1 Introduction

. . . structure is columnar, planar, or a combination of these which a designer can intentionally use to reinforce or realize ideas. In this context, columns, walls and beams can be thought of in terms of concepts of frequency, pattern, simplicity, regularity, randomness and complexity. As such, structure can be used to define space, create units, articulate circulation, suggest movement, or develop composition and modulations. In this way, it becomes inextricably linked to the very elements which create architecture, its quality and excitement.[1]

The potential for structure to enrich architecture

Clark and Pause's statement above begins by describing the architectural qualities of structure and then suggests how structure might enrich architecture. But is such a positive attitude to structure realistic? What was the last building *you* experienced where structure either created the architecture or contributed a sense of excitement to it? Where do we find examples of structure playing such active architectural roles as defining space and modulating surfaces? And, how else might structure contribute architecturally? These questions set the agenda of this book, informing its focus and scope and initiating an exploration of architecturally enriching structure.

Some readers may consider Clark and Pause's attitude towards structure as a fully integrated architectural element rather unrealistic. So often our day-to-day experience of structure can be described as unmemorable. In much of our built environment structure is either concealed or nondescript. Opaque façade panels or mirror-glass panes hide structure located on a building's perimeter. Inside a building, suspended ceilings conceal beams, and vertical structural elements like columns, cross-bracing and structural walls are either enveloped within partition walls or else visually indistinguishable from them. Even if structure is exposed, often its repetitive and predictable configuration in plan and elevation, as well as its unrefined member and connection detailing can rarely be described as 'creating architecture, its quality and excitement'.

Fortunately, in addition to these ubiquitous and bland structural encounters, sufficient precedents of positive structural contributions to

architecture exist. They point towards bolder and more exciting possibilities and have convinced critical observers, like Clark and Pause and others, of the potential for structure to engage with architecture more actively and creatively. Peter Collins, the architectural theorist, shares similarly constructive convictions regarding structure's architectural roles. In concluding a discussion on eighteenth- and nineteenth-century rationalism, he suggests:

> *However much the emphasis on structural expression may have been exaggerated in the past by a craving for ostentation, or reduced by the competing emphases on spatial effects, sculptural effects and new planning requirements, it is still potentially one of the most vigorous ideals of the modern age, and it would not be an exaggeration to say that it is the notion which offers the most fruitful prospects for the future development of modern architectural thought.*[2]

Like the authors quoted above, I will also be looking beyond the physical necessity of structure towards its functional and aesthetic possibilities. Just because structure is essential for built architecture, providing it with necessary stability, strength and stiffness, it does not have to be architecturally mute – unless of course its designers make that choice. This book provides many examples of structures 'speaking' and even 'shouting' in their architectural contexts. In these cases their designers, usually both architects and structural engineers, have made structural decisions that do not detract from, but rather strengthen their architectural ideas and requirements. Structure no longer remains silent, but is a voice to be heard.

Where structure is given a voice, as illustrated in the following chapters, it contributes architectural meaning and richness, sometimes becoming the most significant of all architectural elements in a building. Endless opportunities exist for structure to enhance architecture and thereby enrich our architectural experiences. As designers we can allow structure to speak and to be heard, or to change the metaphor, we can design structure so that its viewers not only see and experience it, but due to its well-considered architectural qualities, are enticed into 'reading' it.

Experiencing and reading structure

Architects analyse structure by experiencing and reading it. In their succinct summary, Clark and Pause suggest possible ways structure might be read, or analysed architecturally. In some architectural reviews of buildings, particularly where structure is exposed, structural readings are made. Although reviewers usually make little more than a passing

comment, the validity of this way of analysing structure remains. The following two examples illustrate architecturally focused structural readings.

Fontein offers a reading of the interior structure of her school of architecture building. She concentrates upon a single column, differentiated from others by virtue of its circular cross-section and increased height. She asserts that this column 'plays a pivotal role in the building' by marking and sheltering the intersection of two internal streets. It also connects that street junction to the school's main collective space whose activities it both supports and obstructs. Ultimately it 'establishes structure as a primary ordering device in the architecture of the School . . . and has the palpable effect of anchoring the life of the School'.[3]

LaVine tends towards less personified readings as he discerns significant architectural roles played by structure in his four house case studies.[4] He notes how a ridge beam can symbolize the social centre of a house, and how a superstructure orders space by virtue of its regularity and hierarchy. In other examples, columns 'signify human activities of special significance' or 'portray a mechanical idealism'. He reads walls as separating occupants from the outside world, and frames as ordering interior space. As he reads structure, each structural element is laden with meaning and makes an important architectural contribution.

All architectural readings incorporate a degree of subjectivity. To a certain extent, each reading is personal. It reflects a reader's background and architectural knowledge. The quality of their experience of a building is another factor which depends on the duration of a visit and the depth of reflection during and after it.

The views of two or more readers are unlikely to be identical. Each person brings their own perspective. For example, an architect and structural engineer will read a structure quite differently. Each approaches it with his or her professional interest and concerns to the forefront. Whereas an architect might focus on how structure impacts the surrounding space, an engineer will most likely perceive structure as facilitating a load-path.

So, my architectural analyses of structure, or structural readings, inevitably reflect who I am and includes my structural engineering background, my experience of teaching in a school of architecture and my intense interest in how structure can enrich architecture.

Before commencing to read building structures and explore their architectural contributions, the next section clarifies the meaning of the book's central focus, exposed structure.

