Designed by Joss Darrow

PRESENTATION

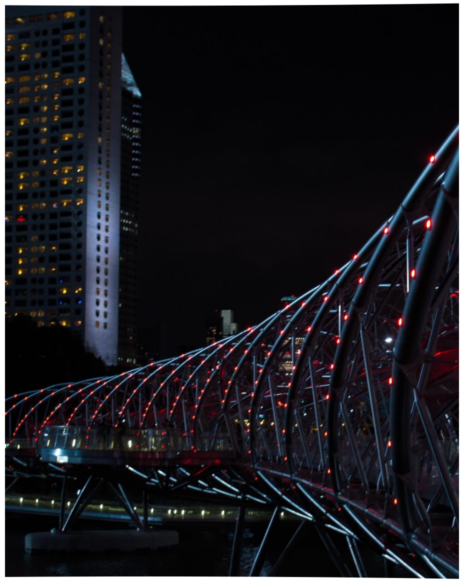
Bridges: The World's Most Grandiose Structures (Their Design and Construction)

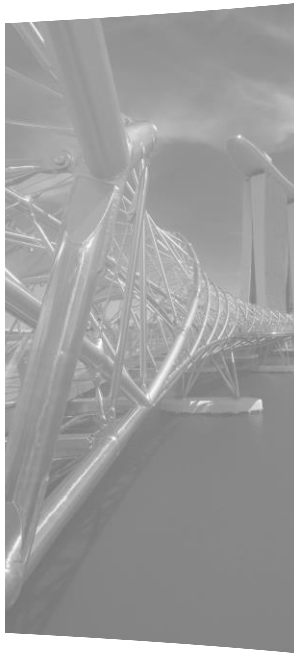
Studying the architecture and engineering of bridges is essential to understanding not only how they span rivers and roads, but also how they impact our lives and the environment. By analyzing their design, function, and influence, we unlock endless possibilities for improving infrastructure and preserving the world around us.

2025

HELIX BRIDGE SINGAPORE

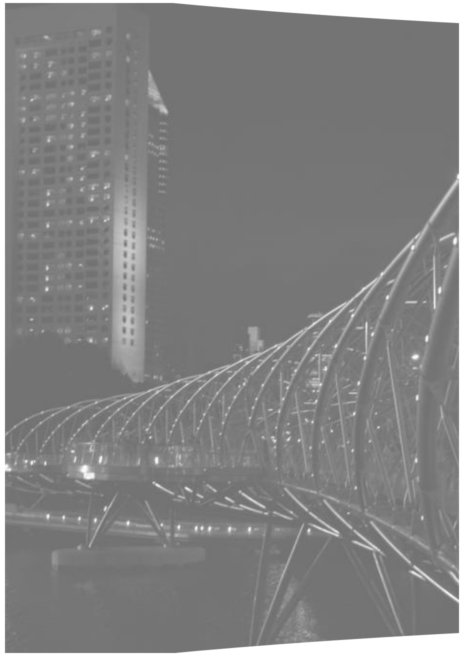
Helix Bridge (Double Helix Bridge; Marina Bay Footbridge) is a 280-meter pedestrian bridge connecting Marina Centre and Marina South in the Marina Bay area of Singapore.

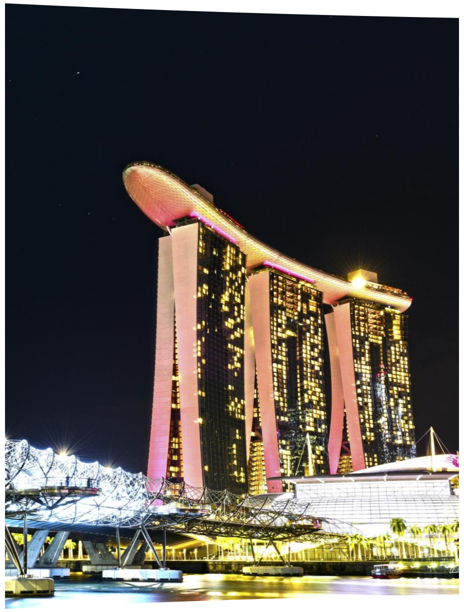


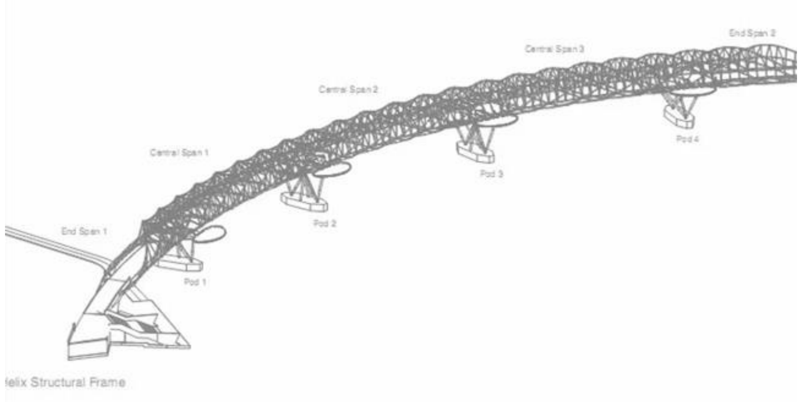


ARCHITECTURE

Designed in the form of a double DNA helix, the bridge features colorful lights embedded in its surface, marked with the letters A, T, G, and C — symbolizing DNA nucleotides.

