

Beyond the Structural Joint: A Multidimensional Framework for Architectural Evaluation

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ABSTRACT

The architectural joint has been traditionally considered a structural component. Actually, it involves four dimensions: spatial, perceptual, symbolic, and technical dimensions that connect the material and the intellectual aspects of architecture. In the literature of expert-based architectural evaluation, there is no report of a standardized quantitative method which assesses these dimensions as a whole. To solve this problem, this study formulated and piloted the Joint Strength Index (JSI), which assumed that a joint's effectiveness is not only determined by technical complexity, but also by its capacity to create meaning in all four dimensions. A total of 55 architectural experts were asked in this research to complete a questionnaire based on the framework, and the results were reported using a five-point Likert scale in a repeated, within-subjects design (Cronbach's $\alpha = 0.757$). Normalized JSI values ranged from 0.727 to 0.985 (theoretical range 0.20–1.00). The difference in scores between the integrative cases (the Holy Kaaba, the Church of Light, and the Louvre Pyramid) and the techno-centric or disjunctive cases (Centre Pompidou) was statistically significant (Friedman $\chi^2(12) = 157.38$, $p < 0.001$), and there was a small-to-moderate degree of inter-evaluator concordance (Kendall's $W=0.24$). The study provides three theoretical contributions: the joint as a multidimensional transition mechanism, an analytical matrix that can be applied in different cultural and typological situations, as long as it is tested, and two alternative joint logics: integrative and disjunctive.

Keywords: Architectural joint, Joint Strength Index (JSI), Tectonic theory, Expert-based evaluation, Multidimensional framework.

1. INTRODUCTION

The architectural joint is conventionally defined as the connection between the parts of a building that maintains continuity of form. However, this traditional definition has changed over the years to include the interplay of material, spatial, perceptual and cultural aspects of architecture as an evolving, dynamic place of interaction (**Picon, 2021; Schumacher, 2012**). This mindset has shifted the scope of the architectural joint from a technical matter

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Peer review under the responsibility of University of Baghdad.

<https://doi.org/10.31026/j.eng.2026.10.04>



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Article received: 20/06/2026

Article revised: 27/08/2026

Article accepted: 29/08/2026

Article published: 01/10/2026



to architectural joints as experiences, as communication and translation between the real and the unreal, tangible and the intangible (**Robinson, 2021**). In this sense, the architectural joint can be seen as a conceptual hinge where architecture can maneuver the relationship between matter and meaning, structure and perception, technology and culture, to name a few.

In this study, the architectural joint denotes the specific, operationally defined spatial or material interface identified for each case - for example, a structural connection, a light-mediated threshold, or a formal junction between masses - rather than the evaluated building as an undifferentiated whole. The “material” pole refers to the physical, constructional and perceptual realization of this interface; the “intellectual” pole refers to the symbolic, cultural and conceptual meaning it carries. Accordingly, the unit of analysis throughout this study is the architectural joint as operationalized per case, not the building itself: experts were not asked to evaluate the overall architectural quality of each building, but the degree to which the specified joint condition was realized in the presented case.

Architecture's articulation, transition and interaction have widely been read as carriers of meaning connected to individual formal composition: Frampton's tectonic theory links articulation to structural and expressive integrity, extended through work on sensory engagement and embodied experience (**Mallgrave, 2018**); the phenomenological approach highlights transitional spaces and thresholds and their influence on the atmosphere of architecture (**Spence, 2020**); and transitions are understood as constitutive of identity, social interaction and cultural continuity in the built environment (**Sussman and Hollander, 2021**). By putting together, these visions suggest that the architectural joint must be addressed as a unified whole - a synthesis of spatial, symbolic, technological and experiential elements - rather than as a purely structural connection.

The research problem lies in the fact that although the architectural joint is recognized increasingly in theory as being multi-dimensional, as a mediating condition of architecture, there is still no consistent operational framework for assessing the condition of the architectural joint in a variety of architectural cases. This restricts the systematic comparison of mediation between architectural construction and meaning from architectural joints. The issue of this problem is important because, if there were no common evaluative method, then when discussing architectural success, one would only be able to make descriptive statements, but not ones that are comparable amongst cases. This paper introduces an operational, repeatable measure of the Joint Strength Index, a measure that transforms a previously qualitative and interpretive concept into a construct that can be measured, as a basis for the theoretical, methodological and empirical contributions outlined in Section 6. Therefore, the aim of this study is to redefine the architectural joint as a non-structural entity and to establish an operational framework to systematically evaluate an architectural joint. The study aims to: (1) identify and synthesize the main axes along which the architectural joint can manifest, and through which it can express architectural relationships and architectural meaning; (2) apply the synthesized theory to an expert-based evaluation of architecture through a structured approach; and (3) analyze the applicability of the proposed theory, using comparative architectural case studies.

Prior work on constructional articulation, perceptual characteristics, symbolic significance and spatial organization has largely treated these aspects in isolation (**Robinson, 2024**). Two research questions (RQs) follow from this gap: RQ1 asks whether the architectural joint can be conceptualized and measured as a multidimensional mediating condition rather than merely a structural detail; RQ2 asks whether this realization can be captured in a



standardized, reproducible instrument permitting systematic, cross-case comparison across architecturally different buildings, spaces, time periods, and cultural contexts. This study also addresses both the conceptual/operational gap (RQ1) and the measurement/comparability gap (RQ2) through the framework, instrument and case applications set out in objectives 1-3 above. The central hypothesis is that the effectiveness of an architectural joint is not so much due to the complexities of the structures involved as to their ability to negotiate meaning and promote perceptual shifts between the material and the intellectual. This hypothesis directly operationalizes objective 2 above by predicting that instrument scores will track dimensional integration rather than technical complexity alone.

2. THEORETICAL FRAMEWORK: CONCEPTUAL FOUNDATIONS OF THE ARCHITECTURAL JOINT

In this research, the architectural joint is interpreted as a multidimensional mediating condition between the material and intellectual aspects of architecture, structured by the spatial, perceptual, symbolic and technical dimensions introduced in Section 1. Four complementary theoretical approaches-spatial-temporal intersections, historical transformations, perceptual and boundary conditions, and technological articulations - are used to explore this condition and to ground the integrated conceptual model and analytical framework developed below.

2.1 Critical Review and Theoretical Synthesis of the Architectural Joint

The architectural joint has been explored in many theoretical ways, including: the theory of tectonics, phenomenology, the theory of spatial events, the theory of historical changes, the symbolic interpretation of architectural joints, the threshold studies and the digital/cognitive theory. These thoughts have helped to understand what architectural joints are but have evolved independently and have lacked a unified analytical framework. In this regard, the present study combines these complementary contributions to obtain the analytical dimensions that constitute the conceptual basis of the proposed framework, summarized in **Table 1**. Rather than reviewing the theories one by one, the study identifies the common conceptual components and transforms them into four analytical components, the combination of which can be explained as the mediating role of the architectural joint. This synthesis corresponds to **Table 1**. Read against one another, the eight perspectives in **Table 1** also expose the limitations that motivate the present synthesis. Tectonic theory (**Frampton, 1995; Picon, 2021**) explains the joint's material and structural logic but does not by itself address its perceptual or symbolic registers - a gap taken up by the phenomenological (**Pallasmaa, 2012; Zumthor, 2010**) and symbolic-interpretation (**Pérez-Gómez, 2016; Mahgoub, 2007**) perspectives, which in turn foreground lived experience and cultural meaning but offer comparatively little operational guidance for cross-case measurement. Spatial-event theory (**Tschumi, 1994**) and the thresholds/in-between-spaces literature (**Hillenbrand, 1994; Michell, 1978; Murphy, 2002**) address spatial and perceptual continuity but were not developed as comparative or quantitative instruments. Historical-transformation accounts (**Fletcher, 2001; Colquhoun, 2005; Canizaro, 2007**) supply a symbolic-historical register but, like the others, remain confined to their own disciplinary vocabulary. Digital-architecture scholarship (**Kolarevic, 2003; Carpo, 2012; Oxman, 2006**) extends the technical register into computational fabrication without engaging the symbolic or spatial dimensions. None of the eight perspectives, individually, offers a framework that is simultaneously multidimensional and operational;

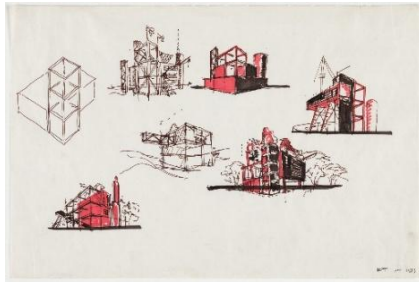
this is the unresolved gap the four-dimensional framework and the Joint Strength Index are developed to fill. **Fig. 1** illustrates representative forms of the architectural joints discussed above across different architectural contexts.

Table 1. Synthesis of the literature review and derivation of the analytical dimensions.

