TECTONIC MATERIALITY

POETICS VS PRAXIS

DOMINIQUE BONNAMOUR-LLOYD, AIA
Georgia Institute of Technology

To resist consumerist simulacra, tectonic theory reclaims materiality as a meaningful constituent of architecture. While offering diverse viewpoints, tectonic theorists call for consistency between whole and parts, for expressiveness of structural and material behavior, and for connections between representation and construction, invoking various levels of authenticity. Most theory remains placed within a somewhat utopian framework of abstraction and exceptions. This paper posits that to resist main stream arbitrariness effectively and to gain operative significance, tectonic theory needs to acknowledge the context of praxis.

> *... architects who have aimed at acquiring manual skills without scholarship have never been able to attain a position of authority to correspond to their pains, while those who relied heavily upon theories and scholarship are obviously hunting the shadow, not the substance. But those who have a thorough knowledge of both, like men armed at all points, have the sooner attained their object and carried authority with them.*
>
> *- Vitruvius*[1]

Vitruvius calls for an architectural inquiry rooted both in theory and praxis. Today's construction industry depends more than ever on powerful socio-economic factors. Peter Rice notes that the industry determines what designers may or may not achieve, rather than vice-versa.[2] Alan Colqhoun remarks that US construction technology is now more guided by pragmatic matters than technological seduction.[3] Technology is no longer idealized as it was during the Modernist era. To posit this discussion within the duality of theory and praxis, the introduction sets up a framework of inquiry that weaves current criteria of constructibility into tectonic theory. This serves as basis of analysis for subsequent sections, that use the study of the Sydney Opera as departure point for discussions.

The nature of tectonic objects with respect to criteria of constructibility

> *When a structural concept has found its implementation through construction, the visual result will affect us through certain expressive qualities which clearly have something to do with the play of forces and corresponding arrangement of parts in the building, yet cannot be described in terms of structure and construction alone. For these qualities which are expressive of a relation of form to force, the terms tectonic should be reserved.*
>
> *- Sekler*[4]

This statement posits three major conditions for a tectonic artifact: 1) that construction implements structure, *structure* dealing with efficiency and appropriateness of systems and *construction* with process and technique; 2) that expressiveness has to do with the play of forces and arrangement of parts; and 3) that expressiveness is not the sole result of constructional consistency, but operates transcendentally. In other words, *tectonic* buildings are not merely rational, but poetic.

This paper focuses on the first point, "construction as implementation of structure," examines its consequences on the second, "expressiveness of play of forces," and investigates the less manageable qualities of the third point, "poetry." To ensure that construction implements structural concepts and that forms reflect principles of construction, it seems essential to understand the available means of construction and the forces that regulate construction.

Building upon Sekler's distinctions, this paper aims at weaving the conditions of praxis into this theoretical framework. To that end, it uses a matrix of investigation consisting of three vectors: necessity (how necessity informs design), possibility (how architects exploit possibilities), and dissociation (how architects integrate dissociation). *Necessity* provides architects and builders alike a set of specific circumstances for the work. The notion of "construction as implementation of structure" requires equal considerations for construing and constructing the structure. Praxis favors specific means of erection that have the power to inform, mediate, or transform intentions. *Possibility* is that which differentiates invention from conventional "putting things together." Exploiting structural and constructional potentials may generate new means of expression. *Dissociation* is inherent to architecture. Architects integrate multiple levels of intentions often slanted by reality. Poetry captures these divergent forces into objects and spaces that manifest either tension or harmony between objectives and their realization. Poetry lies at the intersection of the material

and the imagined, transcends the restrictions of praxis, and also reveals paradoxes between concepts and their physical manifestation.

> *Construction carries a connotation of something put together. . . The visible and tangible form which results from the process of construction can be discussed and judged in various ways. As far as construction is concerned there are all the questions of selecting and handling materials, of process and techniques.*
>
> *- Sekler*[4]

Considerations of constructibility (the ability to construct) are seldom recorded or discussed, yet they frequently play a decisive role in the implementation of design ideas. Constructibility has to do with sequences and means of fabrication, transportation, and erection as well as material, equipment, and workmanship availability. The recent specialization and fragmentation of architectural practices render the integration of building art and science increasingly difficult. Yet, only through understanding constructibility, can architects explore the necessities and possibilities of construction techniques and reintegrate logically the dissociation inferred by design and construction processes.

> *Careful detailing is the most important means of avoiding building failures, on both dimensions of the architectural profession — the ethical and the aesthetics. The art of detailing is really the joining of materials, elements, components, and building parts in a functional and aesthetic manner.*
>
> *- Marco Frascari*[5]

Frascari provides us with an entry into the subject of constructibility, with an emphasis on detailing. He points out the duality of the profession revealed through the detail, which is examined here in terms of functionality. Expanding on detailing criteria outlined by Ed Allen, the following definitions of constructibility apply to design as well as detailing.[6] Criteria can be grouped into two major categories: ease of assembly and efficient use of construction resources (see Table 1).