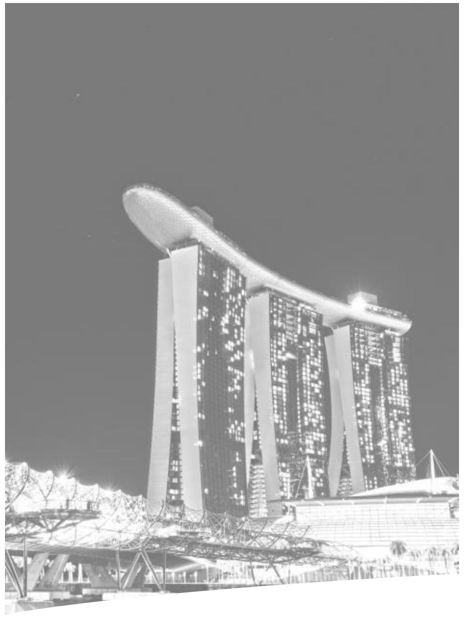


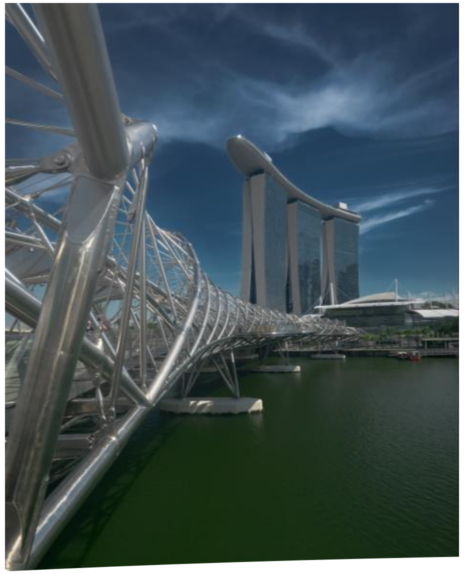


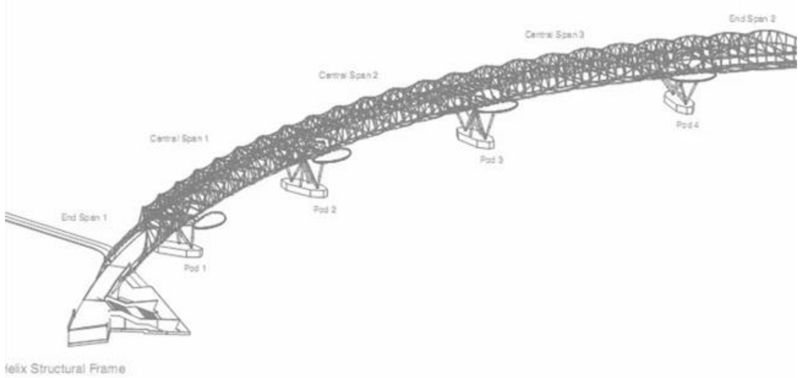


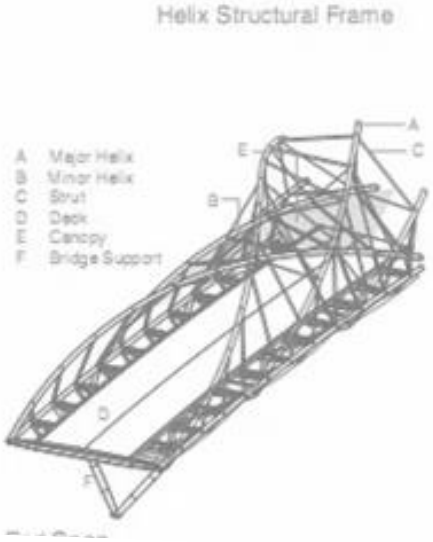
DESIGN

It includes four side-viewing platforms for observing and photographing the cityscape.The structural design was particularly challenging due to the technical requirement of a horizontally curved alignment, which ensures more comfortable pedestrian flow across the bay.



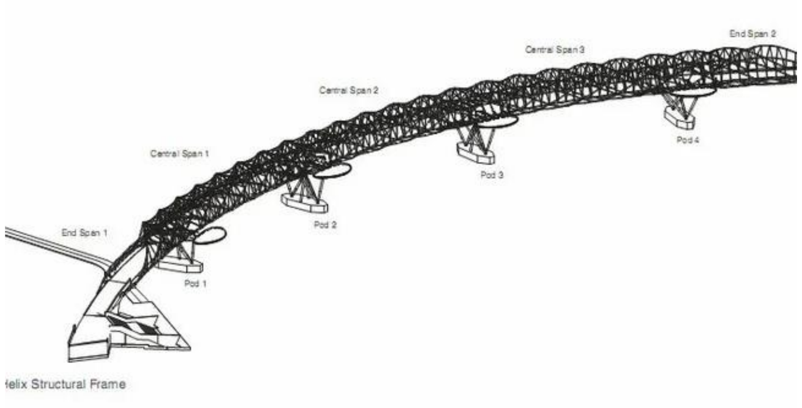


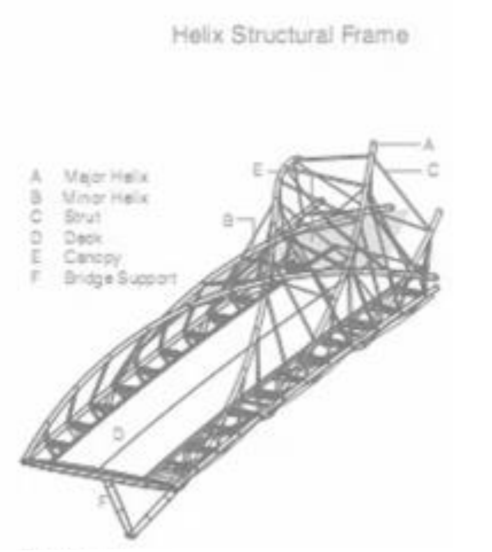


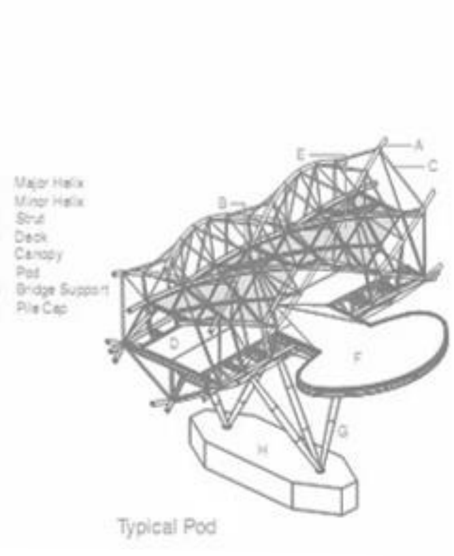


ANALYSIS

The Helix Bridge was officially opened on April 24, 2010, at 9:00 PM; however, only half of the bridge was accessible at the time due to ongoing construction at Marina Bay Sands.

