Building Art, Building Science: The Technical Evolution of the Yale Art Gallery

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While Louis Kahn spent the fall and winter of 1950-51 in Rome, events in New Haven transpired to provide him with his first opportunity to build a major institutional building. His time in Rome had energized him, rekindling his love for ancient monuments, and his visit to the construction site of Corbusier's *Unite d'Habitation* in Marseilles spurred his thinking regarding the architectural possibilities of concrete as a technological yet historically allusive material. All of these factors—his career of designing for utmost efficiency, his desire to translate the *gravitas* of antiquity into modern techniques and the revelation of concrete's expressive potential—came together in the Yale Art Gallery.[1]

Yale's Gallery consisted of a half-built collegiate gothic structure designed by Egarton Swartout and Evarts Tracy, which was abandoned halfway through construction in 1928. A. Whitney Griswold became Yale's president in 1950 and quickly established his commitment to building modern architecture on the campus, in particular the completion of the Art Gallery, whose prominent site at the western corner of campus offered a public face for the University. In Fall, 1950, architect Phillip Goodwin was asked to revise an earlier scheme in conjunction with George Howe, then newly appointed Chair of the Architecture Department, and the Director of Yale's Division of the Arts, Charles Sawyer. Goodwin's earlier schemes had been entirely based on the display of artworks, but Griswold's overriding mission gave greater weight to buildings and programs with a dedicated educational function.

Goodwin resigned from the project in early January, 1951, warning of a difficult road ahead. The United States was at war in Korea, and while building construction was permitted, war materiel such as steel and copper was tightly rationed. Sawyer and Howe, at the recommendation of Eero Saarinen, wrote to Kahn in Rome to offer him the job in association with Douglas Orr, a New Haven architect. While Kahn's remaining time in Rome would present a challenge, Howe felt that the University needed that time to prepare not only a program—which would remain tenuous throughout the project—but also a sense of what sort of building was required.[2] Griswold's insistence on a flexible, largely educational function was not merely pedagogical; it was also practical considering the need to justify rationed steelwork.

Such flexibility, however, could come at the expense of architectural clarity, and for several weeks Howe and Sawyer, with the assistance of Orr, looked at 'loft' construction as a balance between complete functional openness and the desire for an expressive statement. In contrast to the conceptually flexible but usually fixed *plan libre* of the first generation modernists, factory and warehouse construction had pioneered the structural frame as a means to a real, functional flexibility, where machinery, fixtures and partitions could be moved to suit evolving assembly line and storage requirements. These 'loft' buildings had an undeniable power, and Sawyer and Howe were explicit in recommending that the Gallery adopt''loft' construction, allowing for rooms, exhibits and functions to be changed as the times demanded.

SCHEMATIC DESIGN

Following Kahn's return from Rome in March 1951, he spent six weeks commuting between New Haven and Philadelphia with Anne Tyng.[3] Together with Orr's office, they first explored a suggestion from Sawyer to lay galleries out along a long ramp connecting to the third floor of the original building, which was quickly rejected for its vast scale. They followed with somewhat less grand schemes

for simple concrete frames, with loft bays sized according to the assumptions of Sawyer's curators, ranging from a 20' square to 23' x 25'.[4] By the end of April, 1951, Sawyer's ramp had been replaced by a grand staircase, expanded by matched seating to fill two structural bays, that provided access to split levels of loft space, eventually hitting the third floor gallery's level in the original structure. Next to these stairs, Kahn wedged a core precisely into a single structural bay, an optimistic assumption.

Other variations on this scheme followed, as Kahn, Tyng and Orr struggled to reconcile a pure structural grid with the increasingly refined requirements of circulation and servicing.[5] In hindsight, it is apparent that Kahn was operating under what he would come to see as a false pretense. In these early schemes, the structural grid is relentless, forcing some elements (the grand staircase) to expand to its dimension, and others (the core) to contract beyond any reasonable size just to fit within the structural grid. To borrow Kahn's later phrasing, the design's correct Order was yet to be found: the structural system was dominating all others, and there was no room for the orders of circulation and servicing to assert themselves. Nevertheless, under Howe's guidance, Kahn began to develop this loft structure within a carefully conceived container. The exterior began to emerge as a solid wall along Chapel Street, a deep setback between the new building's mass and that of the old, linking both galleries while connecting Chapel Street to the courtyard behind.