- *Ease of assembly* of materials follows some rules of thumb that facilitate building erection, hence proper execution, by acknowledging labor skill (or lack thereof) and the complexity of building systems. These rules promote the use of uncut units; minimum number of parts; parts that are easy to handle; repetitious assembly; accessible connections. They recommend that detailers pay attention to installation clearances, and dimensional tolerances as a means to hold reasonable expectation of the contractor. They call for attention to non-conflicting systems, an increasing concern as buildings become more sophisticated.
- *An efficient use of construction resources* would improve the quality/price ratio while introducing notions of sustainability. Resource efficiency entails a judicious choice of site vs. factory construction, that requires rehearsing the construction sequence. It favors the use of off-the-shelf parts. It recognizes local skills and customs even in a so-called global market. It permits all-weather construction and concerns itself with scheduling issues. It allows pride of craftsmanship. Finally it acknowledges accepted standards imposed by regulations and/or customs.

These constructibility criteria fall within fluctuating planes formed by the vectors of necessity, possibility and/or dissociation. This checklist presupposes a pragmatic logic or *common sense* as a basis for sound design, but does not guaranty good design. The awareness of these principles allows architects to push design practices to a critical level by choosing when to respect or disregard these rules. The knowledge of construction processes is as necessary to the architect as the knowledge of clay behavior and molding processes would be to the potter.

VECTOR I. Construction as Implementation of Structure in Light of Necessity

> *Effectual wisdom is at one with power.*
>
> *- Francis Bacon*[7]

Theoretical definitions and criteria only establish a framework that needs be tested with examples. This section explores how current construction conditions impact the implementation of structure into construction, by examining constructs and context of construction and analyzing the Sydney opera with respect to those schema.

Semper's distinction between the stereotomic and the tectonic proves useful, for it refers directly to the act of making and the resulting expression of forces. The tectonic frame is about conjoining members of various dimensions while stereotomy is about piling up units that act in compression. The term *stereotomic* originates with the cutting of stones, while tectonic refers to a process of assembling pieces together. "The frame," notes Frampton, "tends towards the aerial and the dematerialization of the mass, while the mass form is telluric, embedding itself deeper into the earth. These gravitational opposites, the immaterial of the frame and the materiality of the mass, may be said to symbolize the two cosmological opposites to which they aspire, the sky and the earth."[8]

Distinctions between construct and construction relate to the separation between designing and making. Differentiating the act of "creating" from the "act of constructing," Maegher distinguishes the architect (*architekton*) from the common worker (*tekton*).[9] He places the architect near the foundational principles of the activity of production. His underlying assumption is that human being is a *homo faber* and hence, architecture is the essential human activity. While this may give architects a satisfying sense of significance, it differs radically from the actual position and role of the architect today. Peter Rice emphasizes the complex play of forces that influence building production, most of which fall outside architects' territory.

> *Everything we design will eventually be made, assembled and erected by industry. The building industry is one of the biggest and most powerful*

TABLE 1. CONSTRUCTIBILITY CRITERIA
(summary using Ed Allen's Architecture Detailing: Function, Constructibility, Aesthetics. New York: John Wiley and Sons, 1993)

Constructibility criteria that yield to a design the ability of to be constructed, can be grouped into two major categories:1- ease of assembly and 2- efficient use of construction resources

1- EASE OF ASSEMBLY. Following are eight rules of thumb (numbered only for convenience) that facilitate building erection, hence enable proper execution.

1. UNCUT UNITS. Understanding nominal and actual dimension of standard materials saves unnecessary cutting and trimming, reduces the possibility of errors, prevents unrealistic design, and may be cost effective.
2. MINIMUM NUMBER OF PARTS. Understanding the conditions of the work, i.e. how many tools and nails can a carpenter handle, how many wrenches must a curtain wall installer have, with how many batches of mortar must a mason work at any given time, ensures better execution
3. PARTS THAT ARE EASY TO HANDLE. The size of materials is related to the type of tools that handle them. Industrialization provided more complex means of erection such as hoist and cranes. Understanding their size, capacity, and function become essential considerations.
4. REPETITIOUS ASSEMBLY Understanding the sloppy and dirty nature of construction leads to the use of reversible parts, allowing for Murphy's law. Special conditions always require greater attention. Hence patterns of repetition and simple formwork are preferred over intricacy, complexity, unless desired for aesthetic reasons.
5. ACCESSIBLE CONNECTIONS. Allowing for a comfortable work position has led to the evolution of materials. For instance, glazing details have been modified to allow interior rather than exterior installation of sealant.
6. INSTALLATION CLEARANCES. Clearance has to be provided around most assemblies to allow installation. Tight fitting is only an abstraction or an illusion (examples: at a structural connection, around a window, to open a door, between cabinet work and wall). The role of trims, fillers, and sealant also need to be understood in this context, not merely as decoration.
7. DIMENSIONAL TOLERANCES. Different materials have different levels of tolerance, and different trades perform at different levels of precision (e.g. never attach a finish material directly to a structural element without providing room for correction of different dimensional tolerances; a cabinet maker performs more accurate tasks than a steel worker etc. . .) Generally, notwithstanding a few notable exceptions, construction is a low-tech rather than high-tech industry.
8. NON-CONFLICTING SYSTEMS. With design team fragmentation, segregation of building trades, and the increasing complexity of building systems, conflicts between systems—mechanical, structural, and so on, must be avoided from conception through erection. It is best to provide ample clearance for each of theses systems (within the limits of efficiency of course) and to coordinate carefully the actual requirements of each. Maintaining a relative autonomy of trades ensure better quality control.