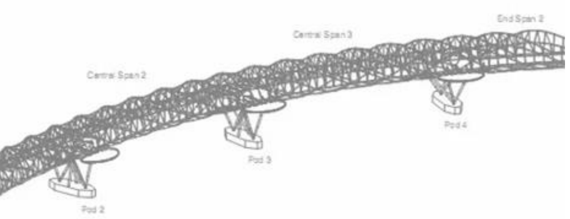


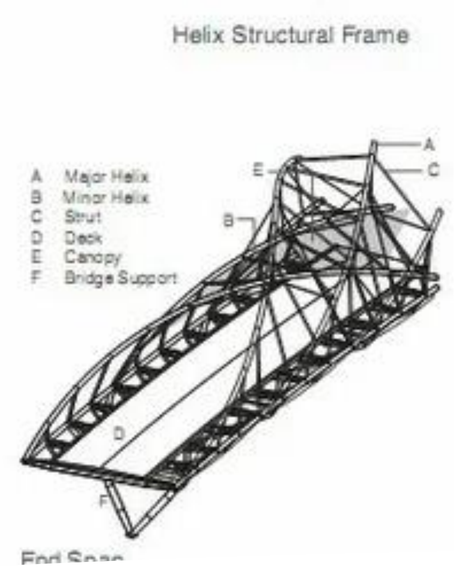


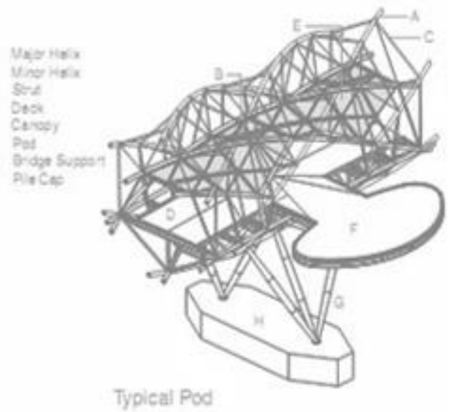


CONSTRUCTION

It is located next to the Benjamin Sheares Bridge and accompanied by the Bayfront Bridge, which serves as a parallel vehicular route. The entire Helix Bridge was fully opened to the public on July 18, 2010, completing the pedestrian loop around Marina Bay.

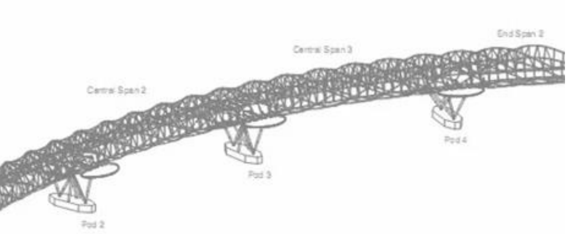


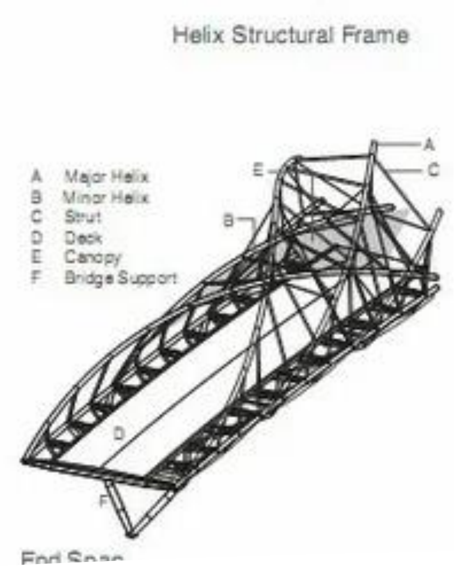


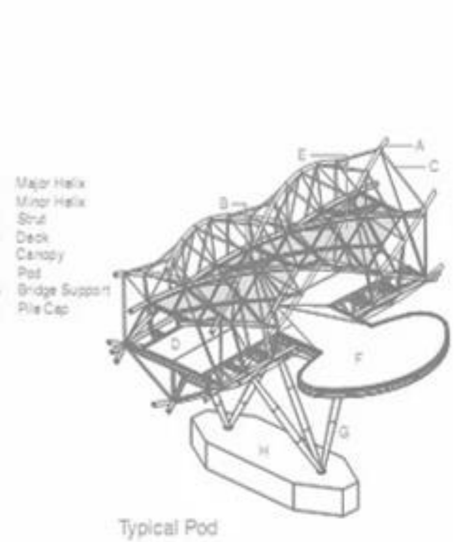


← Control and temporary works →

The bridge has 4 side observation decks for observing and photographing the city panorama. The design solution had additional difficulties due to the fact that the technical specifications provided for the curvature of the bridge in the horizontal plane for a more convenient connection between the shores of the bay for pedestrians.

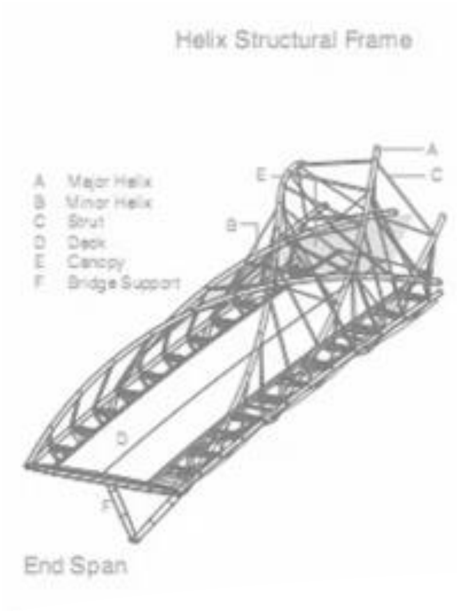


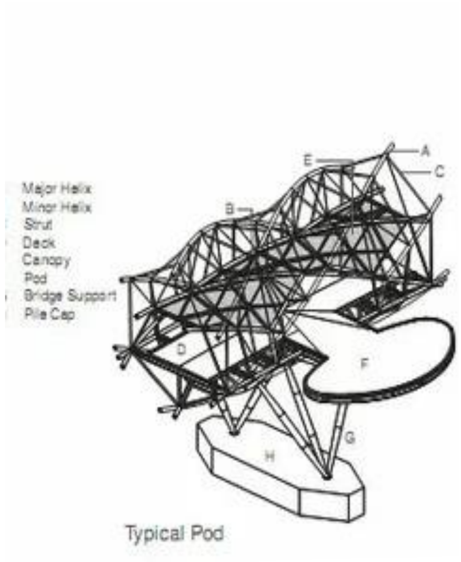




Control and temporary works

The total weight of the bridge is approximately 1,700 tons.