Theoretical Perspective	Principal Contribution	Representative Scholars	Derived Analytical Dimension
Tectonic Theory	The joint is articulated in terms of structure, revealing material logic and constructional honesty.	(Frampton, 1995; Picon, 2021; Cucuzzella et al., 2023)	Technical
Phenomenology	Architectural joints influence the perception of space, atmosphere, embodiment and perception of the sensory.	(Pallasmaa, 2012; Zumthor, 2010; Robinson and Pallasmaa, 2015)	Perceptual
Spatial-Event Theory	A joint as a spatial and temporal cross-section, in the sense of movement, event and architectural experience.	(Tschumi, 1994; Rong and Bahauddin, 2023)	Spatial
Historical Transformation	Architectural joints are instances of intellectual and cultural moments of transition between architectural paradigms.	(Fletcher, 2001; Colquhoun, 2005; Canizaro, 2007)	Symbolic
Thresholds and In-Between Spaces	Transitional spaces are used to create a continuity between adjacent space domains without losing their identity.	(Hillenbrand, 1994; Michell, 1978; Murphy, 2002)	Spatial Perceptual
Symbolic Interpretation	Architectural joints embody cultural memory, identity and spiritual significance in ways that extend beyond the built structure.	(Pérez-Gómez, 2016; Mahgoub, 2007; Al-Suhairi, 2001)	Symbolic
Digital Architecture	Joins become performative mediating interfaces by means of computational design and advanced fabrication.	(Kolarevic, 2003; Carpo, 2012; Oxman, 2006; Hassan and Saeed, 2024)	Technical
Cognitive Architecture	Perception, cognition and environmental experience are the bases of architectural meaning.	(Mallgrave, 2018; Böhme, 2017; Sussman and Hollander, 2021)	Perceptual

2.2 Derivation of the Analytical Dimensions

The following are used to generate the Analytical Dimensions: Based on the literature reviewed, four complementary analytic dimensions can be distilled from the theoretical synthesis presented in **Table 1**. These dimensions are not independent but are complementary to explain the mediation role of the architectural joints in different architectural contexts. The reasoning behind this derivation of the literature and how each theme focuses on a certain analytical dimension around the shared conceptual basis is shown in **Fig. 2**, whereas **Table 2**. shows the analytical dimensions of the Architectural Joint.



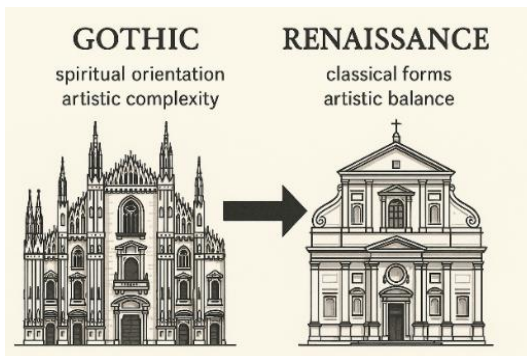
(a) Parc de la Villette, Paris, France



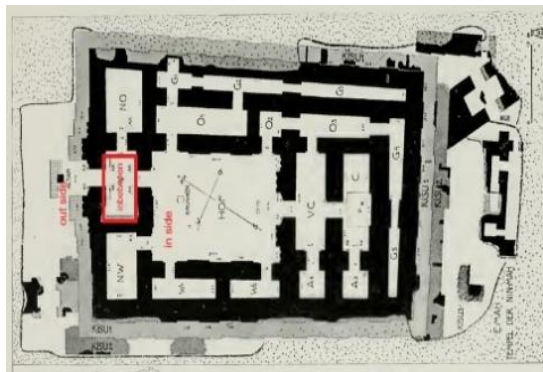
(b1) One of the 19th century buildings



(b2) Bauhaus building in Germany

(c) Right is a Renaissance building
Left is a Gothic building

(d) Muqarnas in Islamic architecture



(e) The courtyard and the in-between space in Mesopotamian architecture



(f) Extended Glass Windows-Villa Savoy

Figure 1. Representative architectural manifestations of the joint and transitional conditions discussed in the theoretical framework: (a) intellectual–cultural articulation, (b1, b2) historical transformation towards modern architecture, (c) historical transition between architectural paradigms, (d) transformative articulation through muqarnas, (e) internal–external articulation through the courtyard and in-between space, and (f) internal–external spatial articulation in Villa Savoye.

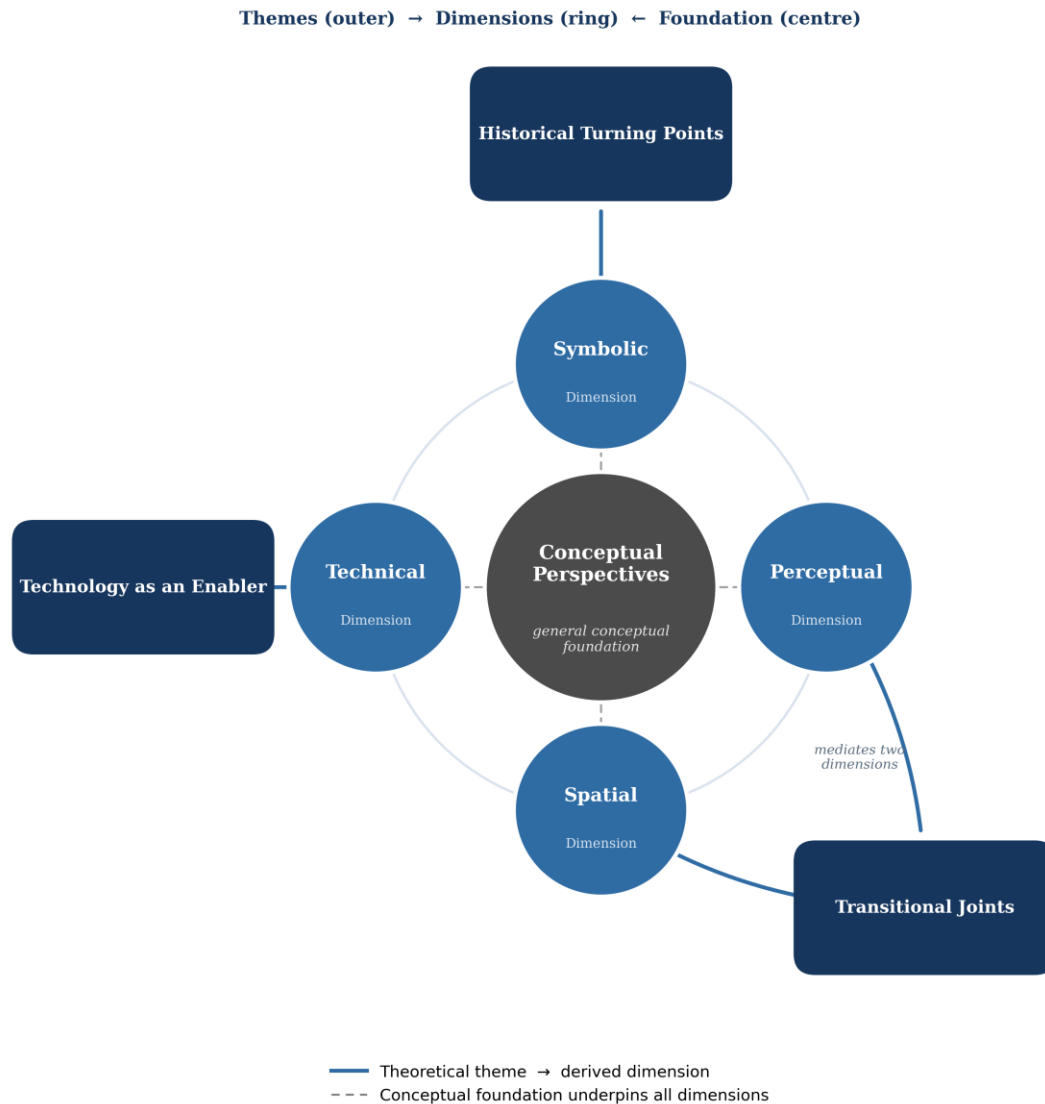


Figure 2. Derivation of the Four Analytical Dimensions of the Architectural Joint.

Table 2. Analytical Dimensions of the Architectural Joint.

Analytical Dimension	Description
Spatial Dimension	Plans spatial relationships, thresholds and spatial continuity between adjacent spaces.
Perceptual Dimension	Experiences shapes through movement, light, atmosphere and space.
Symbolic Dimension	Stories of culture, continuity, memory, and spirituality.
Technical Dimension	Enables structural, material and technological systems to be articulated in a coherent way.

On the other hand, **Fig. 3** shows how these four analytical dimensions combine to create the integrated conceptual model of the architectural joint, which will then serve as the basis to operationalize it into measurable analytical indicators.

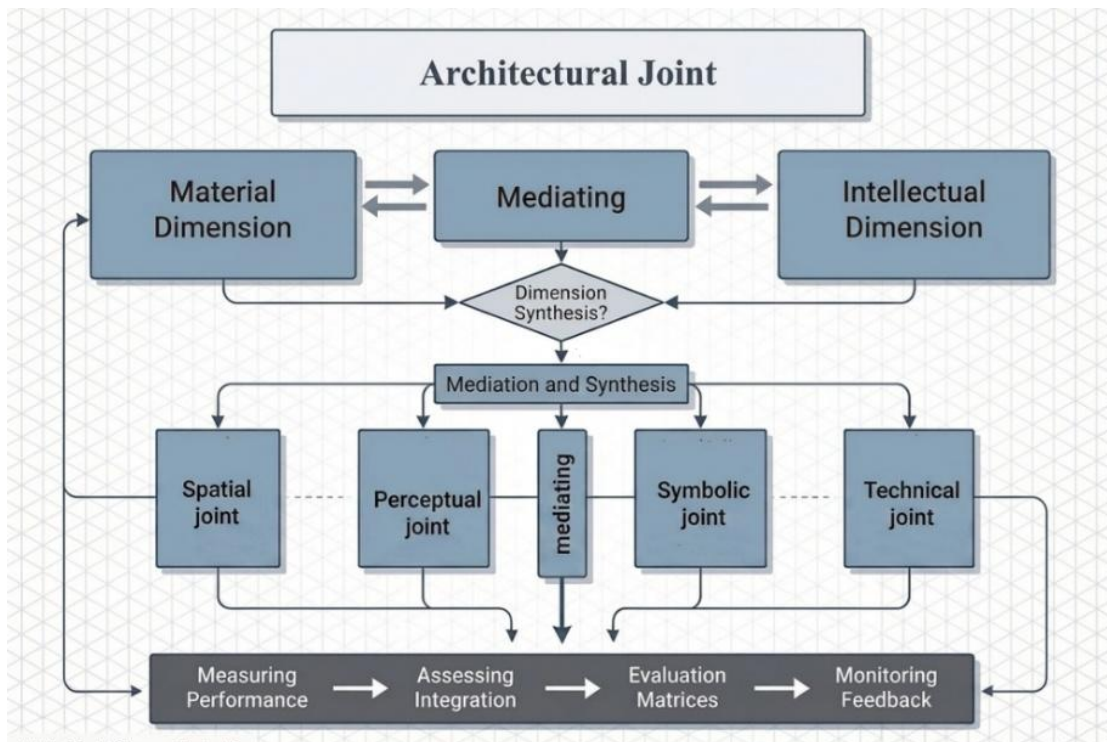


Figure 3. Integrated Conceptual Model of the Architectural Joint.