2- EFFICIENT USE OF CONSTRUCTION RESOURCES. Using construction resources efficiently allows to improve the quality/price ratio. Rarely does an architect work with an unlimited budget, but even then, a sound and efficient use of resources will ensure higher quality. Furthermore, a responsible architect, concerned with issues of sustainability, will include such concerns in his/her thinking process.

1. FACTORY AND SITE. Factory conditions are easier to control, and a higher level of precision can be expected. Factory fabricated parts are limited by modes of transportation. Building components must fit transportation modes: truck, train, boat The choice of shop-fabricated versus site constructed elements is complex.
2. REHEARSING THE CONSTRUCTION SEQUENCE. Rehearsing the construction sequence while designing or detailing is a good habit to ensure constructibility. Architects are not required to know OSHA regulations; yet, a minimum knowledge of the work conditions may enable architects to take advantage of it.
3. OFF THE SHELF PARTS. Standardized building elements lower building cost and speed erection. However, many variations exist between manufacturers, and the architect needs to ensure that the product specified is indeed standard. The "lead-time", or waiting period for shop-fabrication, needs to be considered, for the inconvenience of waiting for a product, particularly at the early stages of the work, may offset standardization's benefit.
4. LOCAL SKILLS AND CUSTOM. Customs and practices of the area in which the building will be erected will affect design more than a global economy would lead to believe. Site conditions may limit import of certain products; workers who are not familiar with a material will need extra-assistance to install it. Each region tends to have a specialty which is often rooted in the vernacular tradition, or results from historical circumstances (examples: masonry in the Southwest, Native American steel workers in the North-East, etc.). The political context will greatly affect the cost of construction (in particular, the status of unions, wage policies, etc.) To design the same building in Chicago and Paris may result in drastically different qualities of execution.
5. ALL WEATHER CONSTRUCTION. Some products require less preparation and waiting time than others. A region's climate will determine which products can be installed during certain seasons, and affect design significantly (e. g. concrete in hot, dry climate; construction in Wyoming). Trades off serve to evaluate which criteria are given priority (e. g. cost or durability versus construction expediency.)
6. PRIDE OF CRAFTSMANSHIP. Working with rather than against the contractor, and allowing the contractor to use his/her skills will result in a sense of ownership which ensures a greater quality. Occasionally, traditional practices interfere with the architect's intention and such compromises need to be negotiated carefully.
7. ACCEPTED STANDARDS. Understanding construction standards (whether regulated or simply a matter of custom) and the difference between skill labor and unskilled labor is critical to the overall success of the work.

Table 1.

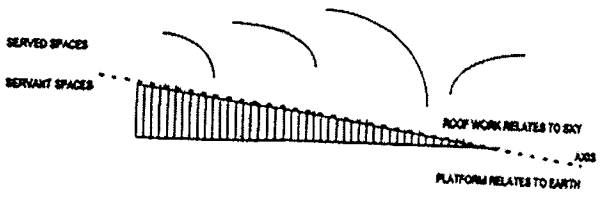

Fig. 1. Sydney opera sectional diagram, showing twin axes of program and construction.

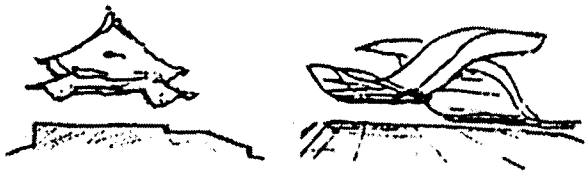

Fig. 2 a. Utzon's sketch of Japanese house showing the roof and platform. b. Early sketch of the opera house showing a curved structure floating above a platform. Taken from Philip Drew. Sydney Opera House. *Jorn Utzon. London: Phaidon, 1995. p. 13.*