Throughout May, Kahn and his collaborators developed a scheme that for the first time broke the square structural grid's tyranny and proved a crucial first step in the final scheme's rapid evolution. Realizing that the bay sizes proposed thus far were an imperfect interpretation of the 'ideal' gallery or office size, they tried a double-square module, 20' x 40', set parallel to Chapel Street. These bays were arranged in a rectangular grid, 3 bays deep by four bays long, providing a narrow footprint and a directional grain that emphasized the circulation connecting the new and old buildings. Kahn strengthened this initial gesture by organizing rooms and galleries on the upper floor'*en suite*, connected by a bridge to the third floor to the upper Swartout building's galleries. Sliding between the middle bay's columns, overlapping the structural grid into the atrium, a grand staircase called out a core that now had a clear organization and order that was—tentatively—independent of the structural grid though still functionally too small. Nevertheless, the new bay configuration and the core's gentle slide out of the grid's confines opened new possibilities. If the original scheme had been overdetermined by assumed bay sizes, this transitional scheme began to cautiously modify that structural order in light of programmatic and site constraints.

AUGUST, 1951 SCHEME

By the end of August 1951, a scheme emerged that in its basic layout and intent would prove definitive, if open to major re-interpretation in its realization. In this iteration, the May scheme's double bay was maintained, but it was arranged in two large gallery lofts per floor composed of four parallel bays each. Between these, a narrower central precinct was wholly devoted to a service core and a grand scissor staircase, essentially relocated from the May scheme's atrium, with operable partitions that could close off the circulation stack from the galleries. A third, smaller gallery provided the transition to the Swartout building, with a narrow end piece containing a fire stair and, where levels met, access to the older painting galleries.

While this basic arrangement is recognizable as the final scheme its proposed concrete structure differs entirely from the structure as eventually built. Given the restrictions on steel, concrete was the only conceivable choice for the Gallery's structure, although even the steel reinforcement for its concrete needed to be cleared with the Department of Defense. Efficiency was, therefore, paramount. Kahn, Tyng and Orr worked closely with Henry Pfisterer, a New Haven engineer, to develop a structure for the August design that would minimize reinforcing steel while expressing the building's loft-like rhythm and permitting mobile partitions to be set up for changing exhibitions. The 20' x 40' bay size was, Pfisterer believed, best supported by a one-way pan joist system. Kahn recognized that a lightweight ceiling system, hung below the rough concrete structure, could conceal ducts and, if shaped properly, act as integral lighting fixtures within the beam's depth, curved to reflect and diffuse light onto the walls and floors below. In the scheme as revised in September 1951, conditioned air was to be distributed by a

pair of main supply ducts on each floor, running north/south and concealed by a plaster ceiling. Smaller ducts were to drop from these main trunks, passing underneath the main girders, and popping up into the void spaces between the concrete joists, diffusing air down the surface of curved ceiling panels to slots arranged along the joists' lower edges.

While efficient, this scheme did not quite rise to the level of Kahn's thinking regarding the integration of structure and services. From the point of view of simply''harboring' the mechanical systems and thus avoiding their impingement on the spaces below, this scheme would have worked quite well, but as Kahn would point out later, this came at the expense of the structure's legibility. Some measure of the building's structural grain might have been made legible by the reflectors' edge details, where the ceiling panels were held back just enough to permit a glimpse of the concrete beam' bottom surface. But the building's constructional and structural logic would have been concealed by the ceiling panels, invisible to the casual patron and thus lost as an opportunity to convey the building's structural order. Nevertheless, work proceeded on construction documents in Orr's New Haven office through March.[6] As drawings were completed, Yale planned on sending drawing sets out to bid in late March, with construction expected to begin on May 1.

THE TETRAHEDRAL GRID

In late March 1952, just as drawings were being finished, Kahn proposed a change in the gallery's floor structure based on experiments in space frame geometry by Tyng. In 1951, she had prepared a conceptual design for an elementary school similar to the explorations of 'octet-truss' space frames by Buckminster Fuller. Tyng's project adopted and expanded Fuller's principle, creating a lightweight flat structure triangulated in all three dimensions, and while it remained conceptual, without cladding or an environmental system, it represented a sophisticated structural idea.