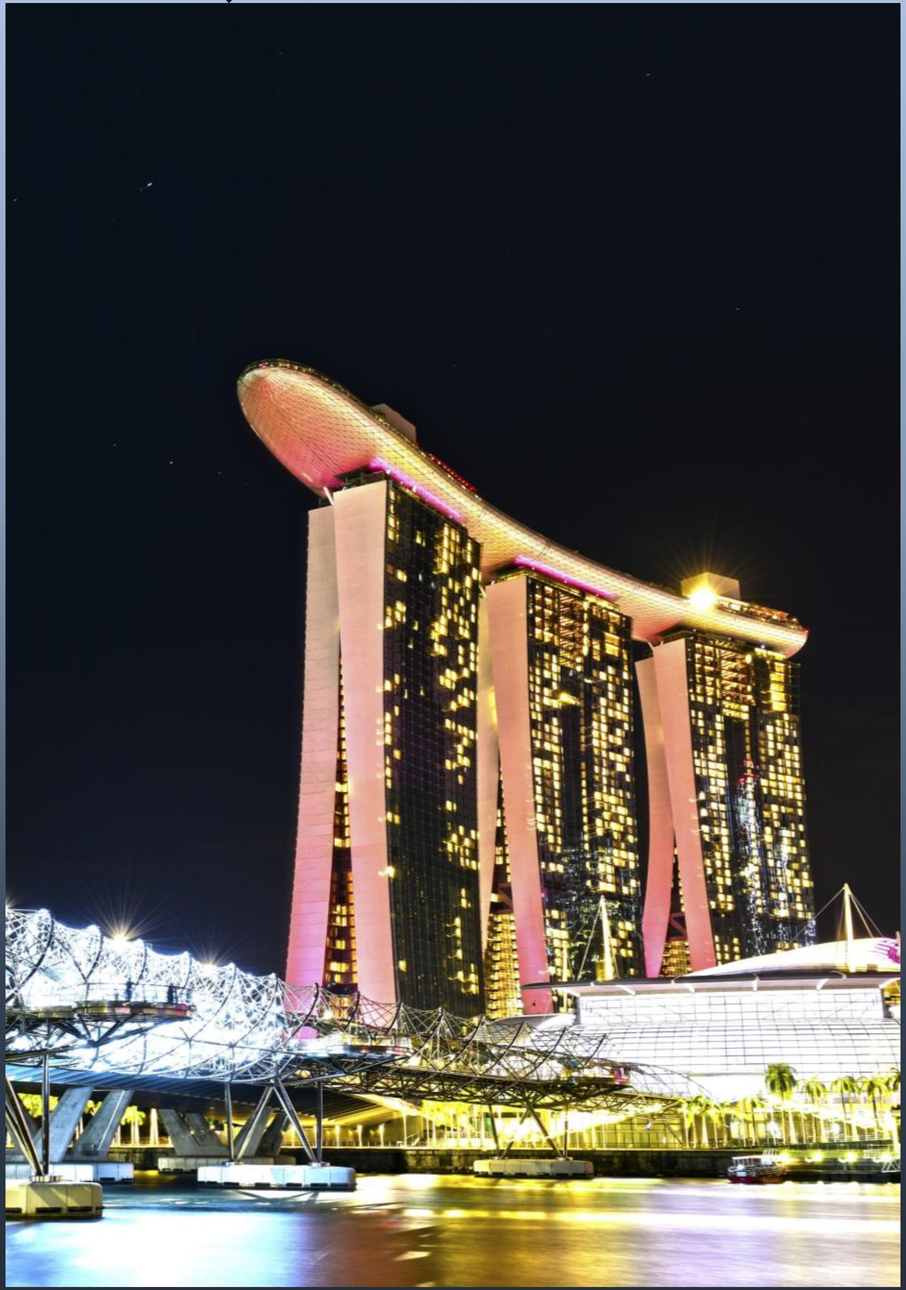


PERMANENT WORKS

ARCHITECTURE

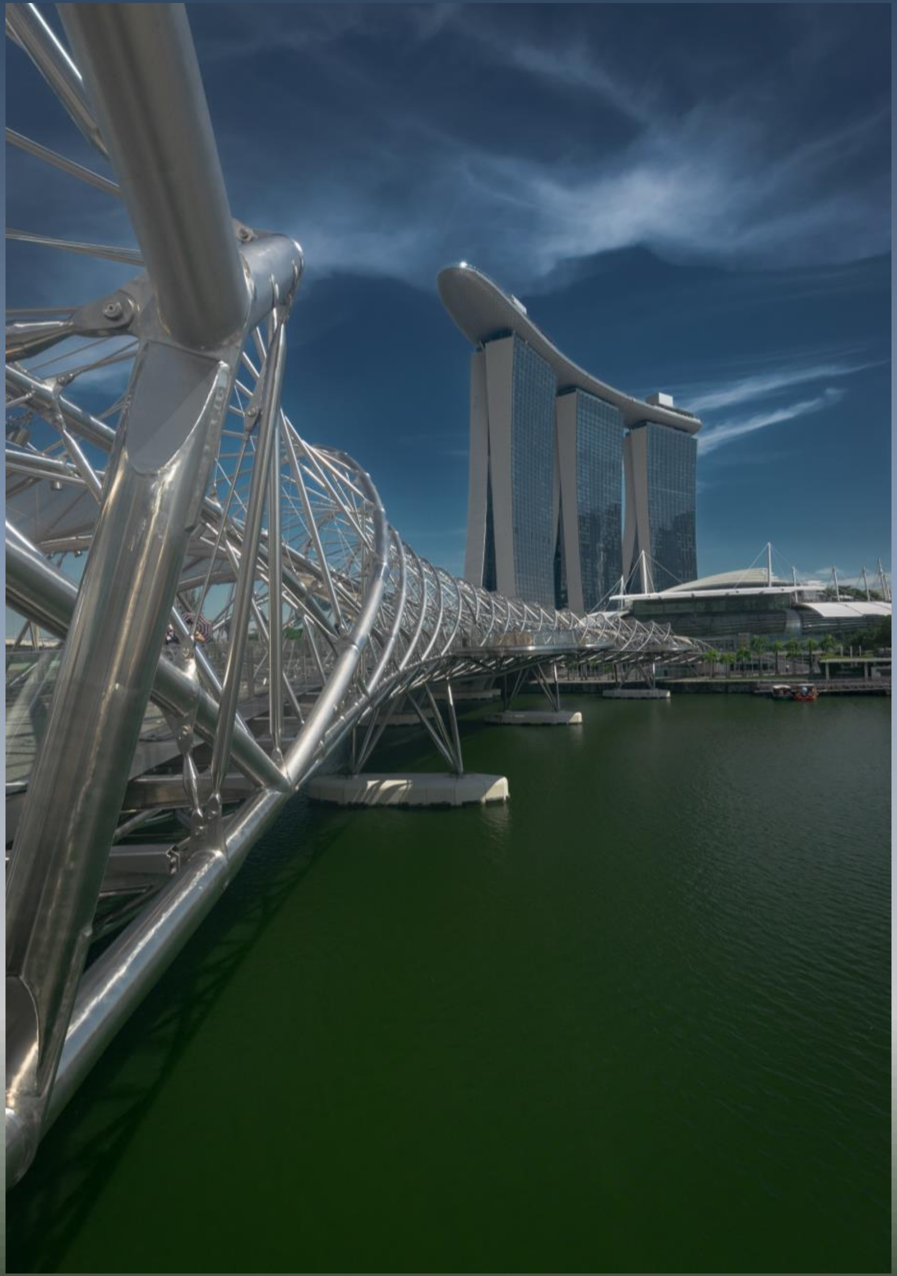
- The design consortium is an international team that includes Australian architects Cox Architecture, engineers from Arup, and the Singapore-based firm Architects 61.
- Canopies made of fritted glass and perforated stainless steel mesh are integrated along sections of the inner walkway, providing shelter and visual appeal.
- The bridge features four strategically placed viewing platforms, offering panoramic views of the Singapore skyline and events at Marina Bay.
- At night, the bridge is illuminated by a series of lights that highlight the double-helix structure, creating a striking visual experience for visitors.
- Paired colored letters — C and G, A and T — glow in red and green at night, representing cytosine, guanine, adenine, and thymine, the four bases of DNA. The intentionally left-handed DNA design, opposite to the natural structure of DNA on Earth, earned the bridge a place in the Left-Handed DNA Hall of Fame in 2010.
- The Land Transport Authority declared the Helix Bridge the world's first architectural and engineering project based on the double-helix DNA structure.
- In the same year, the bridge won the title of Best Transport Building at the World Architecture Festival.It was also recognized by Singapore's Building and Construction Authority (BCA) with a Design and Engineering Safety Excellence Award in 2011.