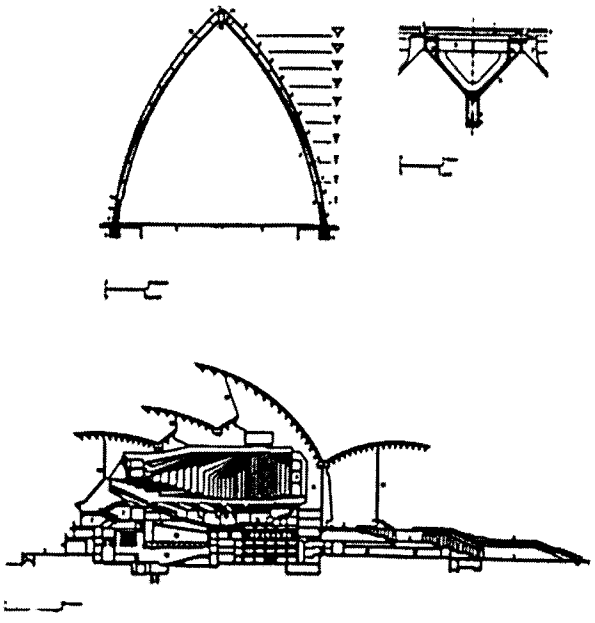

Fig. 3. a. Cross section through main shell rib segment and tile lid. b. Concert hall section. Taken from Philip Drew. Sydney Opera House. *Jorn Utzon. London: Phaidon, 1995. p. 54, 59.*

industries in all Western countries. Indeed, modern building is more a result of developing industrial techniques than a product of designers, architects, inventors or engineers. . . the craftsmen whose contribution, enriching and variable, is overrun by the steamroller effect of corporate decisions, and who are fast disappearing as a factor in the way we build.

- Peter Rice[10]

Perhaps we need to recognize our actual position in the building process rather than invoking mythical powers that have been transferred or diluted. Maegher's hierarchical distinction between *tekton* and *archi-teckton* is now distorted; at best, players speak parallel, occasionally divergent, languages and become mere peons in a game much larger than themselves.

The implications of this gap between making and designing go beyond matters of professional territories. Frascari points out one important reaction to industrialization: the transfer of workmanship to draftsmanship.[11] This structure of the industry opposes the traditional convergence of making and thinking found with master-builders. It deprives constructional thinking from the experience of the executor and transforms the design into a virtual act primarily performed by the design team.

Constructs and construction for the Sydney Opera

Frampton states that Utzon's architecture seems "to have been governed by two interrelated principles: the constructional logic of tectonic form and the syntactical logic of geometry."[12] Is it so?

The first two tectonic principles —r elationship to the earth and to the sky were at the origin of Utzon's idea. The roof work relates to the sky while the platform relates to the earth. Frampton calls them "twin axes of program and construction."[13] (Fig. 1) Within the platform, Utzon buries servant spaces, mechanical and stage equipment. Above the earth axis, he locates served spaces.[14] Initial sketches (Fig. 2) show how the heavy platform leaves the roofs free to float above the ground.

The desire for a column-free system would logically call for a shell membrane. In fact Saarinen, member of the jury, sold the design on the basis it was a four-inch concrete shell. Rehearsing the construction sequence led Utzon to acknowledge the difficulty of forming such complex concrete shells. This led him to choose ribbed vaults, made of prefabricated concrete elements (Fig. 3). His relentless efforts to solve the problem of erecting these shapes eventually paid off, when he devised the single spherical geometry common to all segments (Fig. 4).

What is the constructional logic of the prefabricated elements though? Prefabrication added a greater quality control, and the project is structurally sound. Yet, the elements' large sizes, the uniqueness of each piece forcing their numbering, the difficulty of erection contradict basic principles of constructibility. This leads to question whether this solution is guided by constructional concerns or by the will to achieve a desired form. Furthermore, the

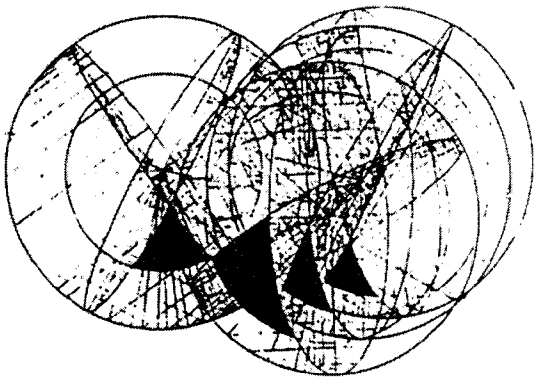

Fig. 4. Shells' geometry coming from a single sphere. Taken from "Architecture d'Aujourdh'ui" Feb 1993 p. 62.

assemblage of elements imposed a stereotomic rather than a tectonic construction for units were in effect stacked on each other.

