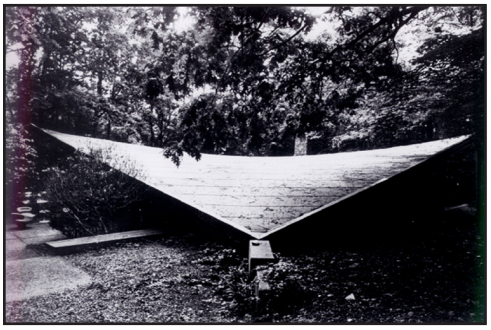
The Historic Dimension Series

A student publication series by the UNCG Department of Interior Architecture



A Marvel of Modernism:
The Hyperbolic Paraboloid

by Mary Frances Daniel **Spring 2011**

America's postwar culture was marked by prosperity and expressed sentiments of optimism, innovation, and experimentation, all of which hyperbolic paraboloids embodied.

Most commonly recognized as the shape of the Pringles potato chip, the hyperbolic paraboloid design had significant meaning to mid-century modernist architecture. Emerging from World War II, mid-century modernism encompassed the progressive optimism that was felt culturally during this period and was thus expressed through the buildings themselves. With such a forward looking ideology, architects transformed preconceived notions about material use and spacial organization and used technological innovations to transform architecture. The hyperbolic paraboloid embodied such notions and came to exemplify these cultural sentiments. While at the time of its inception the public did not always see the true meaning represented in this design, nor what the architects had attempted to convey, today many are beginning to appreciate its significance. Although some premier examples have been forever lost, many still remain and, if preserved, will continue to illustrate the sense of hope and progress felt in the mid-twentieth century.

The Beginnings of Modernism

Modern architecture truly began in Europe in the early twentieth century and soon found its way to the United States. Fundamentally, it was a revolt against style, although ironically it became known as the International Style. It embraced new building technology, which had reduced the need for load bearing walls and had begun to incorporate the structural technology of internal skeleton supports. The three essential traits of modernism were to utilize new material innovations in order to dramatically restructure interior space, to cease referring to past historical styles, and to avoid the use of unnecessary ornamentation. Thus, the two mantras which best summed up Modernist architect were "less is more" and "form follows function." This was perhaps seen most evidently in suburban houses designed in Frank Lloyd Wright's Prairie Style. Moving away from the structured and decorated Victorian architecture, the Prairie Style incorporated a floor plan with multi-purpose rooms that flowed into one another and allowed for open space. Additionally, it applied new building technologies of steel and glass to integrate indoor and outdoor spaces with enlarged windows and roof and deck plans which appeared to extend into nature. Thus, Wright and other architects allowed function and setting to determine the exterior form of a building.

The post-World War II years brought about further changes in Modernist architecture including the use of the hyperbolic paraboloid in roof designs. However, mid-century Modernism expressed several fundamental differences from the International Style. As noted by architect Matthew Nowicki in 1949, mid-century Modernism differed from the earlier design notion that "form follows function," but rather these new designs allowed for functionalism, spaces that were flexible and adaptable according to need. Additionally, mid-century Modernism incorporated the use of structural materials as a form of ornamentation. It also included the principle of humanism,