These four dimensions together form the conceptual model of the architectural joint, providing the basis on which the analytical indicators used in the methodology are built.

2.3 Types of Architectural Joints Derived from the Theoretical Framework

The theoretical framework of the integrated conceptual model developed in the previous section provides a basis for classifying the architectural joints by their main modes of mediation. These joint types are not exhaustive but represent conceptualizations of different combinations of the four analytical dimensions. In this study, thirteen architectural joint types are identified, each of which is a unique way in which architecture can mediate between material construction and intellectual meaning, as shown in **Table 3**.

Table 3. Typology of Architectural Joints Derived from the Conceptual Framework.

Code	Architectural Joint Type
J1	Spiritual Joint
J2	Aesthetic-Light Joint
J3	Historical-Contemporary Intellectual Joint
J4	Transformative Joint
J5	Constructive Joint
J6	Internal-External Joint
J7	Transformative-Technical Joint
J8	Symbolic Joint
J9	Aesthetic Joint
J10	Technical Joint
J11	Intellectual-Cultural Joint
J12	Angular Joint
J13	Constructive-Aesthetic Joint



Each of the thirteen joint types is defined below by its dominant analytical dimension(s) (**Table 4**) and its representative case as stated later in (**Table 7**). J1 Spiritual Joint: spatial and perceptual dimensions organized around a dominant symbolic dimension, mediating ritual movement and collective meaning (exemplar: the Holy Kaaba). J2 Aesthetic-Light Joint: a perceptually dominant joint in which light mediates a secondary symbolic register (exemplar: Church of Light). J3 Historical-Contemporary Intellectual Joint: a symbolically dominant joint with a secondary technical register, mediating between historical fabric and contemporary intervention (exemplar: Louvre Pyramid). J4 Transformative Joint: a joint in which spatial, perceptual, symbolic and technical dimensions each contribute secondarily to a geometric transition between states (exemplar: Muqarnas, Abbasid Palace). J5 Constructive Joint: a technically dominant joint in which the structural system itself is expressed (exemplar: HSBC Headquarters). J6 Internal-External Joint: a spatially dominant joint with a secondary perceptual register, mediating interior/exterior transition (exemplar: Alhambra Courtyard). J7 Transformative-Technical Joint: a technically dominant joint with a secondary spatial register, mediating transition between constructional paradigms (exemplar: Central Bank of Iraq). J8 Symbolic Joint: a symbolically dominant joint with a secondary perceptual register (exemplar: Ronchamp Chapel). J8 is distinguished from J1 in that its symbolic register is generated by the architect's sculptural and luminous composition rather than by ritual practice and collective orientation; the two types therefore differ in the source of symbolic meaning, not merely in its intensity. J9 Aesthetic Joint: a perceptually dominant joint with a secondary symbolic register, distinct from J2 in not being organized specifically around light (exemplar: Louvre Abu Dhabi). J10 Technical Joint: a technically dominant joint in which structural and mechanical systems are exposed as the primary expressive device (exemplar: Centre Pompidou). J11 Intellectual-Cultural Joint: a symbolically dominant joint with a secondary spatial register, associated with disjunctive rather than integrative logic (Section 5.2) (exemplar: Parc de la Villette). J12 Angular Joint: a joint in which spatial, perceptual, symbolic and technical dimensions each contribute secondarily to a formal transition between facades or masses (exemplar: Baghdad Municipality Building). J13 Constructive-Aesthetic Joint: a technically dominant joint with a secondary perceptual register, combining structural resistance with expressive intent (exemplar: Burj Khalifa).

The types below are presented in the theoretical order in which they are derived from the synthesis in Sections 2.1-2.2, rather than grouped by family resemblance, to preserve traceability between each type and its derivation. While each joint type has a predominant mode of mediation, most architectural joints have more than one analytical dimension. For this reason, **Table 4** shows the correlation between the identified joint types and the four analytical dimensions.

2.4 Mapping Architectural Joint Types onto the Four Analytical Dimensions

The different types of architectural joints discussed in the last section are different forms of the integrated conceptual model. There are one or more dominant analytical dimensions for each type of joint, and some are a synthesis of more than one dimension, demonstrating that architectural joints have a multidimensionality. Based on the relative importance of each analytical dimension, the types of joints identified are then mapped in **Table 4**.

**Table 4.** Mapping of Architectural Joint Types Across the Four Analytical Dimensions.

Architectural Joint Type	Spatial	Perceptual	Symbolic	Technical
Spiritual Joint	✓	✓	✓✓	–
Aesthetic–Light Joint	–	✓✓	✓	–
Historical–Contemporary Intellectual Joint	–	–	✓✓	✓
Transformative Joint	✓	✓	✓	✓
Constructive Joint	–	–	–	✓✓
Internal–External Joint	✓✓	✓	–	–
Transformative–Technical Joint	✓	–	–	✓✓
Symbolic Joint	–	✓	✓✓	–
Aesthetic Joint	–	✓✓	✓	–
Technical Joint	–	–	–	✓✓
Intellectual–Cultural Joint	✓	–	✓✓	–
Angular Joint	✓	✓	✓	✓
Constructive–Aesthetic Joint	–	✓	–	✓✓

Legend: ✓✓ = Primary Dimension | ✓ = Secondary Dimension | – = Limited or Indirect Relationship

Table 4 shows that architectural joint types rarely rest on a single analytical dimension, but arise from interactions among dimensions, with one typically predominant. Building on this framework, the study's central hypothesis is restated here: the effectiveness of an architectural joint depends on its capacity to generate meaning across the four dimensions collectively (spatial, perceptual, symbolic and technical), rather than on its technical complexity alone.

3. RESEARCH METHODOLOGY

3.1 Research Design

This research design is a sequential design consisting of theoretical-conceptual development and quantitative expert elicitation; that is, it has qualitative-conceptual and quantitative expert-evaluation phases. The qualitative part will be used to build the theoretical synthesis and integrated conceptual framework presented in the section 2 whilst the quantitative part will be the structuring of the previously mentioned conceptual framework, measurable indicators, and the design of the questionnaire, as well as the collection of expert evaluations of the case studies identified in the framework; and Statistical Analysis with Descriptive Statistics, reliability test, and computation of the Joint Strength Index (JSI). **Fig. 4** shows the overall research design.

3.2 Expert Panel Characteristics

An empirical assessment was carried out with a panel of 55 professionals and academicians from the domain of architecture having been carefully selected for a balanced evaluation of the selected case studies. The panel consisted of university faculty, architectural researchers, practicing architects and structural and design engineers who have experience in architecture design, theory and criticism and professional practice.

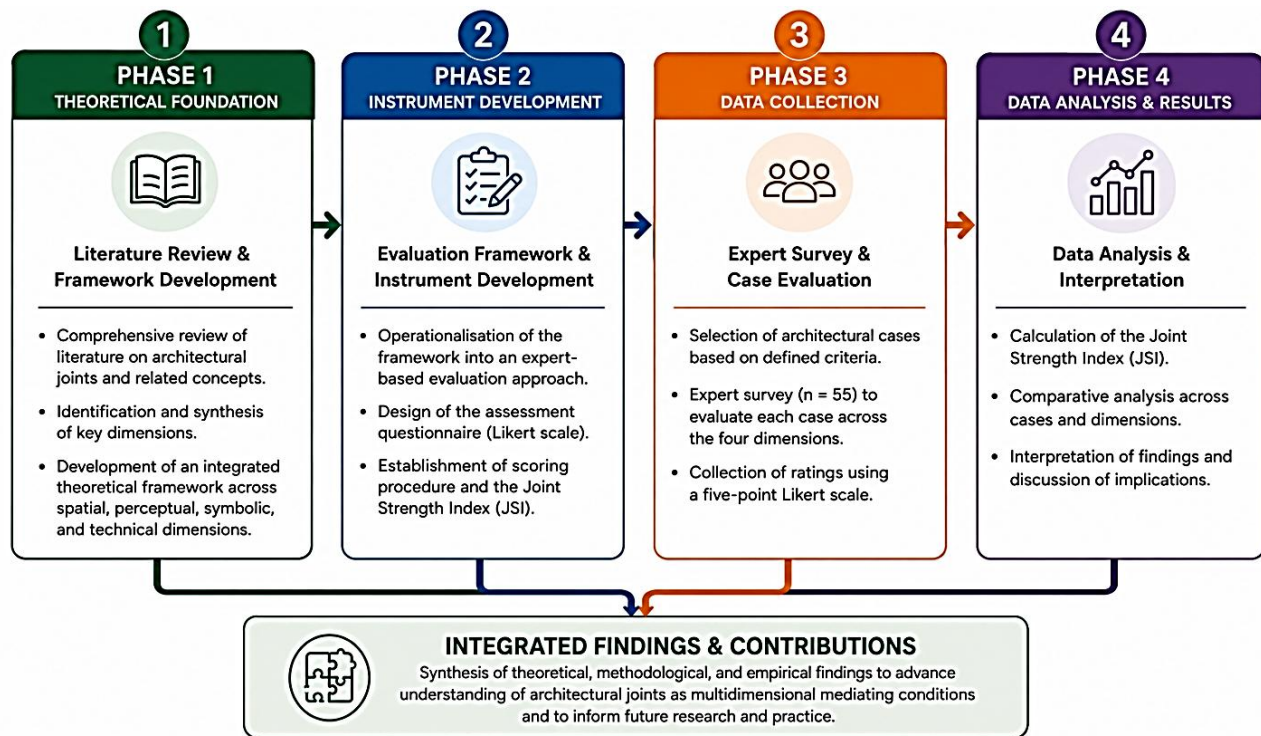


Figure 4. Research design flowchart illustrates the four sequential phases of the methodology.

