AESTHETICS OF STRUCTURAL FUNCTIONALISM: A CASE STUDY OF SANTIAGO CALATRAVA’S ARCHITECTURAL DESIGNS

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Abstract
After building projects have been completed and inhabited by either Clients or Users of the buildings, such buildings begin to exist on their own with little or no information about the designer who conceived the idea behind the designs. This phenomenon leaves interested lay public and young architects curious about whom the designer is. This study aims at showcasing the design style of famous architect, Santiago Calatrava – a Spanish born architect of the post-modernist movement, whose architectural projects can best be described as awesome and breathtaking masterpieces. He is a neofuturist architect, a structural engineer, a sculptor and a painter. This work also studied his early life as a young architect and his inspirations for innovation and creativity which was motivated by his love for biology and anatomy. Lessons where drawn from the life and times of this great architect with many laurels, among which is the AIA gold medal and the IstructE gold medal. Some of his popular projects include; Milwaukee art museum, Wisconsin, U.S.A, the Queen Sofia palace for the arts, auditorio de Tenerife in Canary, Spain and the turning torso building in Malmo, Sweden, just to mention a few among many. This research work concludes by encouraging interdisciplinary studies among young designers, so as to advance technologically driven designs and promote creativity thereby enhancing aesthetically appealing built environments.

Key words: Architecture, Creativity, Innovative designs, Santiago Calatrava, Visual aesthetics,

1. Introduction
Architects strive towards producing standard designs that meet the three principles of Vitruvius’s good architecture, which must satisfy sound and firm structures, meet users’ needs (function) and be visually pleasing (aesthetics). Before the specialization of professionals in the building industry, there was actually no distinction between structural aesthetics and architectural aesthetics (Khan, 1980). This has left architects with functional arrangements and aesthetics as major components of design to deal with, leaving the structural aspects of design to structural engineers. Khan (ibid), defines structural engineering as primarily concerned with logic, reason, mathematics as well as understanding of properties of building materials and
forces of nature. It is however obvious that in trying to solve functional and structural problems, aesthetics is visually expressed in clear and honest forms. Khan also opines that structural aesthetics must consider the external view and perception of the structure, its proportions as well as the internal perception of the structure by the occupants. Most times, when the issue of functionality comes up, people generally conclude that it is how functional a building’s design works. What is generally assumed is known as pragmatic functionality. This misconception was made plain by (Shiner, 2011) who proposes that there are about four key areas attached to functionality in design amongst others. These are: structural functionality (concerned with the form of construction), pragmatic functionality (concerned with meeting human needs), symbolic function (concerned with architectural meanings) and social functionality (concerns human interaction with architecture) such as a sense of wellbeing and a sense of place. Architecture theorists claim that other forms of function include environmental, urban, ethical and even aesthetic. To dismiss design as merely visual is to make a fundamental mistake because style (aesthetics) does not replace substance (functionality), but style and substance in balance work much better. Shiner (2011) suggests that “it seems only natural to expect aesthetics and function to complement each other in architecture, yet it also seems natural to overlook functional defects when aesthetic qualities are outstanding”. For Shiner, early modernist architects refer to Louis Sullivan’s “Form follows function” as structural function (that is form should reflect construction). Others refer to it as practical function (that is form should reflect human needs). However, architectural theorist have assured of other types of architectural function: environmental, urban, social, ethical, symbolic and even aesthetic. Hanssen(2009) & (Shiner 2011) advocate for a “moderate functionalism”, a position which unites a desirable concord between aesthetics and function. Khan (1980), opines that it was the split and separation of professional roles that brought about many incongruities between the form and aesthetics on one hand and function and technology on the other. Khan concludes that aesthetics and technology needs to reunite and a team of specialists need to work together in complementary spirit so as to create the right solutions aesthetically and technologically. Within the context of this study, structural functionality shall be considered in Santiago Calatrava’s designs, where aesthetics fuses completely with structure. Knowing which principle of design between aesthetics and functionality to adopt is one of the biggest challenges designers are faced with during design processes, but Calatrava has been able to harmonize both successfully in most of his designs although not without some hitches. Hitches in novel and highly innovative designs are not surprising or new in architectural practice, especially during construction, although completing a project with lesser mistakes or no mistakes at all is always the designers’ ultimate goal.