Tyng's project was exhibited in Philadelphia in late 1951 and early 1952. She was by then frustrated with the Gallery's conventional construction. As drawings were being finished, Tyng recalls asking Kahn "why bother to build [the Gallery] if you don't use an innovative structure?"[7] Kahn shortly thereafter found himself threading pencils through Tyng's model, noticing that the triangulated members' dimensions offered routes for ductwork and cabling. At the same time, the geometry of the truss's bottom frame offered a provocative rhythm and pattern as a ceiling, repeating a statically efficient triangle across the sweep of the ceiling. Changing the building's material to steel in the war economy was unthinkable, however, and Kahn thus proposed a tetrahedral grid made of concrete—a layer of three-sided concrete pyramids, joined at their bottom corners and supporting a slab at their top vertices. On the eve of the construction drawings' distribution, Kahn suggested a change of course, believing that the new structural idea would provide an expressive solution while the approved concept would yield only efficiency.

This proposal came at a delicate moment. By February 1952, Yale had applied to the Defense Department for the quantity of reinforcing steel required by the August scheme and the 40'-0" bays shown in this version had already added significantly to the reinforcing requirement.[8] In the midst of this process, Kahn's proposal doubled the proposed reinforcing steel allocation, according to Pfisterer's calculations. Kahn, however, campaigned for the revised system on the basis of its mechanical efficiency and its architectural effect. While the steel allocation was being approved on 18 March 1952, Kahn and Orr met with Charles Sawyer, again presenting the tetrahedral system along with a revised main stair that adopted the ceiling's triangular geometry. The spatial impact of this silo and the new ceiling grid's order swayed Sawyer, for he approved the revised structure's inclusion as a bid alternate.

Macomber provided a bid on 29 April, including the tetrahedral ceiling's cost, and the round stair tower. While the bid was over budget, it was within a few percent of the target cost, and was reduced to a figure of about $1.25 million.[9] Macomber had stockpiles of reinforcing steel on hand, absorbing any delay in the requisitioning process and easing the revision upward in steel tonnage, if not reducing its price. The floor system was accepted and included in Macomber's contract, which was formally awarded on 26 May 1952.[10]

While cost was a primary consideration, the new floor system presented two additional challenges for Pfisterer and Macomber: how the floor system's

shapes could be cast, and how they would carry the Gallery's floor loads. Space frames and trusses in an era of manual calculation could only be analyzed by assessing each strut and joint as discrete elements in order to find the axial force within them, and even this method required extensive mathematical effort. What Kahn and Tyng had proposed was not, however, a system of discrete elements with identifiable stresses in tension or compression. Rather, the faces of each concrete tetrahedron were actually concrete diaphragms capable of tension, compression, shear and bending in multiple directions. The integral slab atop these pyramidal shapes would sit on them as on a bed of nails, with hundreds of points of connection. While Pfisterer could estimate the gross scale stresses in the system, how floor loads would actually be transferred from slab to tetrahedron, and thence throughout the network of concrete diaphragms and steel reinforcing, was far beyond his—or any other engineer's—abilities in 1952.

The system's engineering was solved as the tetrahedral idea took shape, in March and April of 1952. Nic Gianopulos and Tom Leidigh met with Kahn and Tyng in April 1952. Gianopulos recalls seeing the mechanical layout for the first time at this meeting, which had not changed from the system woven through the August beam and slab scheme.[11] Its major supply ducts all still ran north and south from the mechanical space on each floor, with minor ducting running east and west, passing through sleeves in the major girders and then running between the concrete tetrahedrons' sloped surfaces. While the tetrahedral slab offered clear runs in three directions, the mechanical and electrical systems were only using one. The difficulties in calculating the load transfer would be eliminated, Gianopulos realized, if the tetrahedrons' faces in the east-west plane were connected to one another, creating long, inclined beams that would connect with the slab above continuously, instead of at discrete points. This would allow them to be calculated as simple beams and slabs, a shortcut to understanding the system's overall performance. At the same time, ducts would have a natural path alongside the inclined joists, and the ceiling pattern below would remain unchanged. The only drawback—other than the compromise of the—'pure' space frame system—was that the additional triangular portions of concrete necessary to transform the pyramids' faces into continuous joists would add weight to the system.

