of the corpus, while direct transfer is the least common mode (Table 6). The interpretive point is not merely that designers prefer abstraction, but why. Abstraction dominates because it is the operation that lets a reference survive translation across media: a biological principle, a sacred geometry, or a linguistic structure cannot be copied literally into inhabitable space, so it must be reformulated before it can be built. Direct transfer is rare precisely because it is available only when the source already possesses architectural properties, which is why the few direct cases cluster in the precedent and symbol categories, where the source is itself a building or an established sign. Read this way, the frequency data are not descriptive tallies but evidence that transformation is a structural necessity of reference-driven design, which is the claim RQ1 sets out to test.

5.2. Source and Mechanism as Analytically Distinct Dimensions: Interpreting RQ2

The cross-tabulations answer RQ2 and constitute the study's principal analytical result: source domain and transformation mechanism are analytically distinguishable rather than co-determined. Two complementary observations establish this. First, distant domains converge on the same mechanism, as when the Erechtheion, a living-organism source, and the Sana'a Commercial Center, a precedent-architecture source, both resolve into direct form-and-symbol transfer despite sharing no common source. Second, a single domain diverges across mechanisms, as when the Nakagin Capsule Tower and the DNA Towers, although both classified within the living-organism domain, follow different abstraction and transfer paths. The counter-pattern cases sharpen the point: the Erechtheion operating through direct symbolic transfer, the Basra Cultural Palace converting a linguistic source into symbol rather than spatial sequence, and Dar Al-Qur'an departing from the symbolic tendency of belief-system references all show that a domain's statistical tendency can be overridden by the designer's interpretation. The reason such overrides are possible is that the domain fixes only the raw material of a reference, whereas interpretation and abstraction, the two upstream stages of the framework, decide which property of that material is carried forward. Because those stages sit between source and outcome, the same source can be steered toward opposite mechanisms and unrelated sources can be steered toward the same one. This is why the tendencies in Tables 7 and 8 are real but non-deterministic, and it is the mechanism that a purely source-based account cannot represent.

This finding also locates the study within existing theory. Jencks reads architecture semiotically, as a system of communicable signs; Rossi reads it typologically, as collective memory carried by precedent; Norberg-Schulz reads it phenomenologically, as the disclosure of place [1,3,4]. Each account explains one column of the present matrix, symbolic transfer, precedent-based reference, and experiential meaning respectively, but treats the

passage from source to form as given. This distinction between source and mechanism explains why no single one of these theories is sufficient on its own: they describe different transfer channels of the same underlying process, and the channel actually taken is not fixed by the source they each privilege. The framework therefore does not displace these positions; rather, it allows them to be interpreted as complementary perspectives addressing different aspects of the broader transformation process, while making explicit the transformation layer that remains implicit in these accounts. The same argument applies to the procedural literature: biomimetic and computational models formalise transfer within one source family or one apparatus [9–13], whereas the present findings suggest that the transfer mechanism can be analysed separately from the source domain, which allows the framework to operate across domains that these models tend to address in isolation.

5.3. *Why the Patterns Emerge: Interpreting RQ3*

RQ3 asks whether references can be systematically mapped, and the matrix answers affirmatively by making two otherwise invisible features legible: convergence zones and counter-patterns. The value of the individual findings lies in what each explains. Within the analysed corpus, spatial and performative transfer occurs only among cases involving substantial abstraction (Finding 1), suggesting that greater reformulation may facilitate the reorganisation of spatial or behavioural properties. Direct transfer, by contrast, is associated in this corpus with formal or symbolic expression. That abstract references alone generate the full range of mechanisms, including the only spatial and performative cases (Finding 2), is the same principle seen from the other side, and it is the study's strongest evidence that abstraction is the enabling operation rather than merely a stylistic preference. That symbolic transfer appears at both extremes of the abstraction axis (Finding 4) shows that meaning-making is orthogonal to visual distance from the source, which explains why belief-system references remain symbolic whether rendered directly or abstractly. Finally, that living-organism references occupy the widest span of matrix positions identifies them as the most transformationally versatile domain, not because biology is richer in imagery, but because it offers form, structure, and performance simultaneously, giving interpretation more independent properties to select from. Each finding, in other words, is explicable from the framework's own logic, which is the sense in which the matrix functions as an explanatory rather than a merely classificatory device.