2. Early Life and Times of Santiago Calatrava
Santiago Calatrava was born on July 28, 1951 in Valencia, Spain to an established family that was involved in industrial agricultural exports. The large rooms in his family’s hillside home was imposing and later became a source of inspiration and an obsession for big spaces in his major projects (Archdaily, 2013). According to Notable biographies (2014), his father who was more of a commercial exporter loved the arts and encouraged his son Calatrava to see Spain’s greatest museum, the Prado in Madrid. This singular event made Calatrava begin showing interest in sculpture and drawing and he later enrolled in art classes in Valencia. Calatrava had always thought of himself as an artist and hoped to be one. When his plans to attend art school in Paris at the Ecole des Beaux-Arts (School of Fine Arts) failed in 1968 due to students protest that year, he returned back to Valencia to attend the EscuelaTecnica Superior de Arquitectura (Technical University of Architecture). Through his hard work, he was able to write two books with his friends while enrolled as students. In 1975, he completed his undergraduate studies at the Valencia Arts School and the Valencia Architecture School. He also completed his graduate work in Civil engineering at
the Swiss Federal Institute of Technology (ETH) Switzerland. His Doctoral thesis in 1979 was on the foldability of space frames. He met and married his wife (Robertina-a law student who later became his lawyer in his business) in Zurich. Before he left school, he and his friends designed a donut-shaped, transparent swimming pool that was suspended above the floor which allowed passersby watch swimmers from beneath-this showcased a tip of the iceberg about his architectural and engineering skills.

He started his own architectural and engineering office in 1981 in Zurich and later opened offices in Paris, Valencia, and New York (Britannica Encyclopedia 2015). The beginning of practice life was rough for Calatrava as a young architect, so he entered many competitions and tried getting a name for himself. This later became successful as he won the competition for the construction of the Stadelhofen railway station (Figure 12) in Zurich which launched him into limelight. The design was unique and had series of individual concrete corridors that look like the rib cage of an animal which was inspired by a dog skeleton given to him by a veterinary student way back in school. Calatrava later mounted the rib cage on the wall of his office as the object was a source of inspiration for him. Expo ’92 was coming to Spain and the city needed bridges for inland access for the exhibition and Calatrava was invited to design a bridge. The Alamillobridge (1989-1992) (figure 8) was built for this reason due to Calatrava’s ingenious ability to create engineering solutions with high artistic visual components. The bridge design brought him prominence and international recognition. The 142meter suspended bridge was very dramatic and supported a span with a dozen pair of cables. The image of the dramatic bridge is symbolic resembling a musical instrument-the stringed harp; this sculptural form transformed the image of the city and enhanced its surrounding landscape. Within the 1980’s and 1990’s, Calatrava designed over fifty bridges in Europe. Calatrava’s other innovative bridges include the Lusitania Bridge (1988–91) in Mérida, Spain, the Campo Volantin Foothbridge (1990–97) in Bilbao, Spain, and the Woman’s Bridge (1998–2001) in Buenos Aires, Argentina (Wikipedia 2015). He is most famous for his bridge and train station designs, Spanish modernist Santiago Calatrava combines artistry with engineering. His works are graced in splendor and can be described as remarkable organic structures.

2.1 Professional Practice as an Architect Engineer

Most of Calatrava’s architectural works are finished in concrete, steel and glass as he employs engineering knowledge to create sculptural structures that are novel and innovative-giving most of his works a whitish appearance (Craven 2005). He claims to have learnt a lot from nature as he has been inspired by natural biomorphic shapes. This is evident in most of his works as they reflect rhythm through repetitions in columns and other structural elements. Calatrava’s ability to transform his architecture into flexible zoomorphic structures is as a result of a combined knowledge of engineering and flare for art, especially sculptures. These are keenly expressed in his buildings, train and bridge structures as evident in Turning Torso (1999–2005), an innovative 54 storey, 190metres high apartment tower in Malmö, Sweden (figure 11a & b). Its sculptural shape suggested a twisting spinal column. For the Lyon (France) Airport Railway Station (1989–94), he created a building that resembled a bird with outspread wings; the interior skeletal steel frame reinforced this birdlike effect. The bird allusion had symbolic meanings as well, since the station served as the end point of the route from Lyon to the airport. Calatrava’s other memorable buildings include a renovation of the Stadelhofen Railway station (1983–90) in Zürich, the BCE Place Gallery and Heritage Square (1987–92) in Toronto, Tenerife Opera House (1991–2003) (figure 9) in the Canary Islands, and several structures (including an opera house, an arboretum, and a planetarium) for the City of Arts and Sciences (1991–2004) (figure 2) in Valencia.

