Global Strategies from Organic Growth

From one man's vision of "total design," Arup has grown into an international, multidisciplinary consulting firm shaping the world

by Monica Schultes

Ove Arup's design of the Kingsgate Bridge, Durham, England, in 1963 was prescient of our current mode of accelerated bridge construction. The two cantilever sections of this pedestrian bridge were swung out and connected in less than an hour. The Kingsgate Bridge was the last project that Ove Arup designed and epitomizes his philosophy of total design integrating engineering and architecture. Photo: Arup.

Ove Arup (1895–1988) was the structural innovator behind the Sydney Opera House, founded a global engineering firm, and was one of the most admired engineers of the 20th century. From those auspicious beginnings, Arup, the engineering firm that he founded, is now a well-established, multidisciplinary consulting firm with more than 90 offices in 30 countries and a large portfolio of construction and infrastructure projects throughout the world. It is well known for its creative approach to structural design and its willingness to innovate.

The Founder's Vision

In 1946, Ove Arup founded his consulting business in London. From the start, he had a clear vision for the company. He was passionate about training the next generation of engineers and believed that hiring the right people was essential to success. For that reason, he personally interviewed many prospective employees.

Late in his career, Arup summed up his principles and vision for the firm's future in what is known as his "key speech."[1] In that 1970 presentation to his partners around the world, he advocated for choosing projects that prioritize quality. "Our work should be interesting and rewarding," he said. "Only a job done well, as well as we can do it—and as well as it can be done—is that. We must therefore strive for quality in what we do, and never be satisfied with the second-rate." In the same speech, he promoted humanitarian values in the workplace, saying, If we can reach a stage where each man or woman is respected for the job they do, and is doing his or her best because the atmosphere is right, because they are proud of what we are and do and share in the general enthusiasm, then we are home."

According to Matt Carter, a principal and the Americas region bridge and civil structures skills leader in Arup's New York, N.Y., office, the firm remains committed to its founder's philosophy. "Arup chooses to work where we can add value, and since we are not driven by growth, we can target those projects where we feel we can make

Tawatinâ Bridge is a new 853-ft-long extradosed light rail and pedestrian bridge over the North Saskatchewan River in Edmonton, Alberta, Canada. The structure is being constructed as a cast-in-place concrete, balanced-cantilever bridge using two moveable form travelers and is part of the 27-km Edmonton Valley Line light rail transit design-build project. Photo: TransEd Partners.

The Arup bridge team faced an array of engineering, technical, and community challenges as it served as the engineer of record for the Gerald Desmond Bridge replacement in Long Beach, Calif. The bridge provides a vertical clearance of 205 ft over the water to accommodate the large ships that use the port. Cast-in-place concrete box girders and tall piers form the approaches to the 1000-ft-long main span cable-stayed bridge. Photo: Marie Tagudena.

a difference—whether it is innovative engineering, technological challenges, or unusual community issues that we need to address. These are frequently large complex bridge projects or pedestrian bridges which have their own unique complexities where we feel we can make more of a difference."

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"We grow organically," he adds. "You won't see Arup making major acquisitions. We pay attention to the hiring of each and every individual. It enables us to keep a strong link to our culture. Each person, as they join the firm, becomes a part of that."

Ove and the original partners left the firm in trust to its employees, and employee ownership remains part of the firm's culture. Each employee is given shares in Arup, which means they profit when the firm profits. If employees leave Arup, they relinquish their shares; as a result, there are no external shareholders. "By having a global profit share, we can work together without internal barriers, especially in the bridge department," says Carter.

Signature Projects

While Ove Arup believed bridges were a way to integrate architecture, structure, and construction through his signature holistic approach of total design, the Sydney Opera House was the most transformational of his designs. When Danish architect Jørn Utzon won an international competition for the project in 1957, he asked Ove Arup to help execute his exceptional design ideas, including the elaborate concrete shells on the exterior. Arup and his colleagues took advantage of emerging computer technology to calculate stresses and then devised a cost-effective technique to build molds, precast the ribs, and prefabricate the shells off site. Construction of the Opera House lasted more than a decade, with its official opening by Queen Elizabeth occurring in 1973.