5.4. *Theoretical Interpretation, Literature, and Applied Significance*

Taken together, the patterns reported above are not merely a refined classification of what architects reference. Their deeper significance is that they isolate transformation as the common element that links a reference to a form and, in turn, to a meaning. Across every case, the reference did not act directly; it became architecture only by passing through interpretation, abstraction, and transfer, and it is this shared operation, rather than the identity of the source, that determines the architectural outcome. The framework therefore reinterprets the role of the reference in design: the reference supplies raw material, but transformation is what converts that material into form and meaning.

This reading marks the study's departure from previous work. Earlier scholarship has approached formal reference along three largely separate lines: the classification of sources of inspiration and their cultural significance [1,2,5,6]; the biomimetic formalisation of how biological principles are abstracted into architecture [9]; and design-cognition research into how designers retrieve and manipulate references during conceptual work [7,8]. Each line clarifies one facet of reference, yet each treats the passage from source to form as given and remains tied to a single source family, apparatus, or cognitive account. The present framework contributes a unified explanation of the transformation mechanism that con-

nects reference, form, and meaning, allowing these earlier positions to be interpreted as complementary perspectives within a broader transformation process rather than as competing alternatives.

The framework also carries a clear applied significance. As an analytical instrument it allows completed architectural projects to be compared on the basis of how, rather than what, they reference, revealing convergences and counter-patterns invisible to source-based description. As a design instrument it can guide conceptual design by prompting designers to work deliberately on the abstraction and transfer of a reference instead of replicating its appearance. And as a teaching instrument it offers design studios an explicit vocabulary for naming, discussing, and evaluating reference-based strategies, so that transformation can be taught as a conscious operation. These interpretations remain bounded by the study's qualitative method and purposive corpus, and therefore support analytical rather than statistical generalization.

6. Conclusions

This study set out to explain how formal references are transformed into architectural form and meaning, rather than simply to catalogue what architects draw upon. To this end it developed the Transformation-Based Formal Reference Framework (TFRF) and applied it to thirty-one purposively selected architectural cases.

The principal contribution of the study is the development of this transformation-based framework and the way it unifies the relationship between reference, transformation, form, and meaning within a single analytical model. By treating degree of abstraction and type of transfer as two analytically distinct dimensions, the framework moves beyond the classification of sources toward an explanation of the mechanism by which references are transformed into architecture, demonstrating that the source of a reference and the mechanism of its transformation are analytically distinct.

These contributions carry direct practical implications. The framework can support architectural education by giving design studios an explicit vocabulary for analysing reference-based strategies; it can support reference-driven design by helping practitioners engage critically with a source rather than replicate its appearance; and it can serve as a shared instrument for both the analysis of existing projects and the guidance of new conceptual design. For computational design research, the abstraction–transfer matrix may provide a structured annotation scheme for building datasets, training classification models, or comparing generative design outputs.

The study is nonetheless limited: it is confined to building-scale architectural projects and rests on a qualitative, interpretive analysis of a purposive corpus, so its findings support analytical rather than statistical generalization. Future research could test the framework quantitatively on larger datasets and extend its application to other design domains and cross-cultural contexts, thereby further examining its explanatory and pedagogical value.

Author Contributions: Conceptualization, M.S.A. and E.Y.; methodology, M.S.A.; formal analysis, M.S.A. and E.Y.; investigation, M.S.A.; data curation, M.S.A.; writing—original draft preparation, M.S.A.; writing—review and editing, E.Y.; visualization, M.S.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The coded dataset underlying the analysis is provided in Table 5 of the article. All case classifications were derived from publicly available documentary sources cited in the manuscript. No additional unpublished dataset was used.

Conflicts of Interest: The authors declare no conflicts of interest.

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