Calatrava started adding movable aspects to his buildings in the early 1990’s. This new concept brought some form of quality into his works especially in Milwaukee Museum of Art (1994-2001) (figure 3 & 4) where he created some movable parts that resembles the wings of a bird as it opens and closes. In other
works, he was able to create segmented roof pieces which are capable of separating and regrouping, creating different shapes and lighting effects. Calatrava received the contract to design the new rail station on the former site of the World Trade Center in New York City in 2004 (figure 6). The following year he was awarded the Gold Medal of the American Institute of Architects. Plans to build Calatrava’s design for the Chicago Spire, to have been the world’s tallest residential building (2,000 feet/610 metres), did not come to fruition.

2.2 Awards
Architect, engineer, and sculptor, Santiago Calatrava received an AIA commemorative gold medallion in 2012 as one of the 15 Architects of Healing for his transportation hub design, a new train and subway station at the World Trade Center site in New York City. Since 1987 when he received the Auguste Perret International Union of Architects prize, Calatrava has received numerous medals as well as 21 honorary doctorates for his designs. Some of his important awards include but not limited to the underlisted:

1. 1988: Fazlur Khan International Fellowship by the SOM Foundation
2. 1990: Medaillé’Argent de la Recherche et de la Technique
3. 1992: Gold medal of the Institute of Structural Engineers
4. 1992: London Institution of Structural Engineers Gold Medal
5. 1993: Museum of Modern Art in New York held a major exhibiton of his works “Structure and Expression”
6. 1993: Toronto Municipality Urban Design Award
7. 1996: Gold Medal for Excellence in the Fine Arts from the Granada Ministry of Culture
8. 1999: Prince of Asturias Award in Arts
10. 2007: Spanish National Architecture Award

2.3 Controversies surrounding some of Santiago Calatrava’s Projects
For some, Calatrava is an ingenious innovative architect engineer, but for others especially his Clients and end users, whom he has disappointed, he is a failed designer. Some of his projects have had problematic issues with time-overrun, budget overrun and material failures. For example, the World Trade Centre’s Transportation Hub which was destroyed in the 2001 terrorist attack, which Calatrava handled its reconstruction, was supposed to be completed in 2015, which was six years behind schedule and for a cost of $4 billion twice the original budget (Daley, 2013). The city of arts and sciences was built over an 86 acre plot of land, and it has the largest collection of Calatrava’s works which include a performance hall, a bridge, an opera house (plate 1), a planetarium, a science museum (figure 2) and a covered walkway and acres of reflecting pools. Britannica Encyclopedia (2015), reports that the project cost the Spanish Government nearly three times its original budget. The project was budgeted for 300 million Euros (about $405 million). The opera house was said to accommodate 150 seats which had obstructed views while the science museum was initially built without fire escapes or elevators for disabled, yet Calatrava was said to have been paid nearly 94 million Euros. Daley (2013) affirms that Calatrava was paid even when repairing his own mistakes- an event that didn’t go down well with many Valencians as they manage through the economic recession and still battle to maintain some of these projects. This dissatisfaction from some of Calatrava’s projects made some opposition party members to start a website which publicized the architect’s shortcomings. A court-case ruling later asked the parliamentarians to remove such websites (Tremlett 2012). Calatrava has had many litigation cases with respect to his projects, and many of them were due to cost overruns, delays and failures from material specification and material usage even shortly after the buildings
are taken over. Being a star architect definitely means his designs are expensive. However, some Clients and even fellow professional architects believe that Calatrava has a stubborn devotion to form and not giving enough time to intricate details of complicated construction which results to some of his projects losing control with faults here and there. Other of his projects which had some form of design or construction problems include a footbridge in Venice (figure 5) which was later tagged “The bridge of broken legs”, (finished in glass tiles but now covered in carpet because pedestrians slip), a winery in the Alava region of Spain his home country, and a massive exhibition and conference centre in Oviedo, Spain and a bridge and airport in Bilbao, Spain.

3. Selected Calatrava’s Masterpieces

Santiago calatrava’s works are easily recognizable due to their clean geometrical lines, similar coloration and pleasing forms that suggest flight or spiritual uplift, as being an engineer also allows him to create daring architectural masterpieces. It is obvious that Calatrava strives to achieve massive design projects that tend to outdo his previous works in style and finesse thereby reshaping the look of the cities all over the world where the projects are constructed. He is currently handling a massive project in Rio de Janeiro called the “Museum of Tomorrow” which is expected to be commissioned in December 2015. The highly anticipated museum, built on the Pier Mauá, features a distinct cantilevering roof that stretches 75-meters over the museum's 7,600-square-meter plaza and 45-meters towards the sea (Murdock 2010). According to Archdaily(2013) "The city of Rio de Janeiro is setting an example to the world of how to recover quality urban spaces through drastic intervention and the creation of cultural facilities such as the Museum of Tomorrow and the new Museum of Art.”

