Digital Tectonic Design

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Digital tectonic design is a fresh approach to architectural design methodology. Tectonics means a focus on assemblies of construction elements. Digital tectonics is an evolving methodology that integrates use of design software with traditional construction methods. We see digital tectonic design as a systematic use of geometric and spatial ordinances, used in combination with details and components directly related to contemporary construction. The current approach will, we hope, lead to an architectural curriculum based on generative form making where the computer can be used to produce systems of forms algorithmically. Digital design has tended to remain abstract, emphasizing visual and spatial arrangements often at the expense of materials and construction. Our pursuit is translation of these methods into more fully realized physical qualities. This method offers a rigorous approach based on close study of geometry and building construction elements. Giving a context for this approach, historical examples employing systematic tectonic design are explored in this paper. The underlying geometric ordinance systems and the highly tuned relationships between the details in these examples offer design vocabularies for use within the studio curriculum. The paper concludes with a detailed example from a recent studio project demonstrating particular qualities developed within the method.

The method involves a wide range of scales, relating large-scale gestural and schematic studies to detailed assembly systems. Designing in this way means developing geometric strategies and, in parallel, producing detailed symbols or objects to be inserted. These details are assembled into a variety of arrays and groups. The approach is analogous to computer-aided design's tradition of shape grammars in which systems of spatial relationships are used to control the insertion of shapes within a space. Using this approach, a three-dimensional representation of a building is iteratively refined until the final result is an integrated, systematically organized complex of symbols representing physical building components. The resulting complex offers substantial material qualities. Strategies of symbol insertions and hierarchical grouping of elements are familiar in digital design practice. However these strategies are usually used for automated production of preconceived designs. In contrast to thsse normal approaches this presentation focuses on emergent qualities produced directly by means of the complex arrays of symbol insertions. The rhythmic combination of small scale elements into large fabrics tends to produce special qualities. Like the intricate combinations of warp and weft that make up the unique character of every textile, the interlinking relationships of coursing, bonding and attachment patterns prove to be fundamental sources of character for this architecture. These productions work as an analog of a full-scale building.

Examples from Mies van der Rohe and Frank Lloyd Wright are included here. The first of these is Mies' apartment project at 860 and 880 Lakeshore Drive in Chicago, completed 1951. The project shows systematic construction positioned as an integral aspect of the bounding envelope. This envelope is explicitly tectonic: the individual components and joints are deliberately articulated. The articulation of individual tectonic components is not done for the sake of showing the skin as infill between the structure or hung on the outside. Instead Mies van der Rohe preferred the ambiguity of fusing the skin and the structure causing the skin and structure to be merged by means of the unifying exterior mullions.[1] We can see this clearly by comparing the plan of a corner column at 886-880 Lakeshore in figure 1b and 1c with the plan of a column of the Seagram Building of 1958 in figure 1a, an example where the skin is hung outside the structure.