The criteria for expert selection were: (a) postgraduate academic qualification in architecture or related disciplines; (b) experience of at least five years in architectural design, theory or evaluation; and (c) experience in conducting architectural analysis and critical assessment. Experts were recruited using purposive sampling based on these predefined eligibility criteria. A total of 60 eligible experts were invited to participate in the study through online communication channels. Of these, 55 completed the electronic questionnaire, yielding a response rate of 91.7%. A variety of panel participants were intentionally created, from academic research to design practice and engineering, so as to strengthen the assessment's face validity and mitigate bias arising from the various disciplines in assessing architectural joint realization. The composition of the panel is given in **Table 5**.

Table 5. Composition of the Expert Panel.

Expert Category	Number
University Faculty Members (Academics)	19
Practicing Architects	14
Architectural Researchers	13
Structural and Design Engineers	9
Total	55

3.3 Evaluation Methods: The Expert Questionnaire

The level of achievement of the chosen case studies' architectural joints was assessed by developing a structured questionnaire based on the theoretical framework developed in Section 2. The aim was to make the idea of the architectural joints measurable and thus to enable quantitative analysis and comparison. For each of the thirteen case studies, experts



were provided with the proposed joint type, a brief explanatory statement, and a representative visual image. The questionnaire contained a single holistic evaluative statement, purpose-written to reference the specific joint type assigned to that case (**Table 3**) and framed in language drawn from the corresponding analytical dimensions (**Table 4**). The method therefore operationalizes the four-dimensional framework at the level of the theoretical typology and item wording, not as four separately scored sub-scales: each case received one overall realization rating rather than four dimension-specific ratings, and dimension-level scores are consequently not available for separate reporting or separate reliability analysis. The matching between the theoretical model and the wording of each evaluative statement was kept throughout the process of designing the questionnaire to support face and content validity. The participants rated each case-specific evaluative statement on a 1–5 Likert scale, where 1 represents Very Weak Realization, and 5 represents Very High Realization. In the absence of a separate pilot-testing phase, the method's face and content validity rest on this direct, traceable derivation from the theoretical framework and on the documented item-by-dimension wording match, rather than on empirical pre-testing with an independent respondent group; pilot testing of the instrument is recommended for future applications.

The questionnaire was administered electronically, and each of the 55 experts was asked to provide an overall realization rating for each of the 13 case studies. This was a fully crossed within-subjects design, because each case study was independently rated by 55 expert judges ($N = 55$ per case) and because the design required a repeated-measures structure for the within-subjects inferential procedures reported below in Section 3.5.5. The answers were then collected, anonymized, coded and statistically analyzed.

The expert evaluators received visual information for each of the thirteen case studies along with the proposed type of joint for that particular study and a short explanatory statement. The question of whether the designated architectural joint was achieved in the submitted case was the subject of the accompanying evaluative question. To ensure uniformity of the evaluation procedure, all participants completed a structured electronic questionnaire. Evaluators then gave an overall realization rating, on the above-mentioned five-point Likert scale, for each case.

3.4 Selection of Case Studies

Thirteen architectural case studies were chosen to show a variety of architectural manifestations of the architectural joint in different historical eras, cultural traditions and spaces. The selection process was done in accordance with four criteria, which are shown in **Table 6**.

Table 6. Case Study Selection Criteria.

Selection Criterion	Description
Architectural significance	Case study shall be a well known and well documented case of an articulation in architecture that has received a high level of scholarly interest.
Joint manifestation	The case study must be clear and demonstrate one or more of the following 13 types of joints in the theoretical approach.
Historical and cultural diversity	Variations in history, geography and culture from the sample in general.
Documentation availability	Architectural documentation, literature and visual material should be sufficient so as to be practical for expert evaluation.



The thirteen case studies have been purposefully chosen to be representative of the architectural joint types identified in the proposed theoretical framework and are compared at the level of the operationalized architectural joint construct rather than as holistic comparisons between entire buildings. Therefore, for the purposes of this study, the unit of comparison is the architectural joint, rather than the building itself. All case studies are compared at the level of the four analytical dimensions and using a common expert evaluation protocol, which allows for meaningful cross-case comparison of this type while maintaining methodological consistency. This approach emphasizes conceptual representativeness rather than typological uniformity, allowing the framework to be evaluated in the context of a wide range of architectural applications. The case studies and joint types are summarized in **Table 7**.

Table 7. Selected Architectural Case Studies and Corresponding Joint Types.

No.	Architectural Sample	Location	Architectural Joint Type
1	The Holy Kaaba	Mecca, Saudi Arabia	Spiritual Joint (J1)
2	Church of Light (Tadao Ando)	Osaka, Japan	Aesthetic–Light Joint (J2)
3	Louvre Pyramid (I.M. Pei)	Paris, France	Historical–Contemporary Intellectual Joint (J3)
4	Muqarnas of Abbasid Palace	Baghdad, Iraq	Transformative Joint (J4)
5	HSBC Headquarters (N. Foster)	Hong Kong, China	Constructive Joint (J5)
6	Alhambra Courtyard	Granada, Spain	Internal–External Joint (J6)
7	Central Bank of Iraq	Baghdad, Iraq	Transformative–Technical Joint (J7)
8	Ronchamp Chapel (Le Corbusier)	Ronchamp, France	Symbolic Joint (J8)
9	Louvre Abu Dhabi (J. Nouvel)	Abu Dhabi, UAE	Aesthetic Joint (J9)
10	Centre Pompidou (Piano & Rogers)	Paris, France	Technical Joint (J10)
11	Parc de la Villette (Tschumi)	Paris, France	Intellectual–Cultural Joint (J11)
12	Baghdad Municipality Building	Baghdad, Iraq	Angular Joint (J12)
13	Burj Khalifa	Dubai, UAE	Constructive–Aesthetic Joint (J13)

The Holy Kaaba was chosen to be included in the sample not because it is the most beautiful example of spatial orientation, collective ritual movement and symbolic meaning in one architectural condition but because it is the most well documented. It serves as the upper end of the measurement scale and because it is the most impossible to imagine without the conjunction of these elements. It was evaluated only in terms of the extent of realization of the given joint condition, like in all the other cases discussed, and the cultural situatedness of the resulting score is discussed in Section 5.4 and further considered among the study limitations in Section 5.5.

In **Table 7**, the type of joint for each case was operationally defined to the experts by one evaluative statement for each case concerning that case's specific architectural condition (e.g., in the case of the HSBC Headquarters, the statement "Constructive Joint" asked experts to evaluate how functional and aesthetic the structural system and its connection points are revealed as expressive rather than merely technical elements).

**Table 8.** Case-Selection Rationale.

Case	Joint Type	Dimension(s) (Table 4)	Reason for Selection	Criteria Satisfied (Table 6)	Analytical Utility as Exemplar
1. Holy Kaaba (Mecca)	Spiritual (J1)	Spatial, Perceptual, Symbolic (dominant)	Most extensively documented case of ritual/spatial convergence in the sample.	Significance; joint manifestation; documentation.	Tests the ceiling/near- unanimous end of the scale; documents ritual- movement and centripetal spatial logic.
2. Church of Light (Osaka)	Aesthetic- Light (J2)	Perceptual (dominant), Symbolic	Canonical case of light as the sole mediating device.	Significance; joint manifestation; diversity (East Asia); documentation.	Isolates perceptual- symbolic integration without spatial or technical dominance.
3. Louvre Pyramid (Paris)	Historical- Contemp. Intellectual (J3)	Symbolic (dominant), Technical	Paradigmatic historical/cont emporary juxtaposition.	Significance; joint manifestation; documentation.	Tests symbolic- technical dialogue between heritage fabric and modern intervention.
4. Muqarnas, Abbasid Palace (Baghdad)	Transform ative (J4)	Spatial, Perceptual, Symbolic, Technical (all secondary)	Documented example of geometric transition across all four registers.	Significance; joint manifestation; diversity (Iraq/Islamic); documentation.	Only case with a non-zero rating on all four dimensions; useful contrast to single- dimension cases.
5. HSBC Headquart ers (Hong Kong)	Constructi ve (J5)	Technical (dominant only)	Canonical high- tech expression of structure as ornament.	Significance; joint manifestation; diversity (East Asia, commercial); documentation.	Single-dimension technical case for testing whether technical clarity alone yields high JSI.
6. Alhambra Courtyard (Granada)	Internal- External (J6)	Spatial (dominant), Perceptual	Canonical interior/exteri or threshold in Islamic courtyard architecture.	Significance; joint manifestation; diversity (Islamic Iberia); documentation.	Tests spatial- perceptual threshold logic distinct from symbolic/technica l cases.
7. Central Bank of Iraq (Baghdad)	Transform ative Technical (J7)	Spatial, Technical (dominant)	Documented civic modernization case in the author's own national context.	Significance; joint manifestation; diversity (Iraq, civic/modern); documentation.	Tests transition from traditional massing to contemporary construction within a single national tradition (paired with cases 4 and 12).