← DESIGN



- The initial design brief set out several key goals. One was for the bridge to follow a curved path in plan view, allowing it to smoothly connect to the promenades on both sides of the bay.Another goal was to create a lightweight structure, in contrast to the adjacent six-lane vehicular Bayfront Bridge, which appears more massive.
- Due to the tropical climate, the project also required the bridge to provide shade and shelter from direct sunlight and heavy rain.The combination of these needs, along with the desire to create an iconic landmark, led to a new and unique design.The bridge was engineered using BS 5950, in conjunction with the SCI Design Guide.
- The resulting structure consists of two slender helical forms that act together as a tubular truss capable of carrying all design loads.This approach was inspired by the curved shape of a DNA molecule.The two helical tubes touch at only one point — beneath the bridge deck — and are connected by a system of light struts, braces, and stiffness rings, forming a rigid and stable structure well-suited for the curved geometry.The stainless steel bridge rests on concrete abutments at both ends.
- The 280-meter-long bridge consists of three main spans of 65 meters and two end spans of 45 meters.If stretched end to end, the total length of the steel used would measure approximately 2.25 kilometers.
- The large and small helices twist in opposite directions, with outer and inner diameters of 10.8 meters and 9.4 meters, respectively. The bridge’s height reaches the equivalent of three stories.
- The outer helix is formed by six stainless steel tubes, each 273 mm in diameter, equally spaced around the perimeter.The inner helix consists of five tubes of the same diameter.Above the water, the bridge is supported by extremely lightweight conical columns made of stainless steel and filled with concrete. These columns form inverted tripod shapes, each positioned above a pile cap.

