Skidmore, Owings, & Merrill Structural Engineering Traveling Fellowship Essay

An artist will gaze at a flower and admire its vivid color, clear form, disheveled texture and, perhaps, the striking way in which shadows cast against a subtle play of light. A scientist examines an identical specimen and ponders the biochemical properties and interactions that produce such color and form. An engineer analyzes how the hydrostatic pressure within the flower's cells allows it to grow to critical height and size, providing the necessary resistance to lateral and gravity forces. Regardless of how one understands the world, there is an intuitive, universal beauty to it; an attraction to the "natural, 'honest' aesthetic."

Similarly, most people when looking at a complex, steel canopy design do not appreciate the delicate balance of forces supporting it, or the countless hours spent drawing and detailing each structural element. However, one does not have to be an architect, an engineer, or an artist to look up and be amazed by the elegant beauty and harmony. This is the power of the aesthetic. Masterpieces, even structural and architectural, use this power to captivate and inspire; to create a proud connection for the observer to their community and, even, to humanity as a whole.

Figure 1: 'Les Irises' by Vincent Van Gogh

Figure 2: Oriente Station in Lisbon by Santiago Calatrava

Although not every engineering project can or should be a masterpiece, aesthetics should not be an afterthought. Within Structural Engineering aesthetics must be a driving force. Each structure produces a message that is more than just the elegant solution of concrete and steel mathematically conquering nature. Each structure has the potential for creating an aesthetic that speaks to humanity. As Gustave Eiffel so eloquently stated;

> Can one think that because we are engineers, beauty does not preoccupy us or that we do not try to build beautiful, as well as solid and long-lasting structures? Aren't the genuine functions of strength always in keeping with unwritten conditions of harmony? Besides there is an attraction, a special charm, in the colossal, to which ordinary theories of art do not apply.

What we build is an expression of the human condition. Buildings are social artifacts, representative of culture, community, and history. There is a language to architecture, a nonverbal communication between it and its occupants, and observers. It has the ability to change the interaction between a city and its citizens.

The aesthetics of any structure send a particular message to the people who view it. Few people hold any conscious awareness of the psychological significance of the structures that surround them or the background they create. While driving down Main Street, Suburbia, USA, few attend to the inundation of American commercial culture and its message of "buy me now" that calls out from cement block form and economical rectangular constructions designed for quick remodeling when the fad of today moves over for the trend of tomorrow.

For decades, New York's trademark skyline spread out with the unrivaled twin towers rising from its midst. Few recognized, prior to their destruction, how personally connected they had become to the tower's message of strength and invincibility. The horrific mass murders traumatized a country, but the quieter blow came to our national psyche, as we witnessed a hate-filled attack on the American Dream; the destruction of the World Trade Centers' aesthetics.

In 2002, I visited the Pantheon in Rome. I serendipitously walked through the grand doors at solar noon. For a few brief moments, the archway above the entrance was magnificently illuminated by the solar rays shining through the oculus. Everyone underneath the massive dome stopped and stared. I was awe-struck and inspired with the realization that an ancient Roman had used the science and technology of his day to calculate the exact orientations of the building and the path of the sun, such that they would perfectly align to create the shared communication that is: art, the type of art that results when the collaboration of structural engineering and aesthetics results in the synthesis that is part masterpiece and part genius.

When multi-disciplinary teams collaborate and combine their skills profound structures are built; structures that have the power to change people's lives, to revitalize a rundown neighborhood, create cultural icons, or to invoke emotions. In a divided, disconnected, consuming-obsessed country devoid of any unifying culture or sentiment, how do you bring people together, breed tolerance and unity, and create community? How do you gather and represent our common goals, our principles, and celebrate our diversity?

It seems like such an absurdly optimistic, utopian fantasy. However, there are places in the world where a sea of strangers are brought together, and feel a sense of belonging. I think that there are methods for developing economically efficient, socially conscious, structurally sound environmentally respectful buildings and bridges. I also believe that is possible to simultaneously express the structure. I believe there is a beauty to the inner workings of a structure. The chemical-physical interactions of systems and the mechanics possess within themselves an inherent beauty.