8. Ronchamp Chapel (France)	Symbolic (J8)	Perceptual, Symbolic (dominant)	Canonical modernist sacred building with documented sculptural/light strategy.	Significance; joint manifestation; documentation.	Tests symbolic- perceptual dominance in a non-Islamic sacred context, as a comparator to case 1.
9. Louvre Abu Dhabi	Aesthetic (J9)	Perceptual (dominant), Symbolic	Documented contemporary case of mass/material/light composition distinct from J2.	Significance; joint manifestation; diversity (Gulf, contemporary); documentation.	Distinguishes general perceptual- aesthetic logic from light-specific perceptual logic (case 2).
10. Centre Pompidou (Paris)	Technical (J10)	Technical (dominant only)	Canonical exemplar of externalized structural/mechanical systems.	Significance; joint manifestation; documentation.	Second single- dimension technical case (with case 5); tests whether radical technical exposure alone yields high JSI.
11. Parc de la Villette (Paris)	Intellectual-Cultural (J11)	Spatial, Symbolic (dominant)	Theoretically central case of deliberately disjunctive joint logic (Section 5.2).	Significance; joint manifestation; documentation.	Selected specifically to test the integrative/ disjunctive theoretical distinction, not to maximize JSI.
12. Baghdad Municipality Building	Angular (J12)	Spatial, Perceptual, Symbolic, Technical (all secondary)	Documented civic case of formal/geometric articulation in the author's national context.	Significance; joint manifestation; diversity (Iraq, civic); documentation.	Tests on whether local civic significance corresponds to high JSI (it does not, Section 4.2).
13. Burj Khalifa (Dubai)	Constructive-Aesthetic (J13)	Perceptual, Technical (dominant)	Globally documented case combining structural performance and formal expression.	Significance; joint manifestation; diversity (Gulf, super-tall); documentation.	Tests whether global fame/prestige alone predicts high JSI (it does not, Section 4.4).

Because each of the thirteen types is represented by exactly one case, type and case identity remain confounded; the matrix above documents the selection logic actually used, not an independent validation of the typology.

3.5 Statistical Analysis

The data gathered from the expert panel was then put through three consecutive statistical processes: reliability test, arithmetic mean and normalization by Joint Strength Index (JSI).



These procedures, taken together, converted expert judgments into quantitative indicators which could be compared and interpreted across the thirteen case studies.

3.5.1 Reliability Testing: Cronbach's Alpha

The reliability of the questionnaire based on experts has been measured by Cronbach's Alpha coefficient (α), in order to ensure the internal consistency of the questionnaire. Cronbach's Alpha is used to assess the homogeneity/consistency of the questions on the questionnaire, that is, the extent to which the items function together as a coherent scale; it does not, by itself, establish that the method is valid in measuring the intended construct. The following equation was used to determine the coefficient:

$$\alpha = \left(\frac{K}{K-1} \times 1 - \frac{\sum \sigma_i^2}{\sigma_t^2} \right) \quad (1)$$

Where: α = Cronbach's Alpha reliability coefficient

k = number of questionnaire items

σ_i^2 = variance of each individual questionnaire item i

σ_t^2 = variance of the total questionnaire score

The Cronbach's Alpha value of the analysis was $\alpha = 0.757$, and the results of the analysis were satisfactory in terms of internal consistency of the questionnaire items. In the use of the value for research, the acceptable value was determined by the psychometric standard as above 0.70. The value yielded is within the lower end of this range, which is indicative of the evaluative nature of the instrument: It is not expected that experts should have high inter-item agreement on factual items. The coefficient still indicates good reliability of the questionnaire, and the results that can be derived from the questionnaire can be used for further analysis by statistical methods (**Nunnally, 1978**). A formal inter-rater agreement statistic, computed on the original per-expert rating matrix, is reported alongside the limitations of the reliability analysis in Section 5.5. Because the four analytical dimensions jointly define, rather than merely reflect, the architectural-joint construct, the measurement model underlying the instrument is more accurately characterized as formative than reflective; this has implications for the interpretive limits of a single reflective-model reliability coefficient, discussed further in Section 5.5.

3.5.2 Mean Score Calculation

The arithmetic mean was used to calculate the overall expert evaluation score of each of the architectural study cases. The mean is the average of experts' opinions and is the most important number in calculating the Joint Strength Index. It was calculated based on the following equation:

$$\text{Mean} = 1/N \times \sum_{i=1}^n x_i \quad (2)$$

Where: Mean = arithmetic mean of expert evaluation scores for a given case study

x_i = score assigned by expert i on the five-point Likert scale

n = total number of experts evaluating the case study (n = 55)



3.5.3 Joint Strength Index (JSI)

The arithmetic means were then normalized to a common range (the Joint Strength Index, JSI), in order to compare the selected architectural samples and to keep all the scores in the same range. The mean scores are mapped to a common scale of 0.20-1.00 Eq. (3), which enables the case studies analyzed by various expert groups to be compared against one another and for comparison across the various joint categories, regardless of the size of the raw scores. The following equation was used to calculate an index:

$$JSI = \text{Mean}/5 \quad (3)$$

Where: JSI = Joint Strength Index (normalized value, range: 0.20 to 1.00)

Mean = arithmetic mean of expert evaluations for the case study

5 = maximum possible score on the five-point Likert scale

The JSI indicates the relative strength of architectural joint realization in each case study: higher values reflect a more perceptual/symbolic/experiential manifestation, lower values a comparatively weaker one. It is a normalized, transparent and reproducible measure suitable for cross-case comparison within this study's sequential theoretical-conceptual-then-quantitative design, rather than a more complex multidimensional index (see Section 5.3 for its epistemological positioning). Ranks were assigned to the case studies on this basis, supporting comparative visualization of the intensity of joint realization across the analyzed sample.

3.5.4 Normality Testing: Shapiro-Wilk Test

Before the selection of inferential statistical procedures, the normality of the distribution of the expert evaluation scores was checked in each of the thirteen case studies using the Shapiro-Wilk test (W). The Shapiro-Wilk test was chosen because it is known to be more sensitive than other tests in detecting deviation from normality in small sample sizes (such as $n = 55$), as used in **(Razali and Wah, 2011)** study. These findings were confirmed as the score distributions for all 13 of the case studies were also found to be significantly different from the normal distribution (W values ranged from 0.286 to 0.877, all $p < 0.001$). This is not a normal distribution which is expected in ordinal measures and also in items with a high consensus score like the Holy Kaaba ($W = 0.286$, $p < 0.001$). The finding of non-normality ruled out the use of parametric tests (e.g. t-tests or ANOVA) and justified the use of non-parametric inferential procedures as outlined below in Section 3.5.5.

3.5.5 Non-Parametric Inferential Tests

Since the data was confirmed to be non-normal, two complementary non-parametric tests were used to check if there were statistically significant differences amongst the expert evaluations of the thirteen case studies.

To compare the rank-ordered evaluation scores for all thirteen case studies as independent groups, a non-parametric version of one-way ANOVA, the Kruskal-Wallis H test, was used. The results showed that there was a significant difference in the JSI value for the case studies ($H(12) = 131.61$, $p < 0.001$), and that the differences were not due to random sampling variation. The H value is significantly higher than the critical value for $\chi^2(12) = 21.03$ at $\alpha = 0.05$, which suggests that the JSI-based ranking is not merely a representation of the sampling variance of the evaluators, but is genuine in representing architectural differences



in realization of the joints; this significant result is consistent with, though does not by itself establish, discriminatory power beyond what the small-to-moderate effect size reported below (Kendall's $W = 0.24$) indicates **Fig. 4**. Because the same 55 experts rated all thirteen cases (a repeated-measures design), the Kruskal-Wallis test's independent-groups assumption is not strictly satisfied here; it is reported as a supplementary, non-primary cross-check, and the Friedman test below is treated as the primary inferential result for this design.

The Friedman test was also used as a within subjects complement, as each of the 55 experts rated each of the thirteen case studies. The Friedman test result, $\chi^2(12) = 157.38$, $p < 0.001$, was consistent with the Kruskal-Wallis result, indicating that the rank orders found in the JSI values are statistically significant and reflect evaluator-consistent differences in the realization of the joints in the selected architectural sample. The associated effect size, Kendall's coefficient of concordance, computed directly from the reported Friedman statistic as $W = \chi^2 / [N \times (k - 1)]$ with $N = 55$ experts and $k = 13$ cases, is $W = 157.38 / (55 \times 12) = 0.24$, indicating a small-to-moderate, rather than a strong, degree of agreement across the case ranking. Following the reviewers' recommendation, the omnibus Friedman result was followed up with pairwise Wilcoxon signed-rank tests across all 78 possible case pairs (13 cases), computed directly on the original per-expert rating matrix ($N = 55$), with a Holm-Bonferroni correction applied across the 78 comparisons to control the family-wise error rate. Of the 78 pairwise comparisons, 36 (46%) remained statistically significant after correction ($p_{\text{Holm}} < .05$). All 12 pairwise comparisons between the Holy Kaaba and every other case remained significant after correction (p_{Holm} ranging from $< .001$ to $.020$), confirming that the Kaaba's distinctiveness is not an artefact of uncorrected multiple testing. Conversely, the three cases sharing an identical rounded JSI of 0.873 (HSBC Headquarters, Alhambra Courtyard, Central Bank of Iraq) were mutually non-significant after correction (all $p_{\text{Holm}} = 1.00$), as were the two cases sharing JSI = 0.735 (Parc de la Villette, Burj Khalifa; $p_{\text{Holm}} = 1.00$), which substantiates, rather than merely asserts, the "numerically similar" description used in Section 4.1.

All of these non-parametric findings greatly support the interpretative conclusions reached in the preceding section, which show that the hierarchical ranking yielded by the JSI is statistically significant rather than an artifact of the normalizing process, refer to **Fig. 5**.

4. RESULTS AND DISCUSSION

The quantitative results from the expert-based assessment discussed in Section 3 are provided in this section. The results are presented in four ways: the whole data set of arithmetic means and JSI.

4.1 Quantitative Evaluation Outcomes

Once the expert evaluation was completed, the thirteen case studies for architecture were calculated to find the arithmetical mean and the calculated JSI values were calculated using the formula developed in section 3.5.3. The full results are given in **Table 9**; each case study was given a rank according to its JSI value. Cases with the same JSI scores were given the same rank because the underlying level of joint realization, as judged by the expert panel, was the same.