Robert Mark criticizes vigorously Utzon for failing to understand concrete's structural integrity, which led to the outrageous cost of the project.[15] Mark attributes the expenditure of time and engineering energy and the 1800-percent budget overrun to the stubbornness of the architect. Even though Utzon was familiar since childhood with boat construction, he refused to use a metal frame which would have facilitated erection. For Mark, a steel frame structure would have been capable of bending to the desired curvature and of receiving the roof cover with greater flexibility than the massive concrete elements. Nowadays though, engineering calculations could be easily performed and may not require the laborious years of engineering of the Sydney opera. Does this infer that proper use of material evolves with our capacity to grasp their behavior? Or does it challenge the notion that integrity of materials guided Utzon's design?

In fairness to Uzton, one needs to recognize that the opera makes use of four major materials: concrete for exterior shells, tile roof cover, steel for glazed wall mullions, and plywood for interior shells. Even though the concrete shell initiates controversy, the employment of these other materials demonstrate an exemplary consistency between forms and materiality. Steel (Fig. 5) gave the formal flexibility to adjust the curtain wall to the underside of the shell. Plywood (Fig. 6) used for the acoustical ceilings formed by the intersection of spheres allowed the pliability and the malleability necessary to meet acoustical demands and supports overall formal intents. The intricacy and the precision of the tile design followed the logic of their installation.

In terms of praxis, Sydney opera is a good example of the tenuous position of the architect. The execution of Utzon's powerful idea ultimately depended on the dedication and the commitment of the owner Cahill. After his death in 1967, Utzon was eliminated, replaced by inexperienced local architects that satisfied political agenda. Such practices supersede the best intentions and demonstrate the necessity to know the practical and political construction conditions. This entangled political

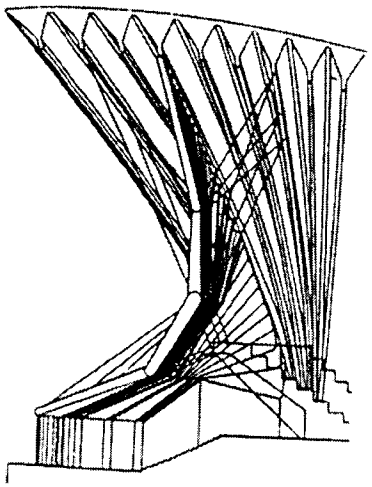

Fig. 5. Major hall section through northern glass wall c. 1961. Taken from Philip Drew. Sydney Opera House. *Jorn Utzon. London: Phaidon, 1995. p. 15.*

crisis sheds some skepticism towards the belief that global conditions prevail. In fact, local powers ended up winning. Such concern is particularly acute today, when such a large proportion of significant architecture is remotely designed. The distance between the designer and the site accentuates the distance between intentions and execution. It precludes synergy with or feedback from the *tekton*. This issue emphasizes the incidence of process over product. The topic of structural integrity and constructional logic is further complicated when political forces negate the power of daring intentions and exacerbate the gap between design and making by introducing complex layers of intervention.

Conclusion Part I

The issue of structural integrity with Sydney Opera is not an isolated example. Many case studies selected for the Georgia Tech seminar on constructibility refuted at least one major rule of constructibility. As another example, Edward Ford refers to Johnson Wax Building as a puzzling example of Frank Lloyd Wright's defiance of the construction industry; this led to technical nightmares, schedule delay, and more than doubling of construction cost.[16] Economically, the icon of Sydney and Australia has generated immense profit since its inception (both for restaurants and as a tourism marketing tool), yielding a return on the investment. Yet new generations of architects must pay for these cavalier attitudes towards budget, common to architects for three decades after WWII. Necessity is now paramount is the mind of clients and critics alike; pragmatism prevails over integrity.

VECTOR II. Expressiveness of the Play of Forces and Arrangement of Parts with Respect to Possibility

Through tectonics the architect may make visible in a strong statement, that intensified kind of

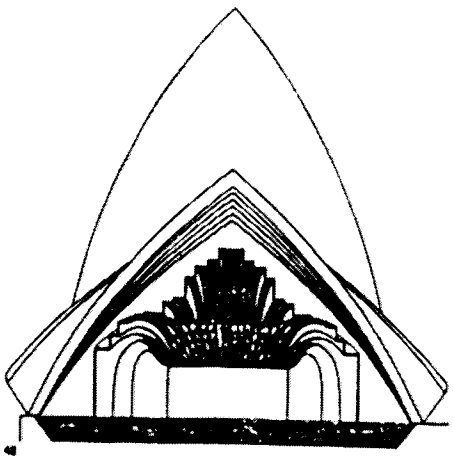

Fig. 6. Cross section through Minor Hall (opera theater) auditorium. Drawing from the yellow book. Taken from Philip Drew. Sydney Opera House. *Jorn Utzon. London: Phaidon, 1995. p. 17.*

> *experience which is the artist's domain — in our case, the experience of forces related to forms in a building. Thus structure, the intangible concept, is realized through construction and given visual expression through tectonics.*
>
> *- Sekler*[17]

Sekler asserts that tectonic theory is not dogmatic, but analytical. He notices that few buildings implement perfectly structural principles. Sekler suggests[18] that the actual construction may in fact *militate against the structural principle,* that *there may be a tectonic negation which tends to disturb the viewer*, as in mannerism, or that there may be *a tectonic overstatement of what was once a simple constructional device*. These three strategies — perfect visibility, tectonic negation, and tectonic overstatement are bringing the materiality of buildings to the forefront of our experiences. Focusing on the notion of visibility, this section aims at clarifying buildings the relationship between expressiveness and technical performance.