ANALYSIS

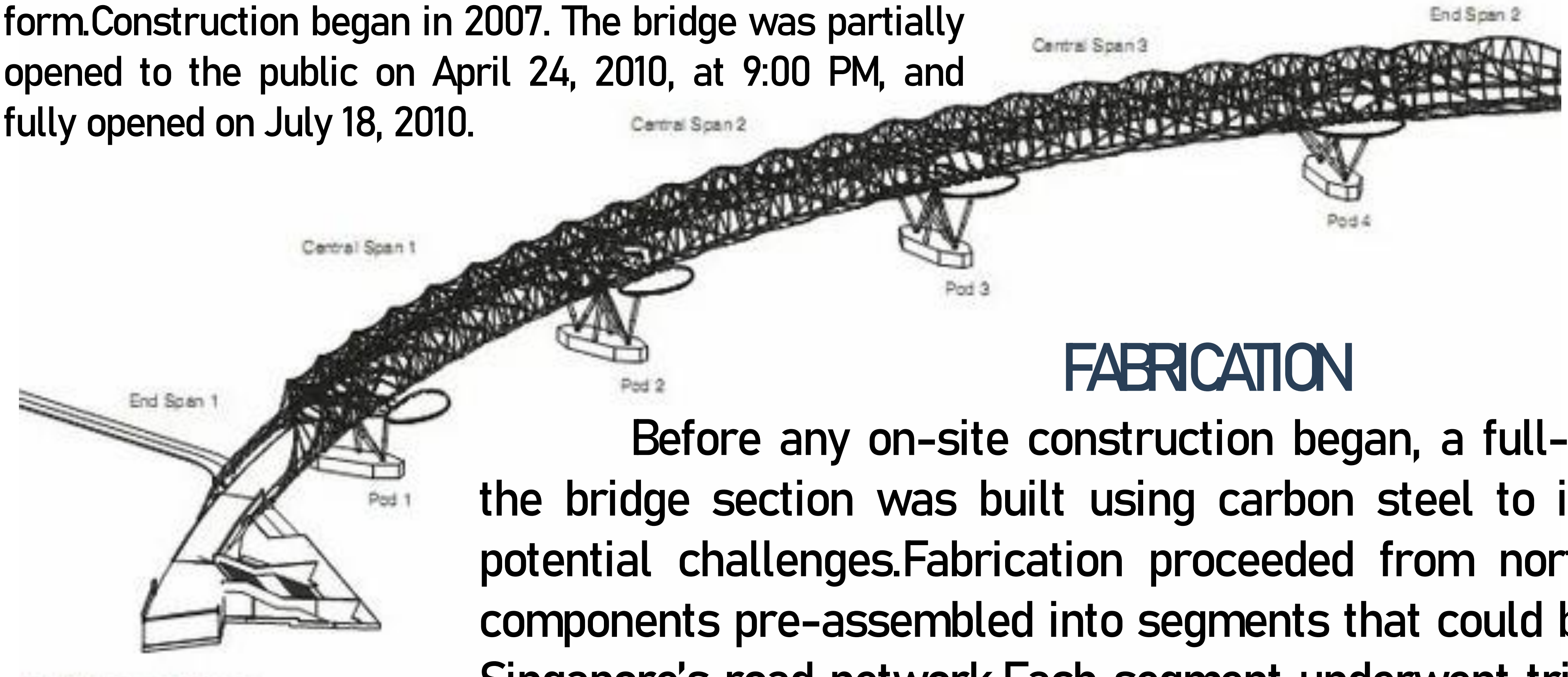


- A comprehensive numerical analysis was conducted using proprietary structural optimization software developed by the engineering team. This process helped determine the most effective method for connecting the two helices.
- Maximum use of steel sections was ensured to support the pedestrian deck, canopies, and lighting fixtures efficiently.Before selecting materials or finalizing the design, the bridge was fully modeled in 3D software to visualize its geometry, spatial alignment, and interaction with pedestrian traffic.
- Additionally, a nonlinear analysis was carried out to assess performance under various loading scenarios and evaluate serviceability criteria, such as vibration response.A stability assessment was also performed to analyze potential behavior in case of accidental or intentional removal of a helical or support element.

CONSTRUCTION

The Helix Bridge is constructed from approximately 650 tons of duplex stainless steel and 1,000 tons of carbon steel, used primarily in the temporary support structures and to help shape the bridge's helical form.Construction began in 2007. The bridge was partially opened to the public on April 24, 2010, at 9:00 PM, and fully opened on July 18, 2010.

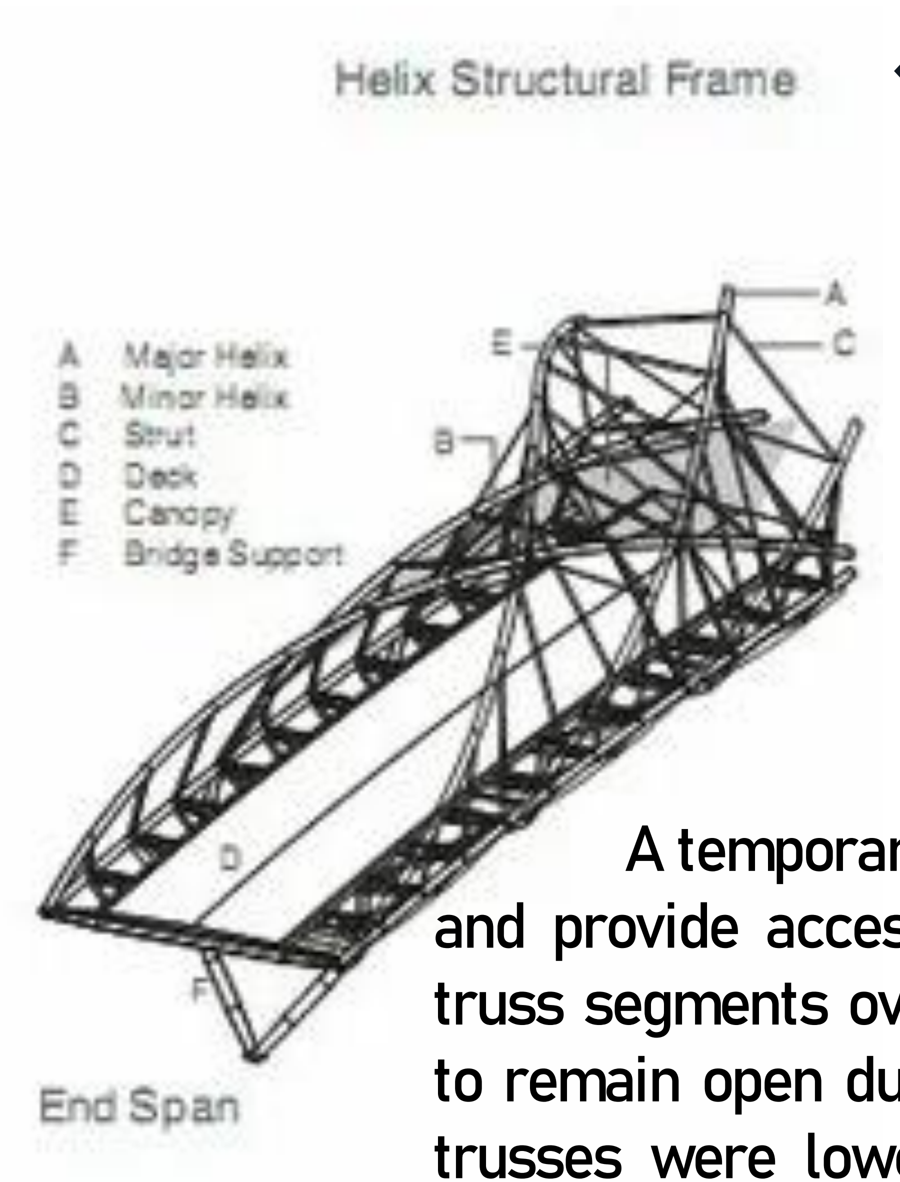
← CONSTRUCTION



Helix Structural Frame

FABRICATION

Before any on-site construction began, a full-scale mock-up of the bridge section was built using carbon steel to identify and avoid potential challenges.Fabrication proceeded from north to south, with components pre-assembled into segments that could be transported via Singapore's road network.Each segment underwent trial assembly prior to delivery, ensuring that any alignment or assembly errors could be addressed beforehand.