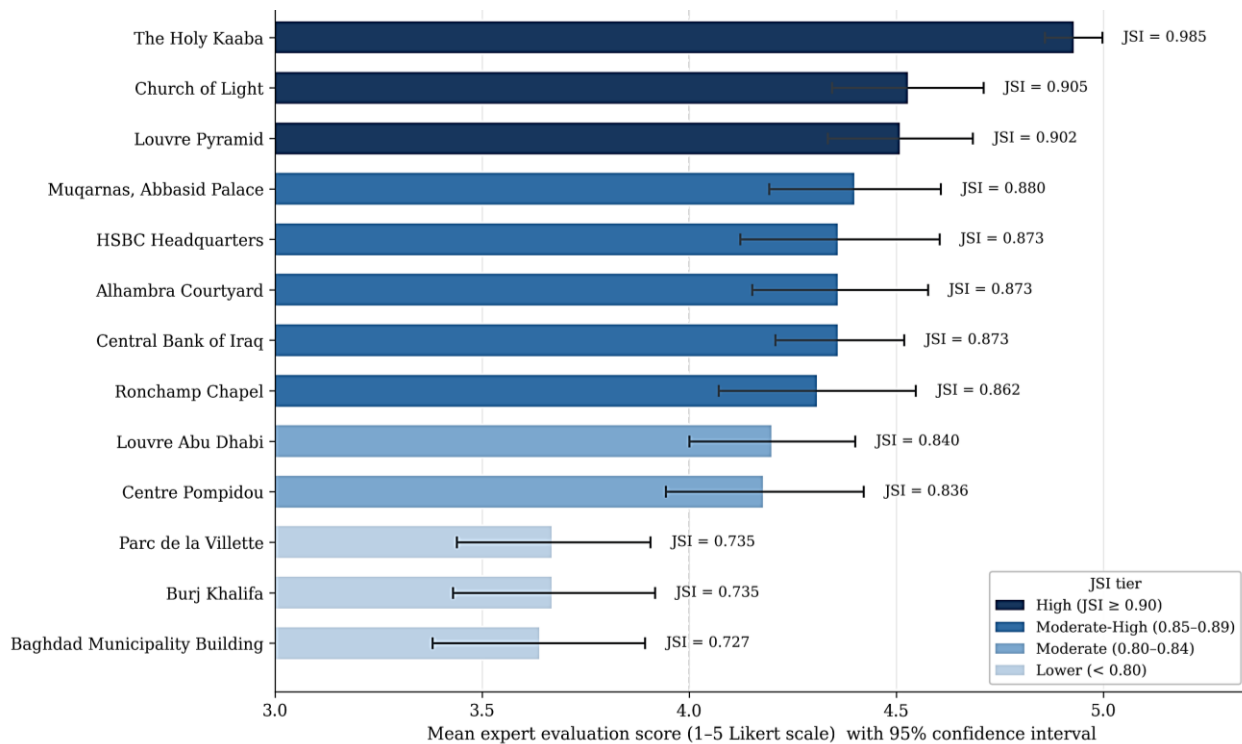


Figure 5. Mean Evaluation Scores and JSI Values across the Thirteen Case Studies.

Table 9. Quantitative Evaluation of Architectural Joints Using the Joint Strength Index (JSI).

Rank	Architectural Case Study	Joint Type	Mean ($\bar{x}$)	SD	JSI	95% CI
1	The Holy Kaaba — Mecca, Saudi Arabia	Spiritual Joint	4.93	0.262	0.985	[4.858 – 4.997]
2	Church of Light — Tadao Ando, Osaka	Aesthetic-Light Joint	4.53	0.690	0.905	[4.345 – 4.710]
3	Louvre Pyramid — I.M. Pei, Paris	Historical-Contemporary Int. Joint	4.51	0.663	0.902	[4.334 – 4.684]
4	Muqarnas, Abbasid Palace — Baghdad	Transformative Joint	4.40	0.784	0.880	[4.193 – 4.607]
5	HSBC Headquarters — Foster, Hong Kong	Constructive Joint	4.36	0.910	0.873	[4.123 – 4.604]
5	Alhambra Courtyard — Granada, Spain	Internal-External Joint	4.36	0.802	0.873	[4.152 – 4.576]
5	Central Bank of Iraq — Baghdad	Transformative-Technical Joint	4.36	0.589	0.873	[4.208 – 4.519]
8	Ronchamp Chapel — Le Corbusier	Symbolic Joint	4.31	0.900	0.862	[4.071 – 4.547]
9	Louvre Abu Dhabi — Jean Nouvel	Aesthetic Joint	4.20	0.755	0.840	[4.000 – 4.400]
10	Centre Pompidou — Piano & Rogers, Paris	Technical Joint	4.18	0.905	0.836	[3.943 – 4.421]
11	Parc de la Villette — Tschumi, Paris	Intellectual-Cultural Joint	3.67	0.883	0.735	[3.439 – 3.906]
12	Burj Khalifa — Dubai	Constructive-Aesthetic Joint	3.67	0.924	0.735	[3.429 – 3.917]
13	Baghdad Municipality Building	Angular Joint	3.64	0.969	0.727	[3.380 – 3.893]



The JSI values vary significantly from 0.727 (Baghdad Municipality Building) to 0.985 (Holy Kaaba) (Kruskal-Wallis $H = 131.61$, $p < 0.001$; Friedman $\chi^2 = 157.38$, $p < 0.001$). The standard deviation (SD) column shows that the Holy Kaaba not only has the highest JSI but also has the narrowest confidence interval [4.858–4.997] indicating that there is an exceptional level of inter-expert consensus. The Baghdad Municipality Building (SD = 0.969) and the HSBC Headquarters (SD = 0.910) have the largest SDs, which suggests that the evaluators' range of disagreement is larger. It is particularly interesting that three totally different architecture types have the same JSI: 0.873, such as the HSBC Headquarters, the Alhambra Courtyard, and the Central Bank of Iraq. They are virtually statistically equal, however, in terms of the level of joint realization achieved through different dimensional emphases, even when they are respectively representing a high-technology commercial tower, a historic Islamic palatial complex and a modernist civic institution. The Burj Khalifa is also in a unique position compared to the other internationally prominent landmarks in the sample, as the extent to which it is seen as a place of international architectural prestige is not necessarily indicated by multidimensional joint realization as defined in this framework (JSI = 0.735; 95% CI [3.429–3.917]).

4.2 Ranking Analysis and Hierarchical Patterns

The findings are grouped into four descriptive, author-defined performance bands (not statistically derived cut-points): High (JSI ≥ 0.90), Moderate-High (0.85–0.89), Moderate (0.80–0.84), and Lower (< 0.80); full values are given in **Table 9**. Results are interpreted through the four analytical dimensions — the comparative currency shared by every case — rather than through the thirteen joint types.

The High tier comprises the Holy Kaaba (spatial, perceptual and symbolic dimensions; ritual movement and centripetal spatial organization), the Church of Light (perceptual and symbolic; light as an experiential threshold between material opacity and symbolic transcendence), and the Louvre Pyramid (symbolic and technical; a historical–contemporary synthesis resonant on the perceptual and spatial registers) (**Table 4**). The shared pattern across all three is multidimensionality itself, not an identical dimensional composition. The Moderate-High tier holds the Muqarnas of the Abbasid Palace (structural, perceptual and symbolic transition), a geometric and ornamental transition also examined in recent Iraqi scholarship on Abbasid mosque and madrasa design (**Ahmed, 2026**), three cases with statistically indistinguishable JSI values of 0.873 — HSBC Headquarters (technical clarity), Alhambra Courtyard (internal–external mediation) and Central Bank of Iraq (transformative civic articulation), confirmed non-significant by the pairwise comparisons in Section 3.5.5 — and the Ronchamp Chapel (sculptural massing and modulated light).

In the Moderate tier, the Louvre Abu Dhabi and Centre Pompidou show that technical visibility alone does not guarantee perceptual or symbolic resonance: the Pompidou's radical externalization of its technical systems does not yield a correspondingly high JSI. The Lower tier — Parc de la Villette, the Burj Khalifa and the Baghdad Municipality Building — shows not an absence of joint realization but that strong perceptual–symbolic impact is harder to achieve through primarily intellectual, formal or technical approaches: Tschumi's folly-as-disjunction is deliberately less perceptually integrative and thus less legible on the intellectual–cultural register; the Burj Khalifa's global prominence does not translate into a correspondingly high multidimensional realization; and the Baghdad Municipality Building's formal geometric articulation produces a comparatively subtle perceptual and symbolic impact, reflecting the instrument's operational definition of joint realization



without contesting the building's independent civic significance (**Al-Assadi and Al-Dewachi, 2020**). This pattern is consistent with broader accounts of mid-twentieth-century Iraqi architecture negotiating international modernist vocabulary against local expectations of monumental representation (**Abdullah and Al-Qaisi, 2024**).

4.3 Interpretive Discussion: Results and the Research Hypothesis

The quantitative findings presented in Sections 4.1 and 4.2 are interpreted in relation to the study's principal hypothesis, formulated in Section 1: that an architectural joint's effectiveness depends less on structural complexity than on its capacity to mediate meaning and enable perceptual transition between the material and the intellectual.

Because meaning-generation and technical complexity were not independently measured as separate constructs, the hypothesis is evaluated indirectly, through case-tier comparison, rather than directly tested; the pattern reported here is consistent with, but does not directly confirm, the hypothesis. The three highest-JSI cases (≥ 0.90), the Holy Kaaba, the Church of Light and the Louvre Pyramid, are precisely those in which the joint is symbolically, perceptually and spatially intense (Section 4.2), consistent with meaning-generation as the stronger determinant of joint effectiveness. Conversely, the comparatively low JSI values for the Centre Pompidou and Parc de la Villette are significant in the same sense: the radical exposure of structural and mechanical systems at the Pompidou is architecturally important but was not accompanied by comparable perceptual or symbolic elaboration in expert evaluation, and Parc de la Villette's abstraction-based intellectual approach produced a more limited expert response, suggesting that abstract modes of operation may be less perceptually available than more direct sensory or symbolic ones.