Structure and its degree of exposure

At this stage it is necessary to come to a common understanding of what constitutes structure, and to comment on aspects of its exposure. For the purpose of sensibly limiting the scope of the book, structure is taken as any structural element that bears load other than that arising from its self-weight or self-induced loads like those from wind or snow.

This definition excludes consideration of purely decorative elements without wanting to deny any significant architectural roles they might play. Imitative structure and authentic structural members that are not load-bearing, even though they might clearly express their materiality and display standard structural dimensions, are disregarded. Examples of the latter category include exposed frameworks whose sole purpose is to contribute to a building's composition, perhaps visually linking disparate forms together. Although this discussion omits structure whose rationale is purely aesthetic, structural elements and details with minimal structural effectiveness are included. Structural details like the attached shafts on Gothic piers fall into this category. Even though their architectural contribution may be seen as more aesthetic than structural, by increasing the cross-sectional area and depth of a pier, the details increase slightly its compression strength and overall stability.

Having established a working definition of structure, an explanation for the focus upon *exposed* structure is warranted and quite simple. Where structure is not exposed but concealed, perhaps hidden within wall cavities, screened by suspended ceilings or undifferentiated from partition walling, it possesses very limited opportunities to enrich architecture. In these situations, where the architecture must rely on other devices and elements for its qualities, any skeletal, wall-like or expressive structural qualities remain latent – structure cannot be read.

Architects take an unlimited number of approaches towards structural exposure. In its fully exposed state, the raw materiality of structure is visible, be it masonry, concrete, steel or natural timber. Even if coatings or claddings partially or fully veil structural members and their materiality, structural form can still play significant and expressive architectural roles. Steel structural members may be wrapped with corrosion and fire protection coatings and even cladding panels, but their structural forms can still enliven façades and interior spaces. Hence, in this discussion, *exposed* structure includes any visible structural forms, whether or not their materiality is concealed.

This apparent preoccupation with exposed structure does not mean it is a requirement of exemplary architecture. Exposed structure has rightly been inappropriate on many past occasions given the design

ideals current at those times. Cowan gives examples of periods in architectural history, such as the Renaissance and the Baroque, where exposed structure would have detracted from the forms and embellished surfaces that designers were attempting to achieve.[5] Absence of exposed structure in contemporary buildings may also be completely defensible. For example, exterior exposed structure might compromise architectural forms exhibiting sculptural qualities and curved surfaces, and interior exposed structure could impact negatively upon an architectural goal of achieving spaces defined by pure planar surfaces.

Decisions regarding the extent to which structure should be exposed in an architectural design, if at all, are best made after revisiting the design concept and asking whether or not exposed structure will enhance its realization. Then, irrespective of the answer, design ideas will be communicated with greater clarity. Structural exposure should therefore be limited to buildings where structure integrates with and clearly strengthens the expression of architectural ideas.

Book outline

Chapter 2 analyses the structures of two contrasting buildings to set the scene for more focused and detailed explorations later in the book. Each building exemplifies structure contributing architecturally in the context of a specific architectural programme. Exposed structure plays significant architectural roles on the exterior of the first building, while in the second, structure creates special interior spaces. Due to the inevitably limited range of architectural contributions exemplified by the two case studies, following chapters explore and illustrate exposed structure enriching specific areas of architecture in more detail.

Beginning with Chapter 3, chapter sequencing for the remainder of the book reflects a typical progression of experiences when one visits a building. First, imagine approaching a building from a distance. When architectural massing only may be discerned, the diversity of relationship between architectural and structural form is explored. Then in Chapter 4, drawing closer to the building, one observes structural elements enlivening façades in various ways, including forming surface patterns and textures, providing visual clues of entry, connecting exterior and interior architecture, and playing diverse expressive roles.

Then having entered a building, the next three chapters attend to relationships between the structure and interior architecture. Chapter 5 examines how structure enhances and in some cases, defines building function. Structure maximizes planning flexibility, subdivides space to facilitate separate functions and articulates circulation paths. Chapter 6

focuses on interior structure as an architectural element in its own right. It addresses the question of how structure enlivens and articulates interior spaces and surfaces. Examples illustrate structure providing a wide range of surface and spatial qualities. Some interior structures read as responding to aspects such as a building's geometry or function, or alternatively, expressing external factors like soil pressures or other site-specific characteristics.

Exploration of interior structure narrows in scope in Chapter 7 by examining structural detailing. After noting the importance of detailing being driven by a design concept, examples of expressive and responsive details are provided. They comprise two categories of details, one of which gains its inspiration from within the building, and the other, from without. Some structural members are so elegantly detailed as to be considered objects of aesthetic delight, increasing one's enjoyment and interest in architecture considerably. A plethora of structural detailing languages with diverse architectural qualities strengthens designers' realization of overarching architectural design concepts.

Chapter 8 investigates the relationship between structure and light, both natural and artificial. It illustrates structure's dual roles, as both a source and modifier of light, and introduces a number of different strategies designers use to maximize the ingress of light into buildings. Chapter 9 reflects on the symbolic and representational roles structure plays. Structure references naturally occurring objects like trees and processes such as erosion, as well as human artifacts, and notions and experiences as diverse as oppression and humour. The final chapter concludes with a brief distillation of the main themes that emerge throughout the book, namely the transformative power of structure, the diversity with which it enriches architecture, and implications for the architectural and structural engineering professions.

REFERENCES AND NOTES

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4 LaVine, L. (2001). *Mechanics and Meaning in Architecture*. University of Minnesota Press.
5 Cowan, H. (1980). A note on structural honesty. *Architecture Australia*, Feb./March, pp. 28–32.