Modern structures require the supervision of both architects and engineers. Additionally, many modern architectural aesthetics require complex structural design. I have limited experience in the field, and I have already noticed that this forced marriage of disciplines is not always a happy one. The increasing inter-reliance on these disciplines begets the need for people who can view and understand the structure, both as an architect and an engineer. Few architects can think as an engineer, and few engineers can think as an architect. The collaborative efforts between architecture and engineering was epitomized by the pragmatic visionary, Dr. Fazlur Rahman Kahn, of Skidmore, Owings, & Merrill. His genius drastically improved the efficiency of high rise construction and made masterpieces, such as John Hancock and Sears Tower possible. As Dr. Kahn once said, “The technical man must not be lost in his own technology. He must be able to appreciate life; and life is art, drama, music, and most importantly, people.”

The importance of this fellowship is to foster this idea in the minds of tomorrow – to expose young engineers to the masterpieces, and hope that the power of experiencing the structures first-hand will ignite a spark in the next generation’s Fazlur Khan. Traveling has been the capstone experience to classic Architecture education for hundreds of years and it is essential to the spirit of the profession. I am not so arrogant as to believe that I will be a Michelangelo or a Leonardo Di Vinci, but my life’s dream is to integrate my passion for Art, Architecture, and Engineering into a fulfilling career, which allows me to work collaboratively to create safe, efficient, beautifully designed structures.

When I tell people that I want to be both a Structural Engineer and Architect, the incredulity of my proposition causes most people’s eyes to widen, their jaws to drop, their noses to squish up, and then they ask in a skeptical tone, “WHY?” I explain that I have been an artist my entire life, but I also enjoy math, science, and engineering. From Lego and erector sets, to Popsicle stick bridge competitions; my passion for building has never waned. My multitude of interests and hobbies include drawing, painting, art history, writing, furniture building and design, history, astronomy, mathematics, language, literature, and of course, architecture. Originally, I thought it would be impossible to combine my interests into a profession -I wanted to be an engineer, but I also loved Art and Architecture, I knew I had to make a decision.

In the spring of 2003, I had the life altering experience of studying abroad in Rome. There I witnessed the integration of Art, Engineering, and Architecture. This professionally formative, profound experience taught me more in 4 months than the previous 4 years of college. I came home not only with thousands of memories, a broadened mind and world perspective, but also a decision. I knew I could combine Architecture & Engineering and I was determined to do so. I declared my major to be in Civil/Structural Engineering with minors in Architecture and Mathematics. After graduation, I plan to continue my education, and attain dual Masters Degrees in Architecture and Structural Engineering.

Designing Structures, bridges or buildings, is a complex and multi-faceted endeavor, which envelopes a variety of disciplines. To divide it, is to divide the art, to diminish the true elegance that lies within its functional beauty. No matter who you are, it is important to be a citizen of the world- to learn from other cultures and to learn from diversity. This of course, also applies to structural engineers. Having an appreciation of our profession's heritage seems fundamental. This fellowship provides that essential grounding and further education. It is the perfect opportunity to meld academic and career goals. Traveling, visiting, studying, and experiencing the sites of important structures is an experience guaranteed to provide a young engineer a lifetime of aesthetic inspiration.

Skidmore, Owings, & Merrill Structural Engineering
Traveling Fellowship Travel Itinerary

Overview

I have attempted to create a study of historic and modern structures that exemplify the integration of architecture and engineering, economic efficiency, and structural innovation. In each of the proposed sites, the designer responded to difficult technical challenges, with elegant solutions that combined economic construction techniques, efficient forms, and timeless, universal beauty. Although, there are exemplary structures all over the world, in which such principles could be studied, I chose to focus my study primarily in Europe and Egypt.

My trip will commence in Egypt, with the Great Pyramids. Then I will travel to Istanbul, Turkey to visit Hagia Sophia. Then I will travel to France to study a variety of Gothic cathedrals. Then, I will depart to Italy to study the major works of Pierre Luigi Nervi, then to Switzerland to study the legacy of bridge engineers Robert Maillart and Christian Menn. Finally, my studies will culminate in Spain with a comprehensive study of the buildings and bridges of Santiago Calatrava. Although I tried to organize the visits chronologically, I will visit all significant structures in close proximity at the same time. The following outline will describe each site I hope to see, why I'm interested in such structures and what I hope to gain from visiting them.