Pfisterer agreed with Gianopulos' suggestion. His guess had been that the space frame as originally conceived would act as a beam and slab system anyway, because of the 20' x 40' column bay's directionality. The east-west chords would, in his view, have become primary members no matter how they were connected to the rest of the system. Likewise, he viewed the original proposal as an essentially steel scheme because of the extraordinary quantities of reinforcing it required. "The floor construction," he wrote, "ends up as *fireproofed steel* rather than *reinforced concrete.*" He proposed, instead, essentially what Gianopulos had suggested.

Macomber was responsible for one final twist on the concrete design. Formwork for the tetrahedrons'''walls'—their joists and smaller inclined triangles—had to be built with both inside and outside surfaces. For cost reasons, this custom formwork had to be reusable, and Macomber suggested that each floor slab be poured only after its joists had cured. The upper joist formwork could then be lifted up, while the bottom formwork could be pulled down. Permanent acoustic paneling could then be laid flush with the top edge of the resulting structure and the top slab could then be poured with robust connections created by dowels and rebar cast into the raw tetrahedral grid. Seen this way, the floor system's actual logic is revealing. It essentially consists of three components; long joists inclined at about 20°, folded triangular 'struts' on which these joists lean and which hold the bottom chord of each joist in place, and a slab on top of this system.

Rather than force the approval process through New Haven's Board of Examiners, the Building Department encouraged Pfisterer to construct a test panel. Macomber scheduled the test for late August, by which time the site would be fully cleared, and the resulting—successful—test drew attention not only from the local community, but also from a number of architectural journals. *Architectural Forum* devoted two pages in its November, 1952 issue to the design.[12]

DETAILING AND CONSTRUCTION

If the spatial, structural and mechanical integration in the gallery's ceilings was a blend of Fuller and Tyng's influences, the building's execution in poured concrete practically shouted its more Corbusian precedents, particularly in the sculptural

main staircase. The handling of this spatially important volume and other nearby core elements borrowed directly the expressed'*beton brut*, which Kahn had seen under construction at Marseilles. To achieve the stair silo's tight radius, Kahn and Orr specified vertical board forms, each a few inches wide, that broke the circular plan down into facets. Drawing on Corbusier's acceptance of poured concrete's appearance at the *Unite*, Kahn accepted the marks, imperfections and roughness of the material in the stair silo and exposed beams and girders at Yale. These records of "how it was done" became part of a dialogue, as at Marseilles, between the coarse and the honed.

Kahn used metal for three major elements in the Gallery—the curtain walls, the service zone's ceilings, and the staircase handrails. These, like most metalwork in Kahn's designs, were set against raw concrete elements, or attached to them in a way that highlighted the distinctions in material, texture and finish between the two. Tyng recalls that Kahn developed his thinking about shadow and light gaps here that emphasized the separation between elements made of different materials, or with different processes. This continued on the steel and glass curtain wall, which was consistently pulled back in one direction or another so that the building's columns could be made visible to the outside—sheathed, admittedly, in blue stone, but nonetheless clearly stated. On the west facade, the curtain wall was nestled in amongst the five main columns, while on the north façade the curtain wall revealed the long dimensions of each bay, while the service zone was clad in solid brick, explaining the functional and spatial logics of the interior.

This, of course, leaves the south façade to be explained. Undoubtedly the Gallery's most famous—and notorious—elevation, this unbroken rectangle of brick and stone clearly explains the structure's horizontal stratification beyond. But the position of the vertical columns behind is left unspoken, hardly characteristic of Kahn's desire to tell us frankly about all aspects of the building's construction and structure. There are clues in the elevation's configuration that suggest a two-fold explanation. On a strictly functional level, the south façade's execution in solid brick keeps out harsh direct sunlight. However this does not explain why the wall has only horizontal divisions. If one imagines the façade composed like this, however, a problem emerges. The galleries' mechanical layout occupies two wings served by a central core, through which all vertical service elements pass. A long section of the building shows a tree-like servicing strategy with a main central trunk and minor horizontal branches. Were this to be expressed on the south elevation, we would get an overwhelming sense of the newer building's centrality and its dense central bay. However, the Swartout building further east on Chapel Street gives an impression of structural rhythm, of movement along the galleries' axis. The brick wall is, therefore, essentially a graphic plane, seeking to carry on the original building's horizontal stretch without asserting the contradictory logic inside. Kahn reconciled these competing desires to express and conceal on the northwest and entry elevations, where the brick wall's depth is clearly shown, with a distinct shadowgap between it and the exposed column. The brick facade, this detail tells us, is exactly that—an applied screen. The new gallery's self-contained logic is told instead on the north façade, where the new building's order can be expressed without interrupting the old building's logic.