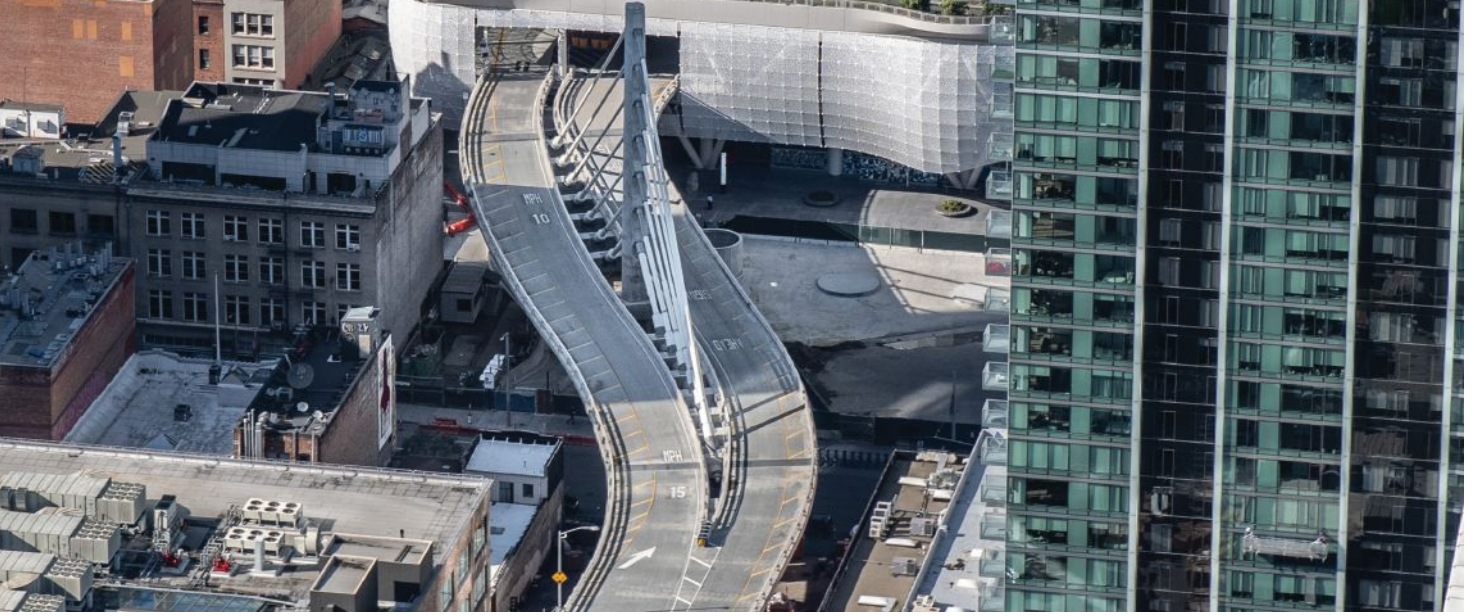
Carter recalls, "Like the Sydney Opera house, there are outstanding bridge projects that demonstrate our work across the globe and demonstrate Arup's version of definition design."

Definition Design

"We use the 'definition design' concept on design-build or public-private partnership (P3) projects to ensure the final design achieves the original intent. We seek the innovation that comes with tailoring the final design to the contractor's means and methods while protecting the architectural quality," explains Carter.

"Recently, we used definition design for a project in Montreal as a way of bringing an architectural vision to life for the Canadian government. The definition design mandates the external form of the structure and allows the project to achieve an aesthetic design within the P3 framework without blowing up the budget that sometimes happens with design competitions."

Carter adds, "During the development of preliminary design, we went to all the stakeholders in Quebec for feedback. With this local review and our own cost estimating, we were confident that the design which was revealed to the public would fit within the budget and would receive support and public endorsement."



Arup provided a wide array of design services for the Salesforce Transit Center in San Francisco, Calif. As the bridge design engineer, Arup collaborated with other members of the project team to find solutions that could meet the stringent right-of-way requirements and design challenges. Photo: Steve Proehl.

In addition, he says, "The technical challenge was heightened as time did not permit an architectural design competition, and simply describing aesthetic requirements within traditional procurement documentation can lead to unexpected results." The key steps of Arup's approach included clarifying the owner's intentions in terms of aesthetics to the bidders, ensuring that technical and visual dimensions of the design were considered simultaneously, and providing a plan for safeguarding architectural integrity through the final design stages of the project.

"Definition design has helped us with design-build and P3 procurement methods to avoid utilitarian structures and allows us to control other aspects of the design," Carter explains. "Having independent architectural input challenges us during this process and provides feedback during preliminary stages. When design intent is revealed for the RFP [request for proposal] stage, there is already endorsement and buy-in from the stakeholders. The owner is confident that they will get the resulting bridge that comes out the other end of the bidding process."

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P3 Consortium

Arup is currently part of a P3 consortium working on the Tawatinâ Bridge under construction in Edmonton, AB, Canada. As the lead designer and engineer of record, Arup is collaborating with American Bridge and TransEd Partners (composed of Bechtel, EllisDon, Bombardier, and Fengate Capital Management Ltd.) to deliver the 853-ft-long asymmetrical bridge by 2022.

The three-span, extradosed bridge uses seven continuous cable stays to support two tracks of light rail and a shared-use path over the North Saskatchewan River. The Tawatinâ Bridge forms part of the Edmonton Valley Line light rail transit, which connects the community of Mill Woods in southeast Edmonton to the city's downtown core. In this unique design, a concrete box girder supports the rail, and a pedestrian bridge is suspended from below. The cast-in-place superstructure is being constructed with the balanced-cantilever method using two moveable form travelers from the central pier outward.

