

STANDING ON THE SHOULDERS OF GIANTS:

AN EVOLUTIONARY PERSPECTIVE OF STRUCTURAL ART

PERSONAL BACKGROUND

Ever since I can remember, I have been fascinated with the built environment. Constructing cityscapes of Lincoln Logs and Legos by the age of 5, I quickly succumbed to the yearning and desire to be a builder. With a passion for math and science, I combined the two, and, upon entering college, I began my journey as a structural engineer. My respective university provided a nurturing environment for me to grow and enhance my technical understanding of structures, but, ever since the beginning of my engineering education, I have felt a void within.

I have an intense passion for design - - a passion for creating something new, something brilliant, something beautiful - - but the rigid undergraduate civil engineering curriculum lacked creative outlets. In a world of x's and y's, I found no language for the aesthetic. Safety and economy reigned supreme over artistic expression, and I remained expressionlessly confined to a purely technical world built of concrete and steel.

To compensate for deficient creative ventures, I pursued minors in English and architectural history. The coursework of the latter introduced me to - - and greatly influenced my personal philosophies of - - architectural aesthetics. It is where I learned of genius master-builders Michelangelo, Brunelleschi, and Alberti, and of modern masterminds Khan, van der Rohe, and Le Corbusier - - modern engineer-architects that continuously inspire me with their supreme examples of structural art. In one of my courses, I learned of a man named Mario Salvadori, a professor who committed his life to bridging the gap that exists between the fields of architecture and engineering. He wrote:

Structure has always had a decisive influence on architecture ... and [it] is often a cause of friction in the relationship between the architect and his structural engineer.

Lucky is the client whose architect understands structure and whose structural engineer appreciates the aesthetics of architecture.¹

And I took his words to heart.

¹ Salvadori, Mario (1990). *The Strength of Architecture: Why Buildings Stand Up*, Norton, New York.

UNDERGRADUATE RESEARCH

Using Salvadori's wisdom as a springboard for an undergraduate research proposal, I was selected as a University Research Fellow at my respective institution. For the past two years, I have been researching the importance of aesthetics in structural engineering, while evaluating structural engineering programs' effectiveness in adequately preparing its students to work with architects in industry. My undergraduate research culminated in a thesis entitled, *Architecture and Engineering: Assessing the Importance of Aesthetic Design in Structural Engineering Curricula*. This research project affirmed that a 'gap' does exist between the two professions, namely due to educational differences in design emphases - on the technical for engineers, on the aesthetic for architects. And although my research identified other sources of deviation in engineering and architectural curricula, the entire experience itself has shown me the crucial importance of aesthetic considerations in all aspects of building planning and design, and it helped me to develop my own language for the aesthetic, while fostering an intense interest in modern structural art.

For me, architecture is all about a beautiful blend of both structure and aesthetics, of form and function, of technical requirement and artistic expression. I firmly believe in the quintessential integration of art and science, and I relentlessly delight in the mastered genius of their visual harmony. In effect, my graduate studies, professional goals and corresponding career objectives truly reflect my firm commitment, to myself and to my profession, to educate both architects and engineers alike, about the beauty that can exist in structural design.

PROCESS OF EVOLUTION

Studying architectural history and conducting research on aesthetics has shown me that architectural theory, practice, and true aesthetic expression in structural design are the result of evolutionary processes. Yesterday teaches lessons in efficient forms, materials, and construction techniques, while dictating what is in fact 'beautiful' in the modern day. I have found common threads in the development of supreme structural art: efficient refinement of structural form, structural expression, and the equilateral triad of efficiency, expression, and economy; and it is by understanding this evolutionary process that I understand that today's building professionals build on the foundation that has been laid throughout the centuries and we undoubtedly stand on the shoulders of architectural giants.