The results also corroborate the internal consistency of the analytical framework: the four-dimensional model (spatial, perceptual, symbolic and technical) identifies salient differences across the diverse case studies, with multidimensional cases generally rated higher than single-dimension ones, consistent with the framework's fundamental principle within the present sample. This is further supported by the questionnaire's internal consistency (Cronbach's $\alpha = 0.757$; Section 3.5.1, Section 5.5). Quantitative results thus open the architectural joint to a new understanding as an active generative mechanism mediating between the physical and mental aspects of architectural experience.

4.4 Consensus Analysis: Inter-Expert Agreement

In addition to the JSI-based ranking, the standard deviation (SD) of expert evaluations provides a complementary measure of inter-expert agreement, a dimension of the data that the JSI, a mean-derived measure, cannot capture on its own: a low SD indicates high agreement among evaluators, a high SD indicates disagreement on the extent to which a case exemplifies its joint type.

The Holy Kaaba shows the clearest pattern of consensus: alongside the highest JSI, it has the lowest SD among the 55 experts, with 51 giving the maximum score of 5, near-unanimous agreement, seen consistently across academic, practitioner and engineering categories, and the narrowest 95% confidence interval in the study [4.858–4.997].

Conversely, the widest confidence intervals and greatest disagreement occur for the Baghdad Municipality Building, the HSBC Headquarters, the Ronchamp Chapel, and the Centre Pompidou (SD values in **Table 8**). In Ronchamp and the Centre Pompidou, the high SD reflects interpretive plurality: architecture whose dual logic generates effects on alternate registers, sculptural massing and light modulation in the first, structural inversion

and programmed exposure in the second, inviting divergent readings from evaluators of different orientations. Re-analysis on the original per-expert data by recruitment category (**Table 5**: Academics $n = 19$, Practicing Architects $n = 14$, Architectural Researchers $n = 13$, Structural/Design Engineers $n = 9$) found significant between-category differences for two cases: the Louvre Pyramid, $H(3) = 9.44$, $p = .024$, and Parc de la Villette, $H(3) = 8.62$, $p = .035$ — tentative evidence that evaluation of intellectual-conceptual joints may be more sensitive to evaluators' disciplinary background. This four-category result, computed directly from the original per-expert rating matrix using the classification in **Table 5**, supersedes a preliminary analysis conducted earlier in the review process using three broader expert categories; the change in category structure, not a change in the underlying ratings, accounts for the different H and p values obtained at that earlier stage.

The Burj Khalifa stands out for the opposite reason: despite being one of the world's most architecturally significant structures, it had one of the lowest agreement scores ($SD = 0.924$) alongside one of the lowest JSI values (0.735). Its median expert response was 3 ('Moderate Realization'), and the wide confidence interval [3.429–3.917] spans low to high realization - evidence that its constructive-aesthetic joint logic, though highly formal, is not equally transmissible perceptually and symbolically to expert evaluators, a nuance JSI values alone do not reveal. The consensus analysis thus adds a second dimension to the JSI-based ranking (Consensus Map, **Fig. 6**): cases with high JSI and low SD (Kaaba, Church of Light, Louvre Pyramid) are the sample's most unambiguous joint realizations, where multidimensional integration yields a clearly visible experiential and symbolic threshold; cases with moderate JSI and high SD are architecturally significant but interpretatively contested, their assessment depending heavily on the evaluator's disciplinary framing illustrated in **Fig. 5**.

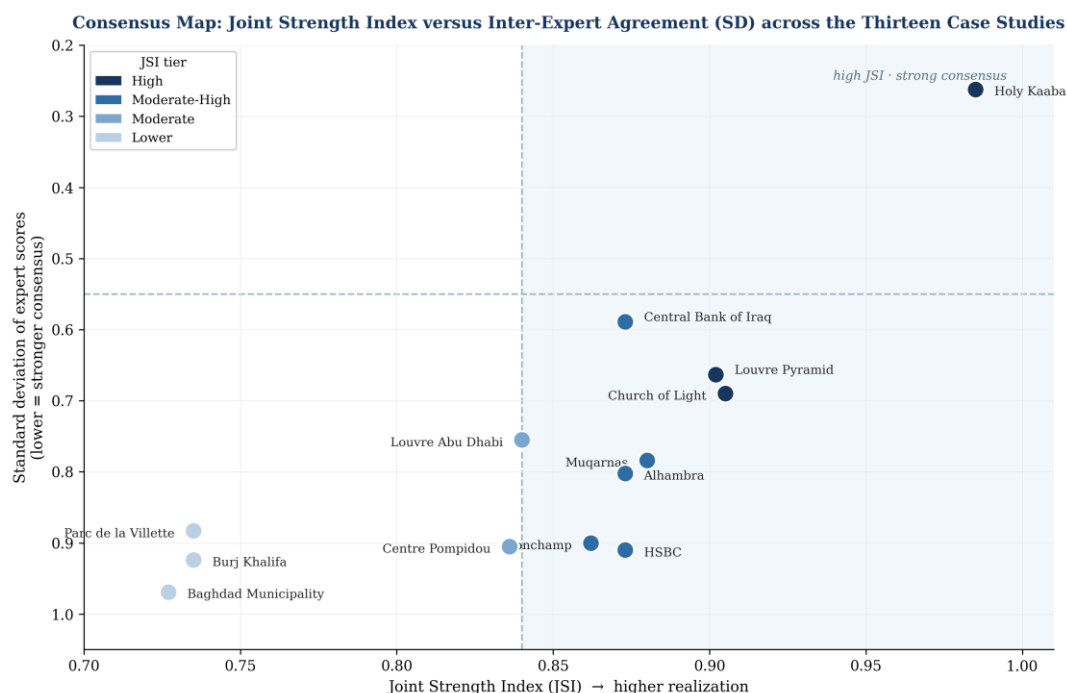


Figure 6. JSI–SD Distribution across the Thirteen Case Studies. The quadrant boundaries (JSI = 0.84; SD = 0.55) are descriptive reading aids chosen by the author to separate the upper and lower halves of the observed value ranges; they are not statistically derived thresholds, and no interpretive claim rests on their exact position. $N = 55$ experts per case; source: expert-rating matrix.

The results of the study outlined in Section 4 demand systematic interpretation in the larger intellectual framework suggested by the theoretical framework and the methodological apparatus used in this study. It is in this section that this interpretative process is carried out, on four levels: the correlation of the empirical results with the multidimensional theoretical model presented in Section 2, the apparent paradox of the comparatively low empirical rank, but high theoretical salience of Parc de la Villette, the epistemological status of the Joint Strength Index as an evaluative device, and the cultural and contextual conditions that inflect expert-based architectural evaluation. Next, the limitations of the study methodology are discussed.

4.5 Alignment with the Multidimensional Theoretical Framework

The quantitative results are broadly consistent with the conceptual 4D model developed in Section 2.2. Across the thirteen cases, the highest-JSI cases combine multiple analytical dimensions, with symbolic and perceptual emphasis recurring among the higher-ranked cases (**Table 4**). This pattern is consistent with Frampton understanding of the joint as a convergence of construction, material and meaning, and with Pallasmaa emphasis on the experiential and perceptual dimensions of architecture (**Frampton 1995; Pallasmaa 2012**). Overall, the findings suggest that higher joint realization within the present sample is associated with multidimensional mediation rather than with technical or formal articulation alone. This interpretation remains descriptive and should be considered within the methodological limitations discussed in Section 5.5, referring to **Fig. 6**. The distribution was calculated using the weights $\checkmark\checkmark = 2$, $\checkmark = 1$, and $- = 0$ (40 emphasis points in total). The outer ring represents each dimension's share, whereas the inner ring distinguishes dominant from secondary emphasis. As these weights were researcher-assigned in **Table 4**, **Fig. 7** represents the analytical framework rather than independent empirical corroboration.

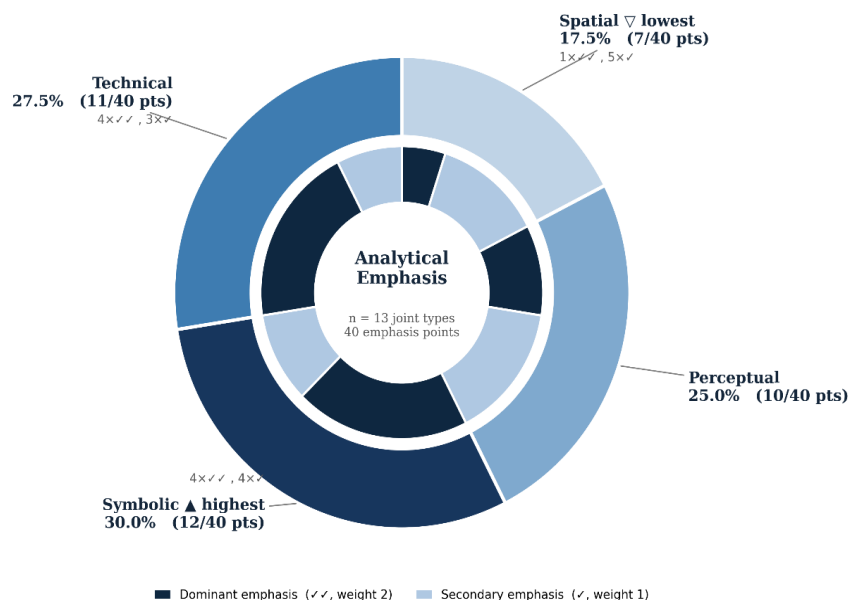


Figure 7. Distribution of Analytical Emphasis across the Four Dimensions.



4.6 The Parc de la Villette Paradox: Theoretical Centrality versus Empirical Outcome

Among the most theoretically instructive findings is Parc de la Villette by Bernard Tschumi (JSI = 0.735), a project theoretically positioned in Section 2.1 as a model of programmatic disjunction and architectural discontinuity. The apparent disconnect between its theoretical centrality and its comparatively low empirical score is not a methodological artefact; it is itself a theoretically significant finding that sharpens a conceptual distinction within this study's framework.

