Mario Salvadori

Champion of Structural Design in Architecture

By Richard G. Weingardt

Named by *Engineering News-Record* (ENR) in 1999 as one of the top 20 structural engineers of the last 125 years, Mario George Salvadori impacted the design/building industry far beyond engineering. A charismatic professor of structural engineering at Columbia University for more than 50 years, he was known internationally not only for his teachings skills but also for his extensive writings and innovative engineering designs. In the United States, especially New York City, he was also well respected in his later years for his dedicated efforts in acquainting inner city youngsters with engineering and the joys of learning.

"With his boundless engineering knowledge and deep sense of public commitment, he made a unique and wide-ranging contribution to both the University and to society at large," said Kenneth Frampton, a fellow professor at Columbia.

Over the decades, Salvadori became a tireless ringleader in getting architects to understand and appreciate structure and structural engineers, and structural engineers to understand and appreciate architecture and architects. He said, "Lucky is the client whose architect understands structure and whose structural engineer appreciates the aesthetics of architecture."

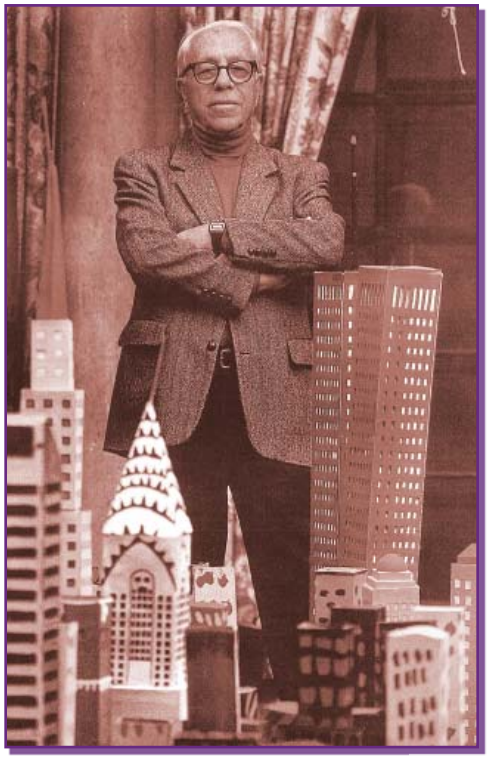
While teaching at universities on two continents, he inspired countless college-aged students to reach for greatness. "His office was considered an ideal training ground for young engineers," reported Frampton. And, in time, his inspirational guidance – and fatherly advice – extended even further, into the elementary and junior high school levels.

In the early 1970s, while still a partner with the consulting engineering firm of Weidlinger Associates in New York City, Salvadori began volunteering to educate disadvantaged junior high students in Harlem, mainly about science and engineering. Ultimately these experiences led to the creation of the Salvadori Center, a nonprofit center that supports modern school reform, trains teachers and educates youngsters. Dozens of inner-city schools in New York continue to use Salvadori's curriculum. By the late 1990s more than 100,000 minority students in NYC had been exposed to, and benefited from, his no-nonsense methods. (The Salvadori Center's current director is Dr. Lorraine Whitman — **whitman@salvadori.org**.)

One of the main elements of his teaching methods – to get youngsters to fully appreciate science and mathematics – included the use of hands-on study of bridges and other structures. His demonstrations of the applications of engineering principles often included using everyday household products like cardboard, string, marshmallows, straws, toothpicks and balsa wood. His use of folded paper models to create various kinds of structures always captured the imagination of young and old alike.

"I think Mario would most like to be remembered for the help he gave to inner-city kids who have so much going against them," stated Matthys Levy, a Weidlinger colleague of 40 years. "He treated them like intelligent people and they responded with intelligence. That's his greatest legacy."

Another notable gift he handed down was his clarity of words. Salvadori wrote more than a dozen books and nearly 200 papers on mathematics, structural and architectural engineering, many of them crafted so the average non-engineering-trained person could easily understand complex technical issues.



Mario Salvadori with an eight-by-twenty-foot display of cardboard models of Manhattan Island structures – 265 buildings in scale – made by Salvadori Center students. Photo credit: Salvadori Center

Two of the most popular were *Why Buildings Stand Up* and *Why Buildings Fall Down*. In the latter, Salvadori offered the opinion that, more than anything else, "all structural failures may be due to a lack of redundancy," and that, "the 'infallible' computer is run by fallible human beings and cannot be trusted to give right answers all the time. No structural engineer should accept the output of a computer unless it agrees (more or less) with what experience tells him [or her] to be the correct answer."