Sekler sheds some light on the issue.[19] The 17th century French term "vraisemblance" literally translates to "appearing true," implies that buildings need not only *be* stable but *look* stable. For Fiedler, the concept of visibility was the manifestation of a mental activity of empathy, of taking possession spiritually. This phenomenological apprehension of visibility engages the question of subjectivity. Expressiveness relies on cognitive and perceptual interpretations. Addressing the topic of expressiveness and authenticity, Ruskins identified one form of architectural deceit: "the suggestion of the mode of structure other than the true one."[20] This implies that analogous and literal structural expressions are acceptable. In other words, the extent to which buildings reveal the nature of their structure and assemblies is subject to interpretation.

Even the clear distinction tectonic Vs stereotomic yields to significant ambiguity of expression. Frampton notes that in the interest of permanence, stones have been cut to assume the form of a frame.[21] In the Gothic church, stressed stones, stereometric elements, assume aerial expressions of the tectonic frame, to suggest man's elevation towards God. Even though stones by nature enact gravity and tend to refer to the earth, Gothic church stones suggest a movement towards the sky. Robert Mark criticizes the Greek temple (and Corbusier for misunderstanding it) as a mere refinement of forms that has little to do with material behavior. Stones are not appropriate for trabeated systems; their lack of resistance in tension engenders an excessive closeness of columns unable to prevent cracks at midpoint. These significant exceptions caution against pure rationality.

The Expressiveness of Sydney's structure

Utzon approached technology with a sense of wonder for its "unanticipated possibilities."[23] Indeed the opera proposal elicited engineering prowess. Testing for wind loads and gravity loading lasted four years. Because seashell-like surfaces cannot be laid flat, a number of simple surfaces had to be mathematically developed and later joined. Utzon's proposal for a single spherical origin greatly simplified calculations. Nonetheless, Ove Arup's engineer Zedlin, had already devised his "limit design" to replace "elastic theory," whereby stresses need not be verified, but the load at which the shell collapses does. Zedlin tested his theory successfully for the Kodak Pavilion at the New York World Fair. In that sense, Sydney contributed to the enhancement of structural possibility, even though generated by Utzon's formal desire rather than through constructional design processes.

One wonders nonetheless why such design efforts did not lead to specific expressiveness. Professor Henry Cowan remarks that "one cannot see much of the concrete shell structure, either from the inside nor the outside. What is seen are the non-structural concrete slabs with the tiles."[24] In this case, the engineer seems to have exploited material possibilities, not the architect. With respect to constructibility criteria, where is the laborer's pride revealed? How does one justify the concealment of such an unusual structure? Missing the expressive opportunities of the intricate process of erection tends to support Mark's argument. Ed Ford points out that expressive structures might be more efficient with respect to materials than ordinary ones; yet, any specialized or labor intensive installation renders redundant and familiar systems more economical.[25]

Conclusion Part II

Exploiting material possibilities needs to be increasingly justified with impeccable quality or expressiveness and is subdued by pragmatic considerations. Maegher's ambiguities of idea and matter face accountability.[26] Maegher's statement, "human being essentially realizes itself through negating what is and transforming it in accord with human idea and will," is objectionable for the human will alone carries little power in the face of current pragmatism. Instead architects who realize fully what materials are, how they are assembled and for what purpose, may link more effectively the act of creating and the act of constructing, the art and the act of building. Kahn asking the brick what it wants

to be, indicates his willingness to work in synergy with the material rather than fight it.

VECTOR III. Dissociation Between the Poetic and the Pragmatic

The term "tectonic" cannot be divorced from the technological ... In this regard it is possibly to identify three distinct conditions: 1. the technological object that arises out of meeting an instrumental need; 2. The scenographic object that may be used equally to allude to an absent or hidden element; 3. The tectonic object which appears in these two modes.

- Frampton[27]

Tectonic theory does not wish to reduce the architectural object to a purely instrumental object, nor to deprive it of its symbolic nature, but on the contrary to reveal both. The poetic dimension adds a Semperian symbolic-structural link. Frampton invokes the representational nature of the tectonic object, that he opposes to the ontological.