In August 2020, crews installed the final set of cable stays on the bridge, and in September, TransEd made the connection of the gap between the north and south riverbanks.

The cable-stayed bridge for the Salesforce Transit Center in San Francisco, Calif., has a dual concrete box-girder superstructure connected transversely with concrete link beams. The link beams are supported by stay cables and a solid concrete pylon that extends 91 ft above the deck. Photo: Arup.

Value-Added Strategies

"As we replace aging infrastructure, clients want long-life bridges, which demand a high quality of design for concrete structures," suggests Carter. Performance-based or prescriptive-based design are both useful in certain circumstances. "We believe that there is a balance to get the right result for durability and aesthetics and that

definition design can assist with getting that balance."

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The Salesforce Transit Center in San Francisco, Calif., is part of $6 billion project that has transformed regional transportation in the Bay Area. The bus ramp bridge system is 1849 ft long and is the first vehicular cable-stayed bridge built in California. Arup collaborated with other members of the project team to find solutions that could meet the stringent requirements of right-of-way and myriad design challenges. (For more on this project, see the Summer 2019 issue of *ASPIRE*®.)

Arup's involvement dates back to 1998, when the team was selected to prepare the Transbay Terminal Improvement Plan. Work on concept validation began in June 2008 and included complete engineering design, bid phase, and construction administration services through project completion. In total, Arup provided civil, geotechnical, and bridge/highway engineering design services, as well as transport and pedestrian planning, extreme events evaluation, pedestrian modeling, fire and life-safety review, tunnel ventilation design, and rail coordination for this landmark addition to San Francisco's infrastructure.

Seismic Solution

The Arup bridge team faced an array of engineering, technical, and community challenges as it served as the engineer of record for the Gerald Desmond Bridge Replacement in Long Beach, Calif. The bridge, which connects the Port of Long Beach to downtown Long Beach and surrounding communities, is a major route for trucking imported cargo inland from the port. The new bridge, which opened in October 2020, is the first long-span, cable-stayed bridge in California, which is one of the most tectonically active regions in the world.

Arup provided an innovative design for the main span and towers where the deck is seismically isolated from the towers through viscous hydraulic dampers. According to Carter, the 515-ft-tall cast-in-place concrete towers are flexible enough to stand by themselves during a major earthquake. "The top of the tower could move as much as 6 ft, with the concrete at the bottom not even cracking," he explains. The approach spans are cast-in-place concrete box girders that were constructed using a movable scaffold system, the first U.S. application of this innovative construction procedure. (For information on the construction of the approach spans for this project, see the Concrete Bridge Technology article on page 33 of this issue of *ASPIRE*.)

Carter also says an innovative traffic feature on this project reduced the need for an additional bridge structure, allowing the Port of Long Beach to regain valuable land. A "Texas U-turn," which is a common feature at intersections in Texas, enables vehicles traveling on one side of a frontage road to make a U-turn without stopping at a traffic signal. The Texas U-turn was introduced to reduce the expense of building (and maintaining) flyover ramps for vehicles entering and leaving the port. This nonstop U-turn is among many key features of the new bridge that facilitate efficient flow of cargo traffic in and out of the port facility.

Looking Forward

Arup faces new challenges going forward. One is digital transformation: making sense of how automation and data-driven design can lead to efficiencies and new products and services.

Another challenge is how to operate responsibly in the shadow of climate change, which threatens to further strain an already ailing infrastructure and increase the risk of natural disasters for communities worldwide.

According to Carter, Arup positions the United Nations Sustainable Development Goals front and center in its business philosophy and strategies. The firm believes climate change should be considered on every project and encourages engineers to participate in discussions about how the world can mitigate and adapt to changes in the environment. By taking this stance, Arup demonstrates that the firm's ethos and culture still reflect Ove Arup's core values.

Ove Arup's Concrete Innovations

Ove Arup's first project was the Penguin Pool at the London Zoo in 1934. The use of curvilinear, self-supporting concrete slabs to construct the spiral ramps was an innovative use of reinforced concrete at the time. "That first project really shows what you could do with the material," says Matt Carter of Arup's New York office.

A project before its time, and the last one that Ove Arup designed, was the Kingsgate Bridge across the River Wear in Durham, England, which was completed in 1963 and was another example of his creativity. Using methods that foreshadowed today's accelerated bridge construction techniques, Arup designed the pedestrian bridge to be built in symmetrical halves on each bank of the river and then rotated to join together across the river. The two concrete halves were built with traditional formwork and pivoted on revolving cones; an unusual tongue-and-groove shear joint connection was then used to bring the two spans together. The operation to join the two halves took less than an hour.

Ove Arup on the Kingsgate Bridge during construction. Photo: Arup.

Reference

1. Arup, O. 1970. "The Key Speech." Speech given on July 9, 1970, in Winchester, UK. https://www.arup.com/perspectives/publications/speeches-and-lectures/section/ove-arup-key-speech.