EFFICIENT REFINEMENT OF STRUCTURAL FORM

Beautiful structures are not just 'created' - - they are refined. Knowledge of architectural history is important in understanding the evolutionary processes involved in structural design. **FIG 1**, for example, shows how arched vaulting systems have become increasingly efficient throughout history. Roman round arches were extruded to construct barrel vaults, which were then crossed to create groin vaults, in order to channel the continuous outward thrusts to four manageable point loads. Further refinements were made to the existing arch system. Pointed arches were found to be much more efficient in controlling the lines of thrust and directing forces to the ground. Today, catenary arches, the most efficient arched forms, are being incorporated into building systems, as can be seen in **FIG 2** - - Gaudí's famous Sagrada Familia.

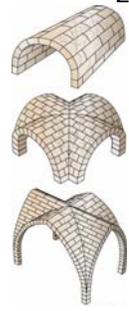


FIG 1. Arch Vault Evolution



FIG 2. Sagrada Família, Gaudí

Similar evolutionary developments can be seen with other structural systems. Tensile roofed structures, post-lintel systems, pneumatic structures, and even the basic Doric, Ionic, and Corinthian architectural orders owe their efficient refinement to evolutionary processes. Evolution leads to efficiency, which in turn, sparks innovation and improved design. Therefore, I believe studying the marvels of the past provides endless inspiration for modern architectural masterpieces.

STRUCTURAL EXPRESSION

What is the difference between architects and engineers? Most would respond in similar fashions: Architects design the form [or skin], while engineers design the skeleton. I believe the true essence of structural art is where the structural skeleton dictates structural form. There is beauty in structural correctness - - and the aesthetic of structural art is in fact the structural system itself. Some of the most supreme examples can be seen in **FIG 3**, Frei Otto's Munich Olympic Stadium, and in **FIG 4** Calatrava's Sundial Bridge - - both are purely expressionistic in structural form and unarguably brilliant works of structural art.



FIG 3. Munich Olympic Stadium, Otto

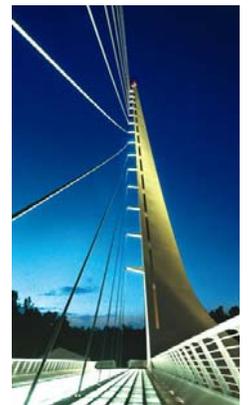


FIG 4. Sundial Bridge, Calatrava

EFFICIENCY, EXPRESSION, AND ECONOMY

Economy is an undeniably important design constraint - - for most large scale projects, it is the most important. However, there are rare circumstances where form efficiency, structural expression, and construction economy blend to create an architectural masterpiece. **FIG 5** shows the CNIT Building in Paris. The building's triangular-shaped plan is sheltered by a three-part concrete vault - - one of the largest ever constructed. This exemplifies the true essence of structural art - - where the structural skeleton dictates structural form - - the 'quintessential integration of art and science' which I mentioned earlier - - and where economy was balanced by material selection and construction technique. I. M. Pei's Fountain Plaza Building in Dallas, Texas, **FIG 6**, is another perfect example. His balance in form, expression, and economy blends to produce an architectural aesthetic even in the simplest of geometric form - - and, for me, it serves as yet another inspirational tour de force as I begin my own professional career.



FIG 5. CNIT Building, Esquillan



FIG 6. Fountain Plaza, Pei

CONCLUSION

I often believe that I lived about 500 years too late, wishing always to imitate the great Renaissance Men who reigned supreme many centuries before - - the da Vincis, the Michelangelos, the Berninis - - the kings of art, architecture, and science who did it all, and did it well. They are my heroes as I seek to integrate my passion for both engineering and architecture in the modern day - - but I know deep down that if I see further it is only by standing on the shoulders of giants such as they. Nevertheless, I wish to make a living doing what I love to do, seeing the fruits of my labor in my own works of structural art, my fellow students, and my colleagues. I wish for significance - - for giving back something to this world that will make it just a little better and a little more beautiful because of me. But above all, I wish for happiness and honor in this life, learning, living, and loving until the very day that I die.

PHOTO REFERENCES

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