Macomber built the Gallery in a burst of activity between June 1952, when excavation commenced and the building's dedication in November 1953. The concrete placement proceeded smoothly, but problems developed with the mechanical system's integration. The tetrahedral grid allowed space between its joists and triangular diaphragms for small round ductwork, however to get air to these small ducts from the mechanical spaces in the core, a connection was necessary to the main distribution trunks. These ran along the core's face, on the opposite side of exposed concrete girders from the triangular ceiling grid. In the preliminary scheme, this connection had been handled by introducing false ceilings below the girders. Kahn's desire to express the concrete, however, had eliminated hung ceilings in the galleries. The only way to get air from one side of these girders to the other was to go through the concrete itself, hollowing out portions of the structurally redundant web. Small ducts branch off from the main trunking, passing through sheet metal cylinders actually cast in to the girder's depth, and then running east/west through the ceiling's interstices. The containment of these ducts within the structure, and the need to coordinate the sheet metal workers with formwork crews and concrete pours, proved problematic. From this point forward,

though, the work proceeded without incident, with each floor taking about eight weeks. Masons and glaziers followed the concrete's progress, working two months behind the concrete to install the building's skin, all of which was completed by March 1953.

If the exterior was designed to reveal the loft structure's horizontal logic and its ambiguous relationship to the original building, work on the interior focused on a dialogue between the concrete frames and lightweight infill partitions and systems. Gallery display walls, office partitions, and stair rails were all developed to contrast with the concrete structure through lightweight material and detailing. Perhaps the most dramatic contrast to the heavy concrete structure was the main triangular staircase, which Kahn and Tyng redesigned several times during construction. The final scheme employed poured concrete stringers and landings, monolithic with the surrounding silo. Precast black terrazzo steps were then placed atop these structural members, leaving the concrete supports' undersides exposed. The stair's handrail was detailed in stainless steel pipe, with balustrades made of woven metal mesh. The resulting composition is iconic, providing a clear history of the stair's construction by segregating materials spatially according to their chronology.

OPENING AND RECEPTION

The Gallery opened in early November 1953, enjoying great attention from both the Yale community and the architectural press. Locally, the building was recognized as the first major modernist statement on a campus that would soon become synonymous with architectural innovation and the flexible, compact gallery spaces were reviewed as worthy successors to the formal but functionally dated galleries of the Swartout building,.[13] Frederick Gutheim, critic for the *International Herald Tribune*, led the analysis of the building's bold pronouncements and subtle ambiguities with an article declaring the Gallery to be'"the outstanding academic building produced by the modern movement."[14]

Oddly, C. Clark Macomber, President of Macomber Builders, sounded a more negative note in *Progressive Architecture's* coverage. While acknowledging that the Gallery's construction was "a privilege given to few builders," Macomber attributed much of the building's success to Douglas Orr's "tempering" of Kahn's "forward looking and experimental theories." Macomber took direct issue with the tetrahedral ceiling's complexity, citing the complex formwork required and noting that while the construction ended up being'"practical and economical….these spans and wide open spaces may be obtained with any standard construction."