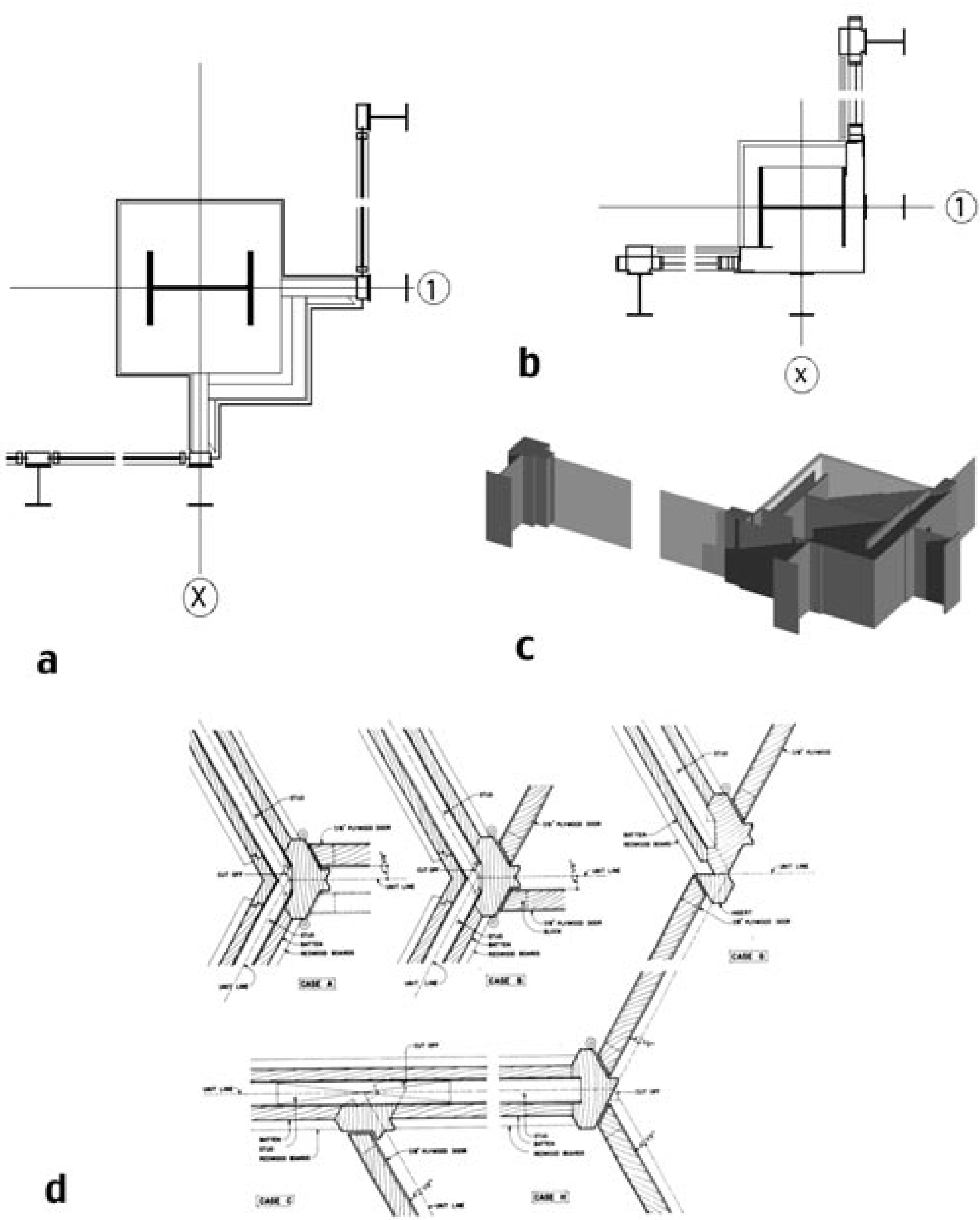

Figure 1: a) Seagram Building, Mies Van der Rohe 1958, corner detail; b) and c) 860 and 880 Lakeshore Drive, Chicago, Mies Van der Rohe 1951, corner detail; d) Hanna House, Palo Alto, Frank Lloyd Wright 1936, detail vocabulary showing “unit lines”.

Throughout Mies van der Rohe's work there is an implied limitless cellular space into which the planes of his abstract space and the tectonic components of his envelopes are inserted.[2] At 860-880 Lakeshore, this cellular space is characterized by a square grid plan whose intersections are the centres of the columns. All other components are positioned in relation to the columns. This approach, where individual components are expressed with particular emphasis on joints between them corresponds with the concept of objects (symbols or blocks) in computer aided design. The assembly of components that represent a column (for example I section steel, fireproofing, drywall, steel plate cladding, angle brackets) can be represented as a hierarchical three-dimensional object with origin at the intersection of the grid lines. Similarly, one bay of curtain wall cladding can be combined into a system consisting of small I beam mullions and window panels with insertion points controlled by the underlying grid system.

A second example is the design of the Usonian houses of Frank Lloyd Wright, the first built version of which was the Herbert Jacobs house of 1936. Each of the Usonian house types (the polliwog, the inline, the diagonal, the hexagonal and the two-story type) had a kit of parts or "grammar" as Wright called it.[3] These parts were grouped according to Gottfried Semper's 19th century theory of four elements of architecture: earthwork, interpreted as a slab on grade with built in radiant heating pipes; hearth, interpreted as a massive central brick pier with fireplace; framework, interpreted as brick piers and a roof of tiered 2x4's; and an enclosing membrane, a "woven fabric" consisting of thin board and batten walls sandwiched together with a thin wood core.[4] Internal partitions followed the same construction as the exterior enclosure. These Usonian parts are like digital symbols inserted in a three-dimensional gridded cage. The Jacobs house follows a two foot by four foot grid with thirteen-inch vertical divisions, corresponding to triple brick mortar joints aligning with joints in board and batten walls.

A particular example is in the enclosure of the Hanna House in Palo Alto whose first phase working drawings date from 1936.[5] Here the underlying grid is a hexagonal mesh and the board and batten walls and partitions weave in and out along the edges of the hexagons. This effectively emphasizes the Semperian conception of an enclosure as woven fabric. The components of the partitions are all drawn so that they can be inserted with respect to the hexagonal grid without measurement. Insertion points are shown for each component (figure 1d). In plan and section the positioning of each component with respect to these "unit lines" is shown.

The digital studio project illustrated in figure 2 employs a similar approach to these historical examples. Façade elements are here developed from individual glazing units in interlocking angled positions. The student project included fine-grained development of mounting details for the envelope system. Attachment points for these hardware systems were translated into insertion points for digital symbols. Like a large scale textile, this skin is built out of arrays of the individual elements. The rhythmic combination of these units gave the project a shimmering surface, like a scaled reptile skin. Thus the interlinking relationships of the attachment patterns directly produce the particular character for this architecture. This approach offers an effective and highly expressive method for design.

Figure. 2: Façade detail,Canadian Embassy in Berlin, digital model by Peter Marshall, University of Waterloo, 1998

Notes

[1] Frampton, Kenneth. Studies in Tectonic Culture, MIT Press, p. 192 , 1996.
[2] Ibid., p. 207.
[3] Sergeant, John, Frank Lloyd Wright's Usonian Houses. Whitney, 1976.
[4] Frampton, Kenneth. Studies in Tectonic Culture, MIT Press, p. 117 , 1996.
[5] Hanna, Paul R. and Jean S., Frank Lloyd Wright's Hanna House, MIT Press, 1981.