Bottisher was greatly influenced the philosopher Von Shelling's view that architecture transcends the pragmatism of building by virtue of assuming symbolic circumstance. For Shelling and Bottisher alike the inorganic and symbolic meaning, and hence structural form could only add symbolic value by virtue of its capacity to engender analogy between tectonic and organic form.

- Frampton[28]

These allusions to Shelling underscore the romanticism underlying Frampton's theory, opening room for controversy. The notion of *organic* (natural) form introduces a dimension outside the *techne of logos* nor of the *logos of techne*; rather it embraces a concept of nature based in external philosophical outlooks. This prescription for organic imagery confuse the notion of poetic expressions of the pragmatic though. To define poetry or beauty as natural versus artificial (man-made) is to imbue a moral (even cultural) character that appears arbitrary.

We need to invoke this poetic dimension cautiously. Symbolism encompasses within the tectonic object a totality that a purely instrumental approach would negate. Yet the imposition of personal values opposes the premises of tectonic theory. To resist the reduction of architecture to empty signs or to commodities requires consistency between the semiotic dimension of the tectonic object and its physical manifestation. Legislating the intangible with questionable assumptions uses the very argument against which tectonic theory is meant to resist.

Tectonic Metaphors at the Sydney Opera

Frampton describes Utzon's work in a chapter entitled "John Utzon: transcultural form and the tectonic metaphor."[29] The focus of this paper on the shell does not minimize the opera's many successful elements. The tiles evoke natural fish scales which the shapes and joints manifest harmoniously. The fanned mullions of the glass wall suggest elegantly the albatross wing; their ingenious erection reveals expressive power and creates a magnificent play of members. The acoustical ceiling integrates its functional requirements into a design that is consistent with the outer shell in its sculptural qualities; in addition it enabled mass production of its individual parts. These parts exhibit consistency between construct and construction, structural and material expressiveness without sacrificing their poetry (see Fig. 5, 6).

The shell metaphor is complex. Does it suggest an inverted boat? In which case why did it not employ a boat construction, as suggested earlier? Did it refer to the structure of the sea shell? If so, what did it learn from this natural structure? Is it a vault, an umbrella, a shell? Its poetry stems mostly from the clarity of its gesture, combined with the complexity its multiple suggestions. But can one call it *tectonic poetry* if not devised from material or constructive logic?

Conclusion Part III

Here lies the greatest ambiguity of the theory as proposed today. While tectonics conjure the possibility that poetry may result from a skillful expression of constructive processes and material behavior, i.e. from self- referentialism, it seems to require that other dimensions be added in order to achieve poetry. This denies the power of materials in and of themselves to generate such poetry.

CONCLUSION: Paradoxes and Validity of Tectonic Theory

There are styles of design in architecture and there are styles of construction in architecture, and the two don't necessarily coincide.

- Edward Ford[30]

The study of Sydney Opera brings forth several contradictions and paradoxes of tectonic theory. Negating pragmatic considerations causes vigorous criticism from those who value common sense and may be particularly difficult to enact to day, given the pragmatism of current architectural production.[31] This emphasis on necessity though needs to be modulated. Historical exceptions suggest that a view that would only consider total integrity of material and constructive behavior might exclude significant examples of architectural history. In fact, history is enriched by these contradictions. Reasonableness may not prevail to the exclusion of beauty. Nonetheless, the notion of structural integrity is confronted with that of practicality. Should tectonic theory be formulated within current praxis, it might take on the vigor needed to resist significantly the impoverishment of architectural artifacts.

L'anteriorité de l'idée ou du dessein interieur au regard d'une oeuvre qui l'exprimerait seulement, ce serait donc un prejugé: celui de la critique traditionnelle qu'on appelle idealiste. Ce n'est pas

un hasard si la théorie—on pourrait dire cette fois la théologie—de ce prejugé s'epanouit sous la renaissance.

- Jacques Derrida[32]

The opera calls for reflections on the relationships between intention and execution. The issue of structural integrity is particularly vulnerable when it rests upon a pure theoretical understanding of material behavior. Utzon's intentions suggest two speculative hypotheses. The first is that the heroic concept of monolithic construction first challenged by Semper still prevails, even though production favors the use of tectonic frames, as notes Ed Ford. The second is that the architectural hero still tends to negate "what is." This example brings into play the limits of intuition and of the architect's will. Engineering gymnastics, i.e. the stretching of current possibilities, are forgiven when they lead to discoveries. Yet they are quickly forgotten once new tools erase initial difficulties, unless the building itself reveals them. The structural gesture of the opera emanates from formal will rather than from tectonic concerns. Should the acrobatic thoughts on structure and materials be revealed more than incidentally, the project may not be subject to such vehement opposition; forms and materiality would become one. The poetry of a paradoxical structure would intensify viewers' experience and add a phenomenological value to the project.