Henry Pfisterer expressed similar sentiments regarding the ceiling structure. As the scheme was being developed, he and Kahn had discussed the tetrahedral grid with Vernon Read of"*Architectural Forum*, who drafted an article for their review. Kahn was troubled by the fact that Read, quoting Pfisterer, remarked that the slab was 60% *heavier* than a conventional beam and slab system.[15] Kahn and Sawyer delayed publication of this article on the design's progress until November 1952, and while Read reported honestly on the weight issue, he also noted the slab's unique appearance and suggested that it would be "an instructive challenge to budding architects studying beneath it."[16] However following the Gallery's completion, Pfisterer wrote a complete description of the floor system that was no less damning, concluding that "the depth-weight ratio is high and…forming and placing costs are very high." In other words, the floor system was largely architectural, in Pfisterer's view, not structural, a line of comment that Kahn's future engineering collaborators would repeat to great effect. Such assessments did not dampen enthusiasm for the structural concept, which was featured again in a special issue of *Progressive Architecture* in June, 1954.[17]

Such critical apologias for the floor system's questionable efficiency stemmed in part from the postwar desire to integrate contemporary technique and timeless architectural principles, as Kahn himself had predicted in his 1944 *Monumentality* essay. Vincent Scully, Kahn's contemporary at Yale, wrote in 1954 on this re-emergence of "Archetype and Order" in American architecture, noting that The Yale Art Gallery was "symptomatic of the new direction in design."[18] For Scully, Kahn was one of the first to apply the "abstract anti-romantic classic order" to the sudden advancements in building technology after World War II, suggesting a *rapprochement* of modernism's empiricist, technical interest with its rationalist, Beaux-Arts heritage, whether fully disinherited or not.

Reyner Banham, then a young critic for the *Architectural Review* in Britain, offered a parallel, though more technically inclined interpretation of the Gallery in his 1955 essay on New Brutalism, a movement that stressed the unself-conscious acceptance of the 'brute' facts of construction as inherently important to a building's aesthetic.[19] Brutalism was really another name for what had, a decade before termed the "New Empiricism," a move away from the latent reliance on composition in modernist designs, toward an expression of techniques, requirements and structure. While resisting any formula, Banham claimed that Brutalism relied on three key factors for its aesthetic impact:""formal legibility," a clear expression of structure, and "a valuation of materials for their inherent qualities 'as found.'" Banham recognized that the Gallery was""uncompromisingly frank about its materials…inconceivable apart from its boldly exhibited structural method…[and] formal in the disposition of its main elements."[20] Perhaps more importantly, he identified a fourth brutalist characteristic that the Yale Gallery exhibited in no small measure, "bloody-mindedness," relentlessness in the detailing and expression of the building down to its smallest components.

Scully and Banham's related but ultimately divergent criticisms marked Kahn's preliminary achievement in reconciling rationalist and empiricist modes of architectural design. Both acknowledged the power of the building's "image," its immediate apprehension in the mind's eye or, in Wittkower's words, a "man-created harmony" as a "visible echo of a celestial and universally valid harmony." On the other hand, Banham's linking of the Gallery to the Smithsons and their disciplined acceptance of materials and components "as found" suggested an opposite, worldly empiricism to Scully's lofty intimations of transcendental order. In this light, the development of the Gallery's plan can be interpreted as a weaving together of these two processes. Kahn's early struggles with imposed bay sizes, the difficulties of the core and the desire to relate to the existing building all suggest a building up of a balance between the Gallery's own logic and the complexity of the site surrounding it. In August 1951, the first step toward asserting a singular image that nonetheless solved problems of function and context emerged, and its 'imageability,' its logic and planning, then planted itself. However the execution of this scheme remained open to debate, and the rationale for the beam and slab construction—its convenience given the controls on steel—did not survive Kahn and Tyng's continuing scrutiny. When a structural system presented itself as an ordering device equal to the overall plan's clarity, even its questionable efficiency as a structural element was less important than its ability to continue the building's visual and spatial hierarchy down to the smallest scale. From that point on, Kahn and Tyng's process was rationalist, as details and elements, in particular the main staircase, were revised or reconsidered based on their expression of the overall order.

Kahn's career from this point forward sought to correct the conceptual shortcomings that had been manifest in the Gallery, in particular the falsity of the 'free plan,' which was rebuked by Paul Rudolph's 1958 design for permanent partitions in the galleries, an evisceration of the building's logic that is only now being corrected. Kahn would gradually seek a balance between functional flexibility and spatial definition that had its roots in this incident. He would also expand on the theme of systems and structural integration that had provoked such a powerful aesthetic presence in the Gallery's ceiling. Perhaps stung by criticism of the tetrahedral grid's inefficiency, Kahn would seek out new engineering partners, new techniques and new principles throughout the next decades that would further develop the idea of 'hollow stones,' arriving at a weaving together of architectural structures and systems. At the same time, Yale represented the knitting together of architectural *gravitas,* advanced technique, historical reference and expressed logic that would provide the basis for much of Kahn's career and philosophy in the coming twenty years.