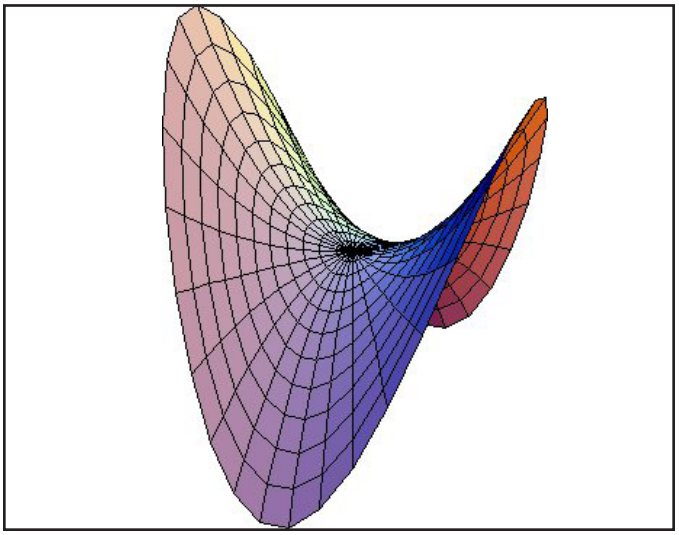


Fig. 2: Hyperbolic Paraboloid Design

Fig. 3: Eduardo Catalano in front of his house Raleigh, NC

which considered the psychological effect of a building's design, as opposed to solely the physical needs of the building's occupants. Due to new structural innovations, it allowed for a sense of buoyancy not typically found in the International Style. Thus, functionalism, humanism, and construction became the foundation for mid-century Modernism. As for its cultural appeal, Nowicki urged that aesthetic judgement not be carried out in conventional ways, but rather, as he stated, "this judgment had to be based on the merits of the philosophy responsible for the form and the directness with which this philosophy was expressed in three dimensions" (Nowicki, *Composition*, p. 406). Therefore, the architecture of mid-century modernism could not be valued the same way that traditional architecture was, but rather be appreciated by understanding what the design represented and said about contemporary culture. One example of this new interpretation within architecture was the hyperbolic paraboloid.

The Rise of the Hyperbolic Paraboloid

Encompassing new building materials and technological innovations, the hyperbolic paraboloid was a true expression of the changes in mid-century Modernist architecture. As seen in Fig. 2, fundamentally the hyperbolic paraboloid is a doubly ruled surface in the shape of a saddle. Architecturally, the hyperbolic paraboloid is representative of both a space structure, in which the building's form is based on three dimensional design and rigidity, and a shell structure, a curved surface made of rigid materials able to resist compression and tension. Most importantly, the hyperbolic paraboloid is able to gain strength from its own form thus enabling it to extend large surface areas without the need for interim columns or support. As a result, it requires less materials in its construction and absorbs tension and compression at any point and in any direction across its curved surface. As important as the material and technological innovations are, the cultural significance of the hyperbolic paraboloid was equally significant.. America's postwar culture was marked by prosperity and expressed sentiments of optimism, innovation, and experimentation, all of which the hyperbolic paraboloid embodied. Locally, its influence was realized through the efforts of the School of Design at North Carolina State University.

The Influence of NCSU's School of Design

Established in 1948, the School of Design grew to international acclaim in part by the efforts of its dean, Henry Kamphoefner. Under his guidance, the school attracted innovative and influential faculty members, including Matthew Nowicki and Eduardo Catalano, who not only taught, but also designed modernist buildings in Raleigh and trained many architects in this style throughout the state. In expressing the progressive and optimistic ideals of postwar America through modern architecture, this mid-century movement left a lasting impact on the local built environment. Their implementation of the hyperbolic paraboloid achieved such goals, and through this design these architects applied new building technologies, reorganized space, and redefined roof planes. However, despite their efforts, this design was never fully accepted by the general public, and because of this underappreciation, some of its premier examples were destroyed.

Catalano House, Raleigh, NC

One such lost example of the hyperbolic paraboloid was the Catalano House in Raleigh, built in 1954, and seen in Fig. 3 with its architect Eduardo Catalano. This hyperbolic paraboloid roof was made of timber construction. Its planks were nailed together in three layers, opposing points secured to the ground with concrete piers that were connected underground by steel tension cables. Thus, the roof extended outward into the air from its

Fig. 4: Patio of Catalano House, Raleigh, NC

two supports, which allowed for areas of openness in some places and areas of seclusion in others, as seen in Fig. 4. The finished product was a 1,700 square foot, three bedroom house with a 4,000 square foot roof measuring 2.5" thick. Representative of a true hyperbolic paraboloid, the Catalano House embodied the ideals of mid-century Modernism by incorporating experimentation and emerging building technologies into its design.