Proposed Travel Itinerary

Egypt

The Pyramids of Egypt are perhaps the most impressive engineering marvel, in terms of construction and aesthetics. They were quite likely the vastest public works projects ever undertaken, and the most massive monuments ever built. The construction of such enormous monuments without the use of wheels, pulleys, or even a metal tool stronger than copper, required an almost implausible intensity of labor. The pyramids are also structurally intriguing, in that the elaborate underground compartments also deflected the load and redirects the downward thrust into the side walls. Additionally, I am fascinated by the precise astronomical and cardinal alignment, which served to ascend the pharaoh to his heaven within the imperishable circumpolar stars. Four and a half millennia ago, the pyramids connected humanity by reiterating how to live in harmony with the universe, and this powerful aesthetic still speaks to people today.

- Step, Bent, and Red Pyramids (Meidum, Saqqara & Dashur, 2700-2100 BC)
- The Great Pyramids - Khufu, Khafra, & Menkaure (Giza, 2500 BC)
- Great Temple Complex (Karnak, 1300 BC)

Turkey

The builders of Hagia Sophia, a geometer and a natural scientist, drew on their collective structural observations and knowledge of geometry, to create one of the most impressive religious structures in the world. They devised an ingenious and unique solution to a difficult structural problem; how to transform a spherical dome, into a rectangular plan. Utilization of pendentives and equilateral triangles formed continuous support along the base of the central dome. Semi-domes and buttresses resist tremendous outward thrust produced by the central dome. The entire structural system is cleverly concealed to create an ethereal, floating sensation within the space. In the process, the structure evokes an emotional response directed towards the heavens above.

- Hagia Sophia (Istanbul, Turkey, Anthemius of Tralles & Isidorus of Miletus, 537, 558)

France

In France, I would primarily study Gothic Cathedrals. Gothic engineering was more art, than exact science. Master masons utilized their structural intuition and knowledge of geometric principles to build cathedrals of unrivaled height. Such great heights were achieved by the development of self-supporting vaulting and buttressing systems that restrained outward thrust and transferred loads to the foundation. Additionally, this system transferred the loads creating non-bearing walls, which allowed the extensive panoramic use of stained glass, such as the rayonnant of Notre Dame, and glass curtain walls in Saint Chapelle. Especially impressive structural innovations lead to improved efficiency of form (especially in Bourges Cathedral.) Gothic Architecture did not portray the 'honest' structural system, but the forms created a sense that the building was not of this world. I hope studying the structural and architectural systems of Gothic cathedrals will exemplify to me the variety of ways in which, structure can serve the art and create powerful cultural icons.

- Abbey Church of St. Denis (St. Denis, Abbot Suger, 1137-1144)
- Laon Cathedral (Laon, Benedictine & Cistercian Order, 1157-1205)
- Notre Dame Cathedral (Paris, Maurice de Sully, 1163-1250)
- Chartres Cathedral (Chartres, 1194-1260)
- Reims Cathedral (Reims, d'Orbais, 1210)
- Cathedral of Saint-Etienne (Bourges, 1195-1255)
- Amiens Cathedral (Amiens, Cormont & Luzarches, 1220-1269)
- Cathedral of Saint-Pierre (Beauvais, Nanteuil, Cressonsac, & Grez, 1225-1384)
- Sainte Chapelle Cathedral (Paris, d' Montereau, 1245-1248)

- Eiffel Tower (Paris, Eiffel, 1889)
- C.N.I.T. (Paris, Zehrfuss/Esquillan, 1968)
- Centre Pompidou (Paris, Piano & Rogers, 1977)
- Millau Viaduct (Southern Aveyron region, Foster & Partners, 2004)

Italy

My previous studies in Italy primarily focused on Ancient Roman architecture. I would return to Italy in order to study the cathedral of Santa Maria del Fiore in Florence, and a multitude of buildings by Pier Luigi Nervi. Brunelleschi's Dome dominates the skyline of Florence, symbolizing the glory of the Renaissance and its zest for life, art, and beauty. It merges art and science to create a veritable mountain, which ascends towards heaven and was the first independently supported dome in the history of architecture. Previous octagonal masonry domes required expensive timber truss-work to support it. However, Brunelleschi's innovative structural vision conjured a double shell dome system with a series of concentric, self-supporting, horizontal rings, which are connected and reinforced with vertical stone ribs.