Among Salvadori's other most well-read technical books were *Numerical Methods in Engineering, Structural Design in Architecture* (co-authored with Levy) and *Structure in Architecture* (co-authored with Robert Heller). About *Structure in Architecture*, the famous Italian structural engineer/architect Pier Luigi Nervi (1891-1979) wrote, "Future architects will find it particularly useful to study this book in depth and to meditate upon it, since even if they can entrust the final calculation of a structure to a specialist, they themselves must first be able to invent it and to give it correct proportions. Only then will a structure be born healthy, vital and, possibly, beautiful."

As a teacher and practitioner, Salvadori was constantly motivating architects and engineers to work together more closely, pointing out that when they don't, building design suffers. He wrote, "There can be structure without architecture, as in any machine, but no architecture without structure. There can be aesthetics without architecture, as in any painting, but no architecture without aesthetics." And he was not one to hold back on issuing an unfavorable critiquing of building designs if the architecture was forced.

Said James Yao from Texas A&M, "Professor Salvadori criticized the TWA Terminal at Kennedy International Airport because those shell structures were designed by 'brutal force.' They're 'monumental' rather than functional structures, and thus are 'ugly.' How much better they would have been if the architects involved would have better understood structural shell analysis."

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CBS Building, New York City (1962). Photo credit: Richard Weingardt Consultants, Inc.

Salvadori wrote in *Why Buildings Stand Up*, "The separation of technology and art is both unnecessary and incorrect; one is not an enemy of the other. Instead it is essential to understand that technology is often a necessary component of art and that art helps technology to serve man better. Nowhere is this more true than in architecture and structure, a marriage in which science and beauty combine to fulfill some of the most basic physical and spiritual needs of humanity."

Born in Rome, Italy, on March 19th, 1907, Mario spent his early years in Genoa where his father, who had been a professor of electrical engineering at the University of Rome, was the city engineer. Later, his father took a job with a French company and the family moved to Spain for five years. By the time he entered junior high school back in Italy, Mario was fluent in French, Italian and Spanish. Although his engineer father, who early on instructed him in science and mathematics, encouraged him to become an engineer, young Salvadori favored music.

Before he reached his teens, Mario was fairly proficient at playing concert-level music, like Beethoven sonatas on the piano. He had high hopes of becoming a orchestra conductor. His parents, especially his father, however, were totally against him pursing a musical career. Said Salvadori, "Most if not all of the male members of my family were engineers and since my early childhood I had been conditioned to say, 'I want to become an engineer.' It did not take much pressure from my loving parents to convince me of the total impracticality of my musical aspirations; I entered engineering school."

In 1925, he earned his engineering undergraduate degree in Rome, finishing first in his class. The same year, Salvadori established the first student jazz band in Italy. He enrolled in graduate school and, between his band and university studies, filled in his time with mountain climbing, becoming an avid and highly skilled climber. He opened 27 new routes in the Dolomites, in the process-barely surviving a serious fall, and became known in the mountaineering press as the "Lion of the Mountain."

By 1932, Salvadori had received two doctorial degrees from the University of Rome, one in engineering (1930) and the other in pure mathematics (1932). Following graduation, he took a position with the University, where he taught until 1938. During that time, he spent a year in London studying photo-elasticity, where he came in contact with refuges from Nazi Germany. He began to realize that Mussolini's fascism was not far behind Hitler's and that it would be wise to consider leaving Italy, which he and his first wife Giuseppina did in 1939, emigrating to the U.S.

After serving in a number of temporary jobs, including serving as a production efficiency engineer for the Lionel Model Train Company, he was offered a substitute-teaching job at Columbia University in the mechanical engineering department. This was soon followed with a permanent position as an instructor in civil engineering. By then the U.S. had entered World War II. Being a faculty member of Columbia's well-respected School of Engineering and Applied Science, Salvadori was enlisted to work on the secret Manhattan project, which he did from 1942 to 1945. In 1959, Mario was appointed to Columbia's School of Architecture, Planning and Preservation. In all, his involvement with the University would span five decades.

In 1945, Salvadori began a long-lasting collaboration with Paul Weidlinger and his New York-based structural engineering firm. There, he rose to the positions of partner, chairman of the board, and finally, in 1991, honorary chairman. At Weidlinger's, Mario became recognized as a world-class expert in thin-shell concrete structures. His work with the Weidlinger group allowed him to extend his classroom design reputation to the real world of construction.