CONTROL AND TEMPORARY WORKS

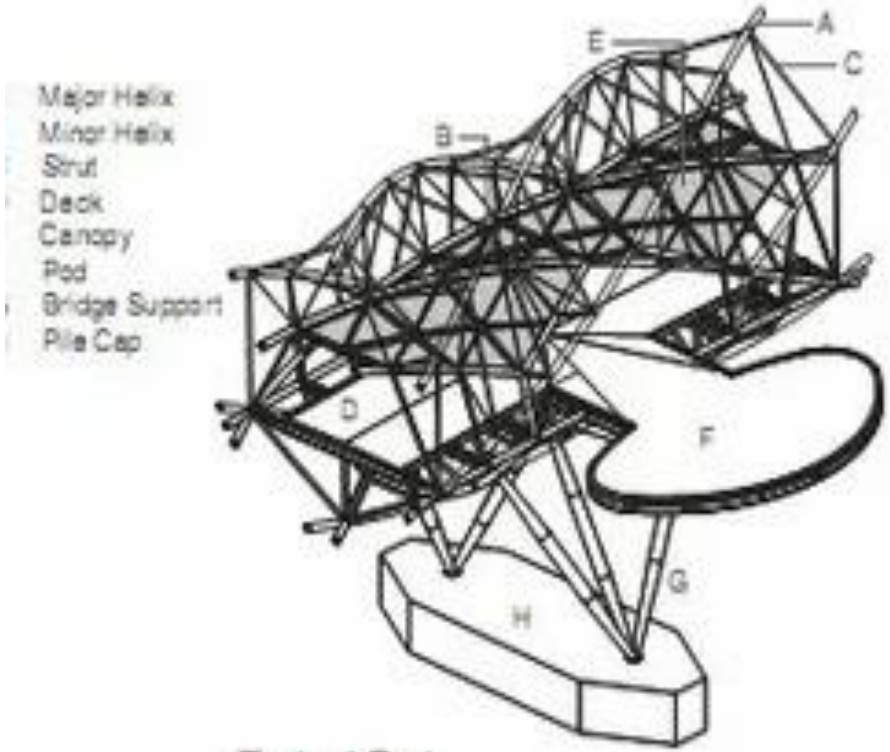
Quality control

The duplex stainless steel used in the Helix Bridge is highly sensitive to contamination from carbon or zinc dust.To prevent this, a dedicated fabrication facility was established to keep Helix components isolated from other carbon and nitrogen-based steels.

Temporary works

A temporary truss bridge was constructed to support the Helix structure and provide access during construction.A key challenge was the lowering of truss segments over the central 50-meter-wide navigation channel, which had to remain open during the build to allow safe passage for other bay users.The trusses were lowered in segments using synchronized lifting by two mobile cranes.This operation was conducted at night to minimize disruption caused by temporary closure of the channel.

PERMANENT WORKS



Typical Pod

- ✓ A mobile gantry crane was installed on the temporary bridge to lift components into position.Construction began at the northern abutment, starting with horizontal prefabricated segments, each approximately 11 meters in length.These segments were bolted together, followed by the installation of deck beams, transverse members, clamps, tie rods, and other secondary elements — progressing upward from the deck level.
- ✓ The helical structures and their vertical supports were then installed.Individual segments of the helices were welded across each span, with these critical joints placed under strict supervision and quality control to preserve the properties of the duplex stainless steel.Finally, a passivation process was applied to remove any iron compounds from the surface, eliminating potential sources of corrosion and ensuring long-term durability.

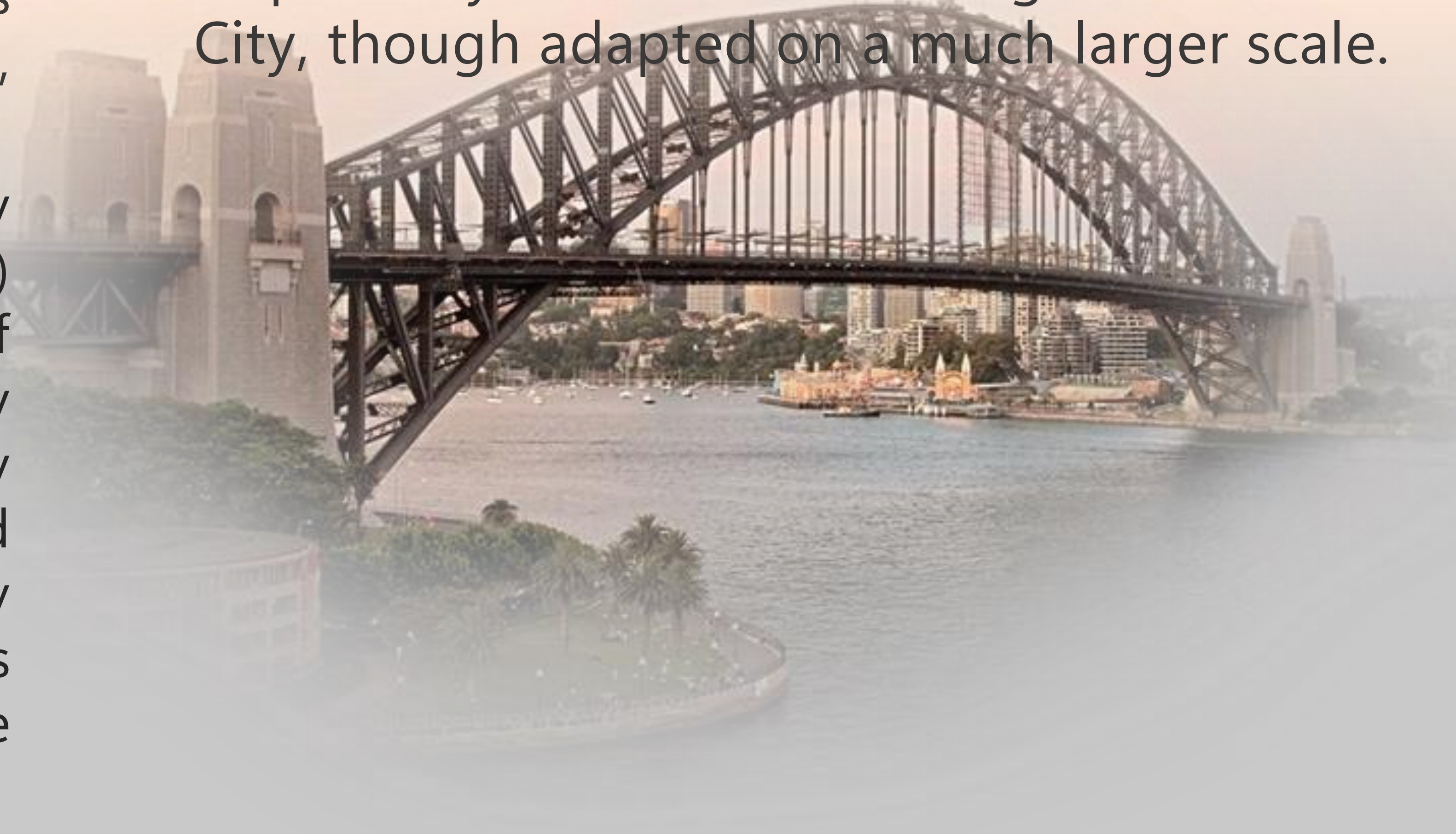
Sydney Harbour Bridge

GENERAL

Sydney Harbour Bridge is a steel arch bridge spanning 1,149 meters across Sydney Harbour (Port Jackson) in Sydney, New South Wales, Australia.The bridge carries road, rail, bicycle, and pedestrian traffic, and was officially opened on March 19, 1932.