Tschumi explicitly theorized a program for Parc de la Villette that was based on the denial of synthesis, totality and perceptual integration. Its twelve red steel follies aren't distributed across the site with the intention of consolidation but to introduce indeterminacy of program and event. This is a system which doesn't seek to mediate between material and meaning but strategically ruptures, or disjuncts, them, placing them in the foreground instead of in the middle. The lower score of the project is therefore not a sign of poor quality or significance, but a testament that the expert panel has rightly acknowledged that the joints in Parc de la Villette are not susceptible to perceptual and symbolic integration (**Tschumi 1994**) (which is what the JSI instrument measures).

This distinction reflects a broader theoretical divide between two architectural strategies: an integrative logic, exemplified by the high-JSI cases, in which the joint combines spatial, perceptual, symbolic and technical aspects; and a disjunctive logic, exemplified by Tschumi's program, in which the joint's productive role is to disassemble and resist experiential consolidation. The JSI as constructed is maximized to detect the former. Parc de la Villette's lower score is therefore not a limitation of the case but a genuine architectural difference that future instruments might be designed to capture directly.

4.7 The Joint Strength Index as an Evaluation Instrument: Positioning and Contribution

A methodological consideration has to be made with respect to epistemological nature of Joint Strength Index. The JSI is calculated by dividing the expert evaluation's average by the maximum scale of five, as mentioned in Section 3.5.3. Its mathematical formulation is a linear normalization which maps the raw mean to a bounded interval [0.20, 1.00]. The JSI is not a new statistical tool; rather, it is best understood as an operationalization strategy: a set of principles that were applied to transform scores in the experts' evaluations to a common standard for architecturally different cases, thus making it possible to perform systematic cross-case comparisons. The specialness of the contribution of the JSI is that it has been applied to a particular domain, not for the novelty of the math. The expert-based architectural evaluation literature (**Groat and Wang, 2013; Sussman and Hollander, 2021**) is thus fraught with the challenge of how to correlate the qualitative evaluation of one building by one expert with the other building's evaluation by the other expert, when the buildings vary widely in period, function, scale and cultural context. Addressing this challenge, the JSI creates a standardized, dimensionless and expert consensus-based metric, enabling a study to be ranked internally to itself, as well as comparing it to other studies in future applications. Thus, it does not bear a mathematically generative value, it is procedural and evaluative. There is future scope for improving the four analytical dimensions with differential weighting and confirmatory factor analysis of the indicator structure, building on the inter-rater reliability coefficients (ICC(3,1), ICC(3,55)) already reported alongside the internal consistency measure in Section 5.5.



4.8 Cultural and Contextual Considerations in Expert-Based Architectural Evaluation

Any interpretation of these results must consider the cultural and context-specific conditions that shaped the expert evaluation: the 55-member panel was predominantly of Iraqi nationality, which carries particular interpretive weight for the highest-scoring case. First of all, the highest value of the JSI (0.985) is for the Holy Kaaba and should be considered in this cultural context. The Kaaba is not simply a building that can be evaluated by professional standards, but it is a site of "living religion" and "cosmology"—an architecture that helps to organize the substance of deep beliefs and embodied practices for a large majority of the expert panel. This reading is in line with the previous scholarship which argues that the geometry of cubic shape is sufficient to create a unique spatial experience which is not related to any specific cultural context of the observer (**Alhawasli and Bemanian, 2018**).

This cultural resonance isn't necessarily a methodological disqualifier, on the contrary, the knowledge and expertise of the symbolic register of a building can be a prerequisite for a correct perception and evaluation of the perception and spirituality of a building. In addition, prior scholarship suggests that cultural embeddedness can act as a constitutive, rather than a confounding, factor in architectural evaluation when the dimension assessed is itself cultural or symbolic in nature (**Mahgoub, 2007**); the present design cannot fully separate this constitutive role from a familiarity or in-group bias, and both readings remain plausible (Section 5.5). JSI however, is uniform for culturally closer buildings like the Abbasid Palace (JSI = 0.880) and the Central Bank of Iraq (JSI = 0.873), but not for some sort of discriminatory cultural bias. The one drawback of the expert panel is that its geographic distribution remains somewhat limited, which would benefit from deliberate diversification of the evaluator panel in the future across cultural, religious and professional contexts of the methodology.

5. LIMITATIONS

Some limitations exist in the interpretation of the results obtained in this study. For the thirteen different joints, the case is each represented exactly once by a geographically concentrated set (three cases in Iraq, three cases in Paris), making it difficult to differentiate between joint type and case identity, as scores could therefore be partly based on fame, sacredness or iconicity of the case, cultural proximity, familiarity, reputation of the architect or documentation and visual quality and thus generalizability beyond the 13 geographically concentrated sets would also be limited. The study, therefore, demonstrates and applies the framework, but does not test it independently.

The expert panel made up of mostly Iraqis, along with the presentation protocol (panelists were told the proposed joint type and provided with a selected set of pictures and descriptions), may have induced expert panel responses towards this classification; the influence of familiarity, prestige and religious/cultural-proximity effects cannot be excluded, especially for the case of the Holy Kaaba's near-ceiling score.

There was no independent validation of the Joint Strength Index against another instrument or sample, no pilot study prior to the main study administration and no test-retest reliability testing with another group of experts. Cronbach's alpha (computed across the 13 case-based items as a summated scale) is internal consistency only and should not be interpreted as evidence of interrater agreement, construct validity, or absence of measurement error; 13 case-level items were used as a summated scale, and dimension-level reliability coefficients



do not apply because a single rating was provided for each case rather than a rating for each of the four dimensions. At the individual-rater level, formal inter-rater agreement was modest $ICC(3,1) = 0.208$, but excellent $ICC(3,55) = 0.935$ for the 55-expert mean underlying the JSI, which was reported here merely as a 'translucid shade' and not a bug.

Finally, the four analytical dimensions and the primary/secondary dimension assignments in **Table 4** were theoretical, not independently coded or reviewed by another panel of researchers, based on the literature synthesis in **Table 1**. Other future applications should include blind classification, neutral case description, random order of cases and items, multiple cases for each joint type, pilot testing, and independent validation using another instrument or an expert sample.

6. CONCLUSIONS

In this study, the architectural joint is not considered as a structural connection but as a multidimensional mediating condition, both spatial and perceptual, symbolic and technical: the former is more material, whereas the latter is more mental or conceptual. This study operationalizes the architectural joint with a Joint Strength Index (JSI), which is an explicit, reproducible normalization of expert judgement and not a novel statistical tool. In all of the case observations, the joints which were able to incorporate more than one dimension were all consistently rated higher than other joints based solely on technical articulation, which is consistent with, but not an explicit test of, the central hypothesis of the study. The distinction of an integrative joint logic "uniting" the four dimensions into a coherent experiential threshold and a disjunctive logic "anti-uniting" them, developed from the empirical results, is treated here as a hierarchy of quality and not as the alternatives for a joint.

The theoretical and methodological contribution is therefore both: The theoretical contribution is the extension of the notions of tectonic and phenomenological account of the joint to a coherent 4-dimensional model of architectural mediation, and the methodological contribution is the demonstration that such a qualitative and interpretative construct is also able to be operationalized via structured expert elicitation. The limitations in these contributions are that they are only relevant to the specific cases of the court in question, which were selected by a group of experts mostly from Iraq and geographically from all over, and that they have not been validated against another instrument, panel or test-retest procedure. Future studies should focus on this type of validation as well as a larger and more varied expert panel and several cases for each type of joint.

Acknowledgements

The author would like to thank the University of Baghdad, College of Engineering, Department of Architecture, for the support and the research environment that made this study possible.

Declaration of Competing Interest

The author declares that she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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ما وراء المفصل الانشائي: إطار متعدد الأبعاد للتقييم المعماري

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الخلاصة

لطالما اعتُبر المفصل المعمارية عنصراً إنشائياً. في الواقع، يتضمن أربعة أبعاد: المكاني، والإدراكي، والرمزي، والتقني، يربط بين الجوانب المادية والفكرية للعمارة. لا يوجد في أدبيات التقييم المعماري القائم على الخبرة أي تقرير عن أداة كمية معيارية تقيّم هذه الأبعاد مجتمعة. لحل هذه المشكلة، صاغت هذه الدراسة مؤشر قوة المفصل (JSI) وجربته، انطلاقاً من فرضية أن فعالية المفصل لا تتحدد فقط بالتعقيد التقني، بل أيضاً بقدرته على خلق معنى في الأبعاد الأربعة جميعها. طُلب من 55 خبيراً معمارياً إكمال استبيان مبني على هذا الإطار، وعُرضت النتائج باستخدام مقياس ليكرت خماسي النقاط في تصميم متكرر ضمن الأفراد (معامل ألفا لكرونباخ = 0.757). تراوحت قيم مؤشر قوة المفصل المعيارية من 0.727 إلى 0.985 (النطاق النظري -0.20-1.00). كان الفرق في الدرجات بين الحالات التكاملية (الكعبة المشرفة، وكنيسة النور، وهم اللوفر) والحالات التقنية المركزية أو الانفصالية (مركز بومبيدو) ذا دلالة إحصائية (اختبار فريدمان $\chi^2(12) = 157.38$, $p < 0.001$)، وكان هناك توافق بين المُقيّمين يتراوح بين ضعيف ومتوسط (معامل كندال $W = 0.24$). تُقدّم هذه الدراسة ثلاث إسهامات نظرية: مفهوم المفصل كآلية انتقال متعددة الأبعاد، ومصفوفة تحليلية قابلة للتطبيق في سياقات ثقافية ونمطية مختلفة، شريطة اختبارها، ومنطقتان بديلان للمفصل: التكاملية والانفصالية.

الكلمات المفتاحية: المفصل المعماري، مؤشر قوة المفصل (JSI)، النظرية التكنولوجية، التقييم القائم على آراء الخبراء، الإطار متعدد الأبعاد.