The engineering genius of Pier Luigi Nervi was balanced by his innate sense of architectural beauty, which guided the design of his superb structures. His inventive economically-efficient construction techniques and magnificent applications or prefabricated concrete and ferrocemento are unparalleled. His works are perhaps the epitome of combined structural innovation, economy, and aesthetics.

- Santa Maria del Fiore Cathedral (Florence, Brunelleschi, 1436)

- Small Sports Palace (Rome, Nervi, 1957)
- Flaminio Stadium (Rome, Nervi, 1959)
- Large Sports Palace (Rome, Nervi, 1960)
- Exhibition Building (Turin, Nervi, 1949)
- Palace of Labor (Turin, Nervi, 1961)

Switzerland

The phenomenal legacy of Swiss bridge-engineers, Robert Maillart and Christian Menn, defies comparison. These structural geniuses overcame a multitude of technical challenges regarding geography, spans, wind, temperature, and traffic loads without sacrificing elegance and eloquence within their designs. Record breaking spans appear to traverse effortlessly across massive piers with lightness and grace. Robert Maillart utilized cross walls to tie the arch to the horizontally curved roadway of his concrete masterpiece, Schwandbach Bridge. He utilized hollow box bridge technology, and produced strength and stiffness by wedding thin arches to the horizontal deck. Christian Menn synthesized technology, engineering innovation, and aesthetics with his graceful, sculptural forms. Ganter Bridge, a masterpiece of pre-stressed concrete, was a hybrid form of both cantilever and cable-stayed bridges. The cantilever spans support the midsection, which, in turn, are supported by concrete embedded cable-stays. Additionally, Menn utilized efficient economical construction techniques, such as using self-supporting building techniques.

- Vessy Bridge (Geneva, Maillart, 1935)
- Schwandbach Bridge (Bern, Maillart, 1933)
- Felsenau Bridge (Bern, Menn 1974)
- Ganter Bridge (near the Simplon Pass, Menn, 1980)

- Stauffacher Bridge (Zurich, Maillart, 1899)
- Felsegg Bridge (Zurich, Maillart, 1933)
- Toss Bridge (Zurich, Maillart, 1934)
- Lachen Bridge (Zurich, Maillart, 1940)

- Salginatobel Bridge (Graubunden Area, Maillart, 1930)
- Klosters Bridge (Graubunden Area, Maillart, 1930)

Spain

My travels would culminate in Spain with a comprehensive study of the buildings and bridges of my favorite modern designer, Santiago Calatrava. In a time of fragmentization and specialization, Calatrava creates a new paradigm to the practice of architecture and engineering. His cohesion of consciousness allows him to be a universal designer, who transgresses the boundary between art, architecture, and technology. His visionary solutions to complex technical problems surpass maximizing benefits and minimizing costs. Delicate consideration of the cultural and intellectual implications of his work promotes a quality of life and gives meaning to the human community. His projects improve cities, landscapes, and communities and have the capacity to propagate an optimism of an epistemological and moral ideal. Designers such as Calatrava are a minority; however, his work to me is beyond motivational, it is confirmation that a magnificent tradition of synergism will continue. This in itself provides my career with a professional purpose.

- Bach de Roda Bridge (Barcelona, Calatrava, 1987)
- Lusitana Bridge (Mèrida, Calatrava, 1991)
- La Devesa Footbridge (Ripoll, Calatrava, 1991)
- Planetarium of the Valencia Science Center (Valencia, Calatrava, 1991)
- Amamillo Bridge (Seville, Calatrava, 1992)
- Kuwait Pavillion (Seville, Calatrava, 1992)
- Puerto Bridge (Ondarroa, Calatrava, 1995)
- Alameda Bridge & Underground Station (Valencia, Calatrava, 1995)
- Tenerife Exhibition Hall (Tenerife, Calatrava, 1995)
- Volatin Footbridge (Bilbao, Calatrava, 1997)