Such profound architecture had value not only for its structural innovation, but also for its cultural significance. Catalano was part of a movement of young architects that sought new ways of constructing the built environment. A native of Argentina, he came to Raleigh as a professor at NCSU's School of Design after working for a period in London. Typical of the mid-century modernist movement, Catalano sought inspiration from international influences and from geometric forms in nature. Always fascinated with the hyperbolic paraboloid design, a form which won him second place in a 1945 General Motors design competition, he began construction on a house for himself in Raleigh in 1954, implementing such a form. Upon completion, his house was praised from architects within the field, including Frank Lloyd Wright, and was named House of the Decade by *House and Home* magazine. Unfortunately, the house received little local praise and produced minimal influence among citizens of Raleigh.

In 1956, Catalano left the School of Design for a position at MIT and never built another house like the one in Raleigh. The Catalano house exchanged hands a few times until it finally sat vacant from 1996 to 2001. Due to issues of neglect, the house soon began to deteriorate. Preservation North Carolina, a private nonprofit statewide historic preservation organization, tried to save the Catalano House by finding a buyer and trying to place protective easements on the house, but to no avail. In 2001 the City of Raleigh condemned the structure and it

Fig. 5: Dorton Arena, Raleigh, NC

was demolished, thus losing one of the premier examples of a hyperbolic paraboloid design not only in the state, but in the country. George Smart, Chairman and founder of the preservation nonprofit Triangle Modernist Houses, stated that some problems in deterioration, which were exacerbated by the building's neglect, existed because the construction technology at the time was more advanced than that of the material science. The positive note is that material science has since caught up with the construction technology and similar issues would not exist today. Although appreciation for mid-century Modernism began to grow in recent years, especially locally through the efforts of organizations like Triangle Modernist Houses, support unfortunately came too late for the Catalano House.

Dorton Arena, Raleigh, NC

Fortunately, Raleigh still retains other representations of the hyperbolic paraboloid form. One existing interpretation is the Dorton Arena, seen in Fig. 5. It was designed by NCSU's School of Design professor Matthew Nowicki and Raleigh architect William H. Deitrick. Constructed in 1952 as a public arena on the North Carolina State Fairgrounds, this building is a prime example of a parabolic suspension structure and exemplified achievements in blending architecture and engineering. Although technically not a true hyperbolic paraboloid due to the mathematical dimensions of its arches and roof surface, the Dorton Arena embodied the basic principles and ideals of the design. The skeleton structure is comprised of concrete and steel, with an exterior covering of metal and glass. Three hundred feet in diameter, this oval shaped structure contains permanent seating capacity for over 5,000 and the capability for additional temporary seating, with a total maximum capacity of over 9,000 seats. The arches are fourteen feet wide and have a maximum height of ninety feet, crossing each

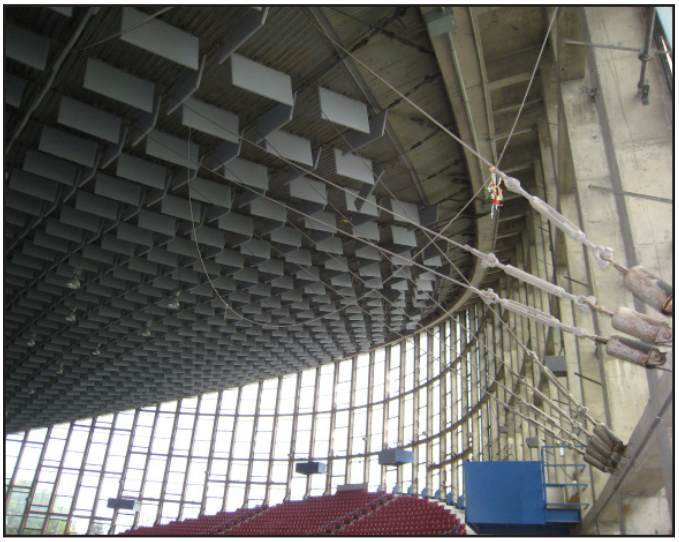


Fig. 6: Cable System at Dorton Arena, Raleigh, NC

other around twenty-six feet in the air. Suspended by a network of cables from its arches, illustrated in Fig. 6, the weight of the saddle shaped roof is equalized. The double curved, metal roof has one set of cables suspended between two compression arches and another set of cables stretched at right angles to the other set. As seen in Fig. 7, this cable roof design allows for interior openness and diminished the need for structural steel supports, resulting in every seat having a completely unobstructed view. Water is drained from the roof by V-shaped spouts placed at each intersection point of the parabolic arches, which direct water into an open container at either end. This drainage system and sound roof construction passed the test of Hurricane Hazel in 1954 as it experienced no leaks or damage.