[1] A complete history of the Gallery project is included in Patricia Cummings Loud, *The Art Museums of Louis I. Kahn* (Durham: Duke University Press, 1989).

[2] Letter from George Howe to LIK, 8 January 1951. Box LIK-107, Folder 107.42, "Correspondence with Yale University."

[3] The following description of the design process up to and including the approved August, 1951 scheme is based on a set of recently found drawings and sketches now in the Yale Art Gallery's Prints, Drawings and Photographs Department, unaccessioned at the time of writing. I am grateful to Suzanne Boorsch and Lisa Hodermarsky of the Yale Art Gallery for bringing these drawings to my attention and working to prepare selections for publication.

[4] Letter from Douglas Orr to Charles Sawyer, 12 Apr 1951. in LIK Folder 84.1, "Yale Art Gallery." Louis I. Kahn Collection.

[5] Anne Tyng's work on the Gallery is confirmed not only by her memoirs, but also by cost account sheets of the project submitted to Yale on 1 Sept.., 1951 showing that she had worked 152.5 hours on the project between March and August, more than anyone in the office but Kahn—who had logged 585 hours. Also interesting is that Tyng was paid substantially more per hour ($3.00) than other staff architects, with the exception of David Wisdom ($3.50) were. Memo, "Cost Account to Sept. 1, 1951—Design Laboratory." in Folder 84.1, "Yale Art Gallery," Louis I. Kahn Collection.

[6] Letter from Charles Sawyer to Laurence Tighe, Treasurer, Yale University, 18 March 1952. In LIK Folder 107.42, "Correspondence with Yale University." Louis I. Kahn Collection. "

[7] Anne Tyng, Louis Kahn to Anne Tyng: The Rome Letters 1953-54. (New York: Rizzoli, 1997) 47.

[8] Letter from H. A. Pfisterer to Douglas Orr, 21 October, 1952. In Yale Manuscripts and Archives, RU 241, "Office Files of Douglas Orr Associates, Records of Yale Art Gallery Expansion, 1951-1954."

[9] This figure is conjectural, as Macomber's original bid does not exist within any of the archives reviewed for this chapter. In October, 1952, Sawyer reported to Griswold that "the actual contractual figures are exceeding the original estimates by approximately eight per cent, or in terms of the total cost of the building by about $100,000." Details on the scope of Macomber's bid do exist in a cover letter sent from Charles B. Solomon, Vice President, George B. H. Macomber Co., to Douglas Orr, 29 April 1952, in Yale Manuscripts and Archives Dept., Record Unit 241, "Office Files of Douglas Orr Associates, Records of Yale Art Gallery Expansion 1951-1954."

[10] Letter from Douglas Orr to George B. H. Macomber Co., 26 May 1952 in Folder LIK 107.45, "Correspondence with Douglas Orr," Louis I. Kahn Collection. Agreed revisions including the depth of the floor system were included in the final agreement, dated 9 July 1952, also in Folder LIK 107.45.

Figure 01. The original elevation planned for the Yale Art Gallery, by Edgerton and Swartout Only the right half of this façade (the SE corner) was ever built, leaving a substantial area for future consideration. (Yale University Library—Manuscripts and Archives Collection)

[11] This meeting is recalled by Gianopulos in Richard Saul Wurman, op. cit., p. 274. Mr. Gianopulos emphasized the role that the pre-existing mechanical layout played in conceiving the alternative idea in an interview at Keast & Hood's offices with the author, 9 Jun 2004.

[12] Letter, Burton Holmes, Technical Editor of Progressive Architecture, to Douglas Orr, 7 Aug 1952. In LIK Folder 107.45, "Correspondence with Douglas Orr," Louis I. Kahn Collection.

[13] News Release, Yale University News Bureau, 7 March, 1954.

[14] The following quotes are taken from "Letters," Progressive Architecture, May, 1954, 15-24.

[15] Ibid.

[16] [Vernon Read], "Building Engineering: Tetrahedral Floor System." Architectural Forum, 97:3. Nov, 1952. 148-9.