Below is a list and a picture gallery of a few of Santiago Calatrava’s projects amongst many others:

1. 1989-1992: Alamillo Bridge, Seville, Spain
2. 1991: Montjuic Communications Tower, at the 1992 Olympic site in Barcelona, Spain
3. 1996: City of Arts and Sciences, Valencia, Spain
4. 1998: Gare do Oriente Station, Lisbon, Portugal (Figure 10)
5. 2001: Milwaukee Art Museum, Quadracci Pavilion, Milwaukee, Wisconsin
6. 2003: Ysios Wine EstateLaguardia, Spain
7. 2003: Tenerife Concert Hall in Santa Cruz, Tenerife, Canary Islands
8. 2005: The Turning Torso, Malmö, Sweden
9. 2009: Train Station, Liège, Belgium
10. 2012: Trinity River Corridor Bridges, Dallas, Texas
11. 2014: Innovation, Science and Technology (IST) Building, Lakeland, Florida
**Picture Gallery**

**Figure 1.** The Opera house of the city of arts and sciences, Valencia. Source: [www.culturespain.com](http://www.culturespain.com)

**Figure 2.** City of arts and sciences, Valencia Spain. Ciutat de les Arts i les Ciències, Valencia, Spain (1996). Source: [www.wikipedia.com](http://www.wikipedia.com)

**Figure 3.** Side view of Milwaukee Art museum. Source: [www.Inhabitat.com/Wisconsin](http://www.Inhabitat.com/Wisconsin)

**Figure 4.** Rear view of Milwaukee Art Museum in Milwaukee, US (2001). Source: [www.wikipedia/calatrava.com](http://www.wikipedia/calatrava.com)

**Figure 5.** A Calatrava foot bridge in Bilbao Spain, paved in glass tiles but now covered in carpet because people trip. Source: Saget 2012

**Figure 6.** Reconstruction of the World Trade Centre’s Transportation hub. Source: Aranda2012
Figure 7. Museum of Tomorrow, Rio de Janeiro, Brazil. Figure 8. Puente del Alamillo at night, made for Expo ’92, Seville, Spain. Source: www.wikipedia/calatrava.com

Figure 9. Auditorio de Tenerife, Canary Islands, Spain. Figure 10. Gare do Oriente, Lisbon, Portugal (1998) Source: www.wikipedia/calatrava.com

Figure 11a&b. Turning Torso in Malmö, Sweden (2005) Source: Flickr 123 (2007) Source: www.wikipedia/calatrava.com
4. Discussions

It appears that Santiago Calatrava’s bridges have less controversial issues compared to his building projects. He needs to take time out and give adequate attention to details as much as he takes time out for the form and finesse of his buildings, since his buildings are different, unique and irregular. Due to the different building materials employed in his building projects, more research work needs to be carried out as well, especially as the building materials react in different weather conditions in the specific locations where they are cited. Since the architect is the master builder and head of the building construction team, Calatrava needs to do some level of monitoring of his main contractors because of the poor level of finishing mentioned in some of his projects, especially with material finishes. This will in the long run reduce the number of litigation cases against him and his construction firm. Be that as it may, Calatrava is no doubt a creative and innovative designer of built structures that are highly innovative. This cannot be taken away from this architect engineer of many sides, who also doubles as a painter and a sculptor, and strongly believes that “architecture is a combination of all the arts”.

5. Conclusion

It is no doubt that Calatrava’s designs have high visual character and could be priceless masterpieces if they were some visual art like painting or sculpture. He has been able to carve a niche for himself through his works and as such won many laurels. His works could be said to be neo-futuristic of the post-modernistic expressionist style. This means his style could be unpredictably astonishing yet visually satisfying through the use of steel, glass and concrete materials in creating repetitive masses that are symbolic to rhythmicism in music. Obviously, the urban fabric of many cities where his works are littered have been altered with gigantic architectural projects that mimic monumental old age dinosaurs, thereby enhancing city appearances and providing inspiration for younger architects and engineers.

References