Among the significant Weidlinger projects worked on with renowned architects were architect Walter Gropius's University of Baghdad (1957) and architect Eero Saarinen's Columbia Broadcasting System (CBS) Building in

North Academic Center, City College of New York (1984). Photo credit: Ramon Ferreira, Weidlinger Associates

Manhattan. The 42-story CBS structure was toted, in 1962, as one of the first reinforced-concrete, bearing-wall highrises in the world. Its four exterior facades – five-foot wide wall columns spaced five feet apart – also serve as shear walls, which in conjunction with an inner core resist all lateral forces. Rigid waffle concrete floor slabs connect the core and exterior walls. Voids in the exterior wall panels allow ductwork access for the building's heating, ventilating and air-conditioning systems.

Two other significant Salvadori-Weidlinger projects were the 1976 Augustus Long Library and Health Sciences Center at Columbia University and the 1984 North Academic Center (NAC) at City College of New York (CCNY). Danforth Toan was the architect for the $30 million Long facility and John Carl Warnecke was the architect for the $130 million NAC.

The upper 16 floors of the 20-story Long building, which is rectangular in shape, had 48-foot by 157-foot column-free floor spaces to permit maximum flexibility in arranging classroom and laboratory modules. On one floor, a 300-seat auditorium was accommodated. The column-free spaces were made possible by the use of 6-foot, 8-inch deep trusses. They form the main structural frames of the 485-foot-high structure. The trusses also allowed the creation of 7-foot-high horizontal mechanical service areas between each floor.

The massive 800,000-square-foot NAC facility, now a landmark on the CCNY campus, was founded on solid rock immediately below the surface. The z-shaped, 8-story structural-steel structure features a 420-seat theatre, a library, offices, classrooms and laboratories.

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Augustus Long Library, Health Science Center at Columbia University, New York City (1976). Photo credit: Ramon Ferreira, Weidlinger Associates

Fiscal difficulties, along with a major fire during construction, prolonged what had been scheduled as a four-year project into one that took eight years.

Over his extensive professional career, Salvadori was a perpetual humanist with extensive interests beyond engineering. He, for example, was a concert pianist of better-than-modest skill, an author of considerable talent and a stanch lover of poetry – he translated into Italian several works of his beloved Emily Dickinson.

In 1997, just shortly before his death, Salvadori received the prestigious Founders Award from the National Academy of Engineering (NAE). The NAE award was but one of many such prominent recognitions Salvadori received during his long and prominent career. In 1978, he received an honorary doctor of science degree from Columbia University and in 1994, a doctor of humane letters from Lehman College of the City University of New York.

Other noteworthy honors included the 1991 Michael Pupin Medal (for outstanding service to the nation in both architecture and engineering) from Columbia, 1991 George Winter Award (its first recipient) from the American Society of Civil Engineers (ASCE), 1993 Hoover Medal (a joint award of five engineering societies including ASCE), and 1993 Topaz Medallion (for excellence in architectural education) from the American Institute of Architects (AIA) and the Association of Collegiate Schools of Architecture.

Mario Salvadori and a Salvadori Center instructor, Nevin Salen, with students in a classroom at the Salvadori Center Photo credit: Salvadori Center

He was an honorary member of both AIA and ASCE, a fellow in the American Society of Mechanical Engineers and in the New York Academy of Sciences. He was a life member of the Italian Academic Alpine Club.

The revered professor and famed structural engineer died at age 90, on June 25th, 1997. Salvadori was survived by his second wife Carol, his son Vieri and Carol's son Michael – and their wives – and three grandchildren.

He had remained alert and active professionally until the end. His book about earthquakes and volcanoes, *Why the Earth Quakes*, was published when he was 88 years old. At the time of his death, he was still active at Columbia as the James Renwick Professor Emeritus of Civil Engineering and professor emeritus in the School of Architecture, Planning and Preservation.

Mario Salvadori's legacy will endure as being a world-class designer of leading edge structures, an internationally renowned educator and inspirer of young people, and as America's most enthusiastic champion in helping link the highly intertwined fields of structural engineering and architecture, for the betterment of both professions.▪

Richard G. Weingardt, PE, is CEO of Richard Weingardt Consultants, Inc. in Denver, CO. He is the author of eight books. His latest Engineering Legends, published by ASCE Press, features numerous great American structural engineers. Weingardt was the 1995-96 national president of ACEC. ***rweingardt@aol.com***