This leads to the most difficult aspect of tectonic theory: Dissociation between the pragmatic and the poetic. The symbiosis of formal intentions and poetic expressions leads to unquestionable tectonic artifacts, i.e. for the glazed walls, the ceiling or the tiles. Where metaphors enrich the process, they create powerful expressiveness. Yet, removed metaphors that are not exploited technically nor revealed spatially add distorting layers of personal intentions that ultimately result in ambiguity. Even though expressiveness cannot be described in constructional and structural terms alone, maybe tectonic poetry needs to be left to the realm of circumstances. Maybe it emanates from the art of making and from the serendipity that emanates from doing and composing at the same time. Dissociation results from creating art, as Melville points out in his poem entitled *Art.*[33]

In placid hours well pleased we dream
Of many a brave embodied scheme.
But form to lend, pulsed life create
What unlike things must meet and mate

NOTES

[1] Vitruvius, *On the Art of Building in Ten Books*, Joseph Ryckwert et al., ed. (Cambridge: MIT Press, 1996), 6th Ed.

[2] Peter Rice, *An engineer imagines* (London: Artemis, 1994), p. 133.

[3] Alan Colqhoun, "Regionalism and Technology," *Essays in Architectural Criticism* (Cambridge: MIT Press, 1995), p. 209.

[4] Eduard Sekler, "Structure Construction, Tectonics", G Kepes, ed. *Structure in Art and Science* (New York: Braziller, 1965), pp. 89-95.

[5] Marco Frascari, "The tell the tale detail", *VIA 7: the Building of Architecture* (Cambridge: MIT Press, 1984), pp. 23-27.

[6] Allen, Edward, *Architectural Detailing: Function Constructibility Aesthetics* (New York: John Wiley & Sons, 1993), pp. 129-139 and 159-175.

[7] quoted by Maegher, "Techne" *Perspetta (# 24*, 1988), pp. 158-165.

[8] Kenneth Frampton, "Rappel a l'Ordre: The Case for the Tectonic" *Architectural Design V60* #3-4 (New York: St Martin's, 1990) p. 21.

[9] Maegher (*Perspetta # 24*, 1988).

[10] Peter Rice (Artemis 1994), p. 133.

[11] Marco Frascari, "The tell the tale detail", *VIA 7: the Building of Architecture* (Cambridge: MIT Press, 1984), p. 26.

[12] Kenneth Frampton, *Studies in Tectonic Culture: The Poetics of Construction in 19th and 20th Century Architecture* (Cambridge: MIT Press, 1995), p. 251.

[13] Ibid, p. 247.

[14] Utzon differentiates the platform and the plateau: the former finds its origin in Japanese architecture, emphasizes the lightweightness of the earth, and calls for an attraction to the floor. The latter is found in Mayan architecture, emphasizes a rock-like inertia, and calls for an attraction to the wall.

[15] Robert Mark, *The Mystery of the Masterbuilders* (Nothbrook,Il.: Coronet Films, 1988) This statement is actually inaccurate, for the building of foundations consumed the totality of the original budget, following an erroneous preliminary soils report. The many program changes also contributed to delays and the escalation of cost.

[16] Edward Ford, *The Details of Modern Architecture*, Vol. 1 (Cambridge, Mass: MIT Press, 1991), p. 343.

[17] Edward Sekler (Braziller, 1965), p. 92.

[18] Ibid, p. 94

[19] Ibid, p. 91-92

[20] John Ruskin, *Seven Lamps of Architecture*, 1880 Ed. (Mineola: reprinted by Dover, 1989).

[21] Kenneth Frampton (St Martin's, 1990), p. 21

[22] Robert Mark, Op. Cit.

[23] Kenneth Frampton, (MIT Press,1995), p. 252

[24] quoted by Forrest Wilson, "The Sydney Opera: A Survivor", *Architecture* (Sept. 1989), p. 104

[25] Edward Ford, *The Details of Modern Architecture, Vol. 2* (Cambridge, Mass: MIT Press, 1996), Conclusion pp. 422-429.

[26] Maegher, *Perspetta # 24* (1988).

[27] Kenneth Frampton (St Martin's 1990), p. 21.

[28] Ibid, p. 22.

[29] Kenneth Frampton (MIT Press 1995), p. 247.

[30] Edward Ford (MIT Press 1991), p. 15.

[31] —, (MIT Press, 1996), Conclusion pp. 422-429.

[32] It would be a prejudice to give precedent to the idea or internal intention for a work of art that would merely express them: that of traditional critique that one calls idealistic. It is no coincidence that such prejudice's theory—this time one might say theology—flourished during the Renaissance. Jacques Derrida, *L' Ecriture et la Difference* (France: Seuil, 1967).

[33] Melville, "Art", *The Columbia Anthology of Poetry*, ed. Jay Parini (New York: Columbia UP, 1995), p. 235.