Dorton Arena designer Matthew Nowicki was born in Poland in 1910. After traveling throughout Europe and working as a planner in the reconstruction of Warsaw after World War II, he moved the United States in 1947 and soon joined the faculty of NCSU's School of Design. Nowicki believed that humanism was the main principle within the modernist movement, with people and their way of life being the prime source of inspiration for his designs. Commissioned by the Department of Agriculture, the Dorton Arena was built to serve North Carolina's agricultural, industrial, commercial, and general needs within the State Fairground complex. Tragically, Nowicki died in a plane crash on his way to India in 1950 and Dietrick carried out his design plans and oversaw the building's completion. Originally named the Livestock Judging Pavilion, the name was changed in 1961 in recognition of fair manager J.S. Dorton.

Lauded for its parabolic suspension, its blending of architectural and engineering innovation, and its combination of forces of tension and compression, the Dorton Arena, again seen in Fig. 8, soon achieved national and

Fig. 7: Interior of Dorton Arena, Raleigh, NC

international fame. In 1953 the American Institute of Architects awarded the building its First Honor Award and The Architectural League of New York bestowed upon it its Gold Medal in Engineering. In 1957 the AIA named it one of the ten buildings of the twentieth century expected to exert the most significant influence on the future of American architecture. The same year photographs and a model of the building were highlighted in the Milan International Exposition of Modern Decorative and Industrial Arts and Modern Architecture. Such acclaim and innovation led the Dorton Arena to be the first modern building nominated to the National Register of Historic Places. Admitted before the usual fifty year requirement, the Dorton Arena was placed on the National Register in 1973 due to its status of "exceptional importance."

Pam-Oil Gas Station, Fayetteville, NC

As the influence of the hyperbolic paraboloid spread throughout Raleigh, other cities in North Carolina began to appreciate its innovative design and to implement similar structures. Fayetteville, North Carolina is home to an example where the public embraced this design in commercial structures. In 1956 the Pam-Oil gas station was erected on Bragg Boulevard. It incorporated a hyperbolic paraboloid design to distinguish itself from other competitors on Fayetteville's busy commercial street which served local residents and members of the growing Fort Bragg military base. Seen in Fig. 9, the building's two opposing ends reach into the air while concrete supports hold the other two ends to the ground. Adding to a further impact on the street, this self-supporting roofline is asymmetrical with the front corner higher than the rear. Its structure consists of concrete and steel reinforcements with a facade of glass walls and a roof made of a 2.5" thick layer of concrete. This structural innovation represented yet another feat of engineering as well as one of the first examples of concrete being used conspicuously and decoratively.

Fig. 8: Side of Dorton Arena, Raleigh, NC

Built by North Carolina architect J. Hyatt Hammond, a graduate of the NCSU's School of Design in 1953 and a student of Catalano, Hammond choose the hyperbolic paraboloid form after much study of it under his professor. Soon after completion the building achieved its intended impact and was featured in *Southern Architect* magazine in 1957 and in *The State* magazine in 1958. Representative of design ingenuity and cultural achievements of the time, the Pam-Oil gas station still stands as a testament to the hyperbolic paraboloid design and the spread of its influence throughout the state. Such local examples show the influence that the School of Design had in North Carolina, but the impact of the hyperbolic paraboloid was also felt on a national level.