[17] "Toward New Structural Concepts." Special Issue of Progressive Architecture, June, 1954. Kahn's work was featured on pages 102-103, see below. Candela's essay contained extensive illustrations of curved and folded plates, including diagrams remarkably similar to those consulted in early phases of the Kimbell Art Museum's design. See Chapter 4.

[18] Vincent Scully, "Archetype and Order in Recent American Architecture." Art in America, v.42, no. 4. December, 1954. 250-261.

[19] Reyner Banham, "The New Brutalism." The Architectural Review. vol. 118, no. 708. December, 1955. 355-361.

[20] Ibid., 357.

Figure 02. Kahn and Orr's first scheme for the new Gallery wing employed literally Charles Sawyer's suggestion of a building-wide ramp gradually ascending to the third level of the original building. (Yale Art Gallery)

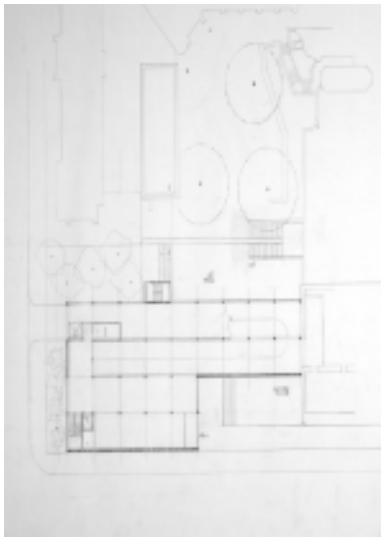

Figure 03. Early schemes by Kahn show a relentless adherence to the square gallery grid casually suggested by Sawyer and Howe—an a priori *condition that Kahn would gradually reject in favor of a more nuanced interpretation of the 'loft' structure.*

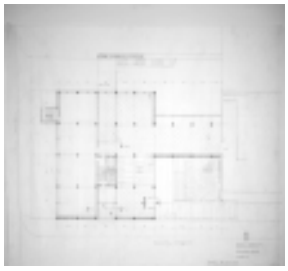

Figure 04. (left) A key moment in the design of the Gallery came when Kahn first broke the rigid square grid of the earlier plans, experimenting with a structurally less efficient—but spatially more compelling—double bay grid that allowed service elements to 'slip' out of the rigid grid. (right) The final plan of the Gallery is recognizable in the scheme prepared and presented in August, 1951. While the massing here is virtually the same as the completed building, the structure is rendered in a conventional post-and-beam system.

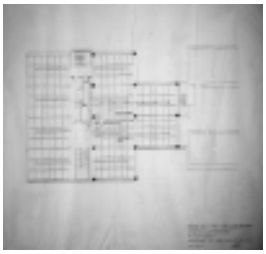

Figure 05. Anne Tyng's drawing of the revised structural system for the Gallery's floors, prepared even as bid drawings were being costed in Spring, 1952.

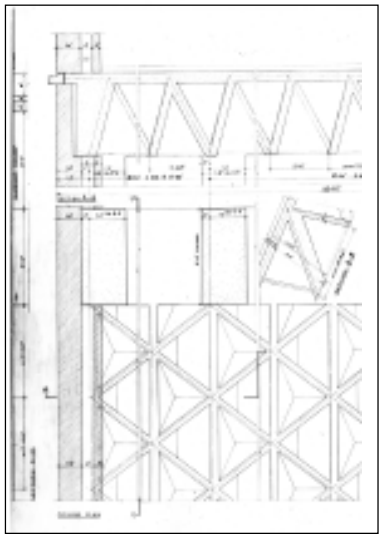

Figure 06. Construction of a typical tetrahedral grid element. Note the embedded metal ductwork and the exposed rebar that will be encased in the floor slab itself, soon to be poured.

Figure 07. Construction of the Yale Art Gallery, showing the concrete framework being concealed by the southwest façade.

Figure 08. The north elevation of the Gallery clearly telegraphs its functional division, with the central, service bay expressed and the bluestone-clad columns presented to the viewer, all in contrast to the more notorious south façade.

Figure 09. The Gallery's interior with the original, George Howe designed "pogo panels," soon replaced by Paul Rudolph's solid plaster partitions.