TWA Terminal, JFK Airport, NYC

Eero Saarinen's 1962 TWA Terminal at JFK Airport in New York, shown in Fig. 10 and Fig. 11, represented one such national example. When TWA commissioned Saarinen to build a new terminal in 1956, he declared that his primary objective for the project was to create a unique and memorable structure that expressed the drama and excitement of flight. Saarinen rejected the idea that a building should be a literal representation of anything, but that design should be a pure abstraction. As seen in Fig. 12, his creation abstractly represented aviation and paired together the notions of visibility and immersion, with the building's interior placing travelers in an area of free flowing space and form. Saarinen himself stated of the design, "As the passenger walked through the sequence of the building, we wanted him to be in a total environment where each part was the consequence of another and all belonged to the same form-world" (Stoller, *The TWA Terminal*, p. 3).

Saarinen was a Finnish American who studied sculpture in Paris before attending the Yale School of Architecture. He graduated in 1934 and after a tour of Europe returned to America to work for his father's renowned arts

Fig. 9: Pam-Oil Gas Station, Fayetteville, NC

and crafts academy. Before beginning his design for the TWA terminal, Saarinen expressed concern that modern architecture was in peril of falling into a mold because it utilized the same design technique again and again. Thus, he pledged that his terminal would be distinctive from the rest. The result was a concrete shell composed of four separate domes, which emerged from four aerodynamic Y-shaped concrete piers that curved inward to meet at the top of the terminal. Glass walls reached to the ceiling, with steel reinforcements that allowed them to lean outward from the building. The tremendous weight from the concrete required hidden steel reinforcements as well as visible buttressing around the edges. Sadly, Saarinen died in 1961 before the opening of the terminal, but he expressed strong pleasure at its design on his last visit to the site that same year when he stated "TWA is beginning to look marvelous. If anything happened and they had to stop work right now and just leave it in this state, I think it would make a beautiful ruin" (Stoller, *The TWA Terminal*, p. 5).

Form was of the utmost importance to Saarinen, who produced his final technical drawings only after his final form had been modeled. This sparked some backlash from critics who said this strayed from modernists' mantra of "form follows function." Others in the architectural field complained that Saarinen's creation was too dramatic and was designed to catch the attention of corporate America and stir up excitement at board meetings. Additionally, cultural appreciation of the terminal was lukewarm. The 1950s and 1960s were periods of rigid social and architectural values, with little appreciation for those who broke the mold. Hence, Saarinen's unorthodox design did not receive wide praise by most of the nation's population. Despite the lack of broad appreciation, the TWA terminal became a destination point in itself by hosting stylish restaurants, clubs, and lounges which attracted many visitors. Other acclaim was re-

Fig. 10: TWA Terminal, JFK Airport, NYC

ceived before its completion from architectural journals such as *Architectural Record* and *Progressive Architecture*, which praised Saarinen's terminal for its original and memorable design. Even after Saarinen's death, mixed feelings about his lasting legacy existed. Some dismissed him as a minor master in the field of architecture, but in 1962 the AIA awarded him their highest honor, the Gold Medal for Architecture. Today, shifting architectural ideologies allow for greater public appreciation of what Saarinen was trying to achieve, and in 1994 his terminal was designated a Landmark by New York City's Landmarks Preservation Commission. Unfortunately, the terminal has sat vacant since TWA's demise in 2001. JetBlue's terminal currently occupies part of Saarinen's creation, which they call Terminal 5, and although they have demolished several of its sections, they do plan to restore the main portion for active use. Such ideas for use include a possible museum or restaurant. Despite mixed reviews and its currently vacant status, the TWA Terminal stands today as a cultural representation of the glorification of air travel in the 1960s and the optimism and excitement of flight that was once felt. As airplanes have become yet another mode of mass transportation, the importance of preserving Saarinen's TWA terminal is crucial in order to remind people of the hope and enthusiasm that once epitomized this method of transportation.

Worthy of Preservation

The lasting legacy of the hyperbolic paraboloid design remains today as a testament to mid-century Modernist architecture and its expressions of optimism, ambition, and innovation in postwar America. Through the influence of NCSU's School of Design and influential architects such as Catalano, Nowicki, Hammond, and Saarinen, the hyperbolic paraboloid expressed such sentiments through its design. Although at its inception popular cultural appreciation was lacking, today sentiments are beginning to shift in understanding and valuing what

Fig. 11: TWA Terminal, JFK Airport, NYC

this design was attempting to convey. Additionally, modern interpretations of the hyperbolic paraboloid are still being built, such as the example in Fig. 13, which was built in 2007 and is located in Raleigh's Cameron Village neighborhood. As time continues to pass, it is safe to assume that admiration for the hyperbolic paraboloid will continue to grow. Therefore, as many of these structures remain standing, with some sitting abandoned, it is of the utmost importance to preserve them in order to convey their true meaning. In this ever increasing era of pessimism, their message of optimism, innovation, and hope for the future that was once felt are more important than ever to retain.

Bibliography

Foster, M. (2008, Mar. 27). Moved Once, Saarinen's TWA Trumpet To Fall. *National Trust for Historic Preservation*, Online Only. Retrieved from http://www.preservationnation.org/magazine/2008/todays-news/moved-once-twa-trumpet-to-fal.html

Goodnight Raleigh. (2010). *The Passing of a Legend, an opportunity lost*. Retrieved Feb 22, 2010, from http://goodnightraleigh.com/2010/02/the-passing-of-a-legend-an-opportunity-lost/

Mumford, L. (1952). A Backward Glance. In L. Mumford (Ed.), *Roots of contemporary American architecture: A series of thirty-seven essays dating from the mid-nineteenth century to the present* (pp. 3-30). New York: Reinhold Publishing Corporation.

North Carolina Historic Preservation Office, City of Fayetteville. (2009). *Fayetteville Modern Architecture Survey*. Fayetteville, NC: MdM Historical Consultants, Inc.

Nowicki, M. (1952). Composition in Modern Architecture. In L. Mumford (Ed.), *Roots of contemporary American architecture: A series of thirty-seven essays dating from the*

Fig. 12: Interior, TWA Terminal, JFK Airport, NYC

mid nineteenth century to the present (pp. 404-410). New York: Reinhold Publishing Corporation.

Schafer, B. H. (1973). *The writings and sketches of Matthew Nowicki*. Charlottesville: University Press of Virginia

Siegel, C. (1962). *Structure and form in modern architecture*. New York: Reinhold Publishing Corporation.

Stoller, E. (1999). *The TWA Terminal*. New York: Princeton Architectural Press.

Tofts, D., Jonson, A., & Cavallaro, A. (2002). *Prefiguring cyberculture: An intellectual history*. Cambridge, Mass: MIT Press.

Triangle Modernist Houses. (2007-2011). *Eduardo Fernando Catalano*. Retrieved Feb 22, 2011, from http://www.trianglemodernisthouses.com/catalano.htm

U.S. Department of the Interior, National Park Service. (1994). *Early Modern Architecture in Raleigh Associated with the Faculty of the North Carolina State University School of Design, Raleigh, North Carolina*. Washington, DC: David Black.

U.S. Department of the Interior, National Park Service. (2006). *The Development of Modernism in Raleigh 1945-1965*. Washington, DC: M. Ruth Little.

U.S. Department of the Interior, National Park Service. (2009). *Post-World War II and Modern Architecture in Raleigh, North Carolina, 1945-1965*. Washington, DC: M. Ruth Little.

Acknowledgements

Many thanks to George Smart at Triangle Modernist Houses for providing thoughtful insight on the Catalano House.

Fig. 13: 2007 Interpretation, Raleigh, NC

Photo Acknowledgements

Figure 1: Preservation North Carolina
Figure 2: Wikipedia (image only)
Figure 3: Preservation North Carolina
Figure 4: Preservation North Carolina
Figure 5: Courtesy of the author
Figure 6: Courtesy of the author
Figure 7: Courtesy of the author
Figure 8: Courtesy of the author
Figure 9: Triangle Modernist Houses
Figure 10: New York Architecture
Figure 11: New York Architecture
Figure 12: New York Architecture
Figure 13: Courtesy of the author

The Historic Dimension Series is a collection of briefs prepared by UNCG students under the direction of Professor Jo Ramsay Leimenstoll. For information on other topics in the series please visit the website at go.uncg.edu/hds