It connects the Sydney Central Business District (CBD) with the North Shore.The view of the bridge, along with Sydney Harbour and the nearby Sydney Opera House, is widely considered an iconic image of both Sydney and Australia.The bridge is nicknamed “The Coathanger” due to its arch-based design.

- The total weight of the bridge is approximately 53,800 tons;
- The steel arch alone weighing 39,000 tons.
- The design of the Sydney Harbour Bridge was inspired by the Hell Gate Bridge in New York City, though adapted on a much larger scale.



BRIDGE CONSTRUCTION

The first ideas to connect the northern and southern shores of the harbor with a bridge were proposed as early as 1815 by Francis Greenway. However, at the time, Sydney’s economy and the lack of appropriate construction materials made it impossible to realize such a large-scale project.

With the onset of industrialization, Sydney began to expand rapidly.By the early 20th century, the city’s population had exceeded one million residents, and the need to connect both sides of the harbor became increasingly urgent.At the turn of the century, the New South Wales government began seriously exploring the possibility of constructing a bridge across the bay.

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Initial design proposals for the bridge emerged in the early 1900s. In 1903, an Advisory Board was established under the leadership of John Bradfield to review potential construction plans. At the time, Bradfield was also responsible for the electrification of Sydney’s suburban railway network, and he proposed the idea of incorporating rail tracks into the future bridge.

In 1912, Bradfield began developing a detailed design for the bridge, and it was he who first envisioned a single-span arch structure. Alternative designs were also considered, including cable-stayed and multi-span arch bridges.

ARCH CONSTRUCTION

After the end of World War I and the continued rapid growth of the city, the issue of building a harbor bridge resurfaced.On November 24, 1922, the Parliament of New South Wales passed the Harbour Bridge Act, which initiated a formal tender to select a general contractor for the bridge's construction.Following the tender process, the English company Dorman Long and Co Ltd was awarded the contract to build the bridge.

On March 24, 1924, the New South Wales government officially signed the construction contract with Dorman Long.The company then assigned engineer Ralph Freeman to develop the detailed design of the new bridge crossing.

In 1924, approximately 800 families were evicted from the bridge construction site, and their homes were demolished. These families received no compensation for their displacement. The main construction works began in January 1925.

By 1928, the bridge approaches and supporting foundations had been completed. Construction of the main bridge structure began simultaneously on both shores of the harbor in December 1928.

Work on the arch itself started in 1929.At both ends of the arch, special cranes were installed to lift the steel components, which were fastened together with rivets as the arch gradually extended from each side.

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At 10:00 PM on August 19, 1930, the two halves of the arch were joined. Once the arch was completed, work began on constructing the roadway, tram tracks, and railway lines, which was finished in 1931.The entire construction was completed on January 12, 1932.In February 1932, the bridge underwent load testing, during which 96 pairs of locomotives were driven across the bridge to test its strength. The Sydney Harbour Bridge was officially opened to the public on March 19, 1932.

ROAD CONSTRUCTION

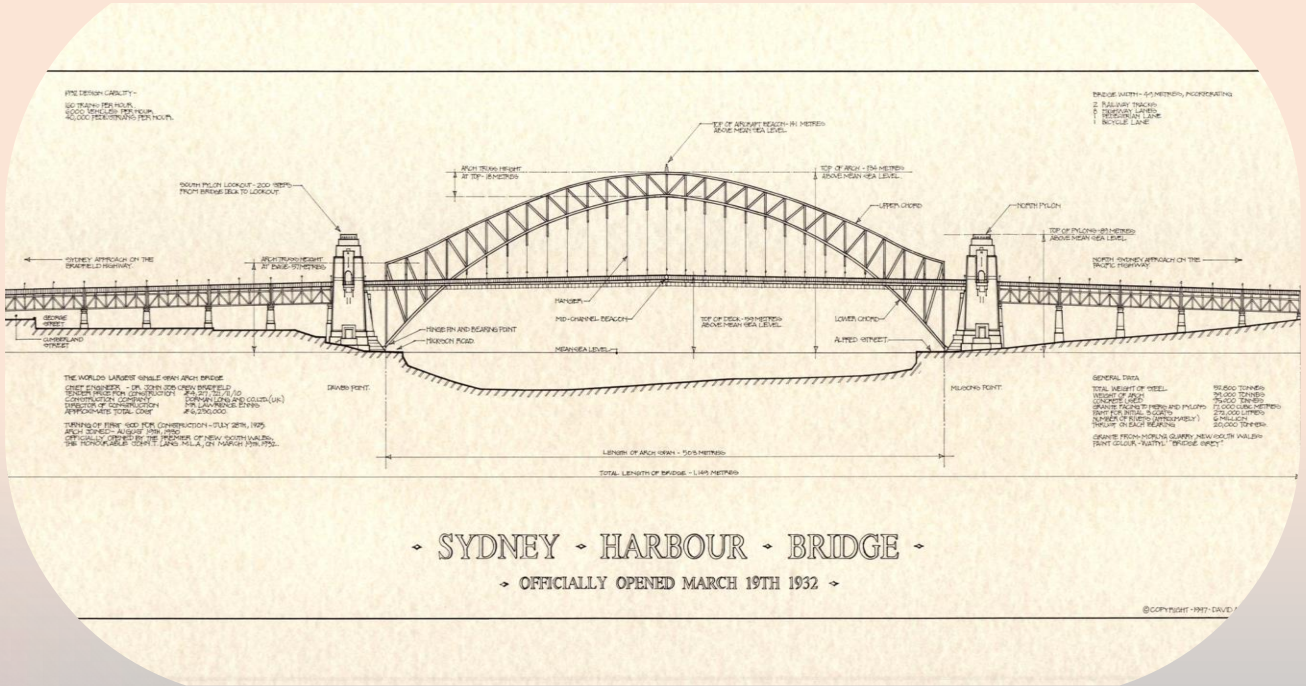
The construction of the Sydney Harbour Bridge lasted eight years, from 1925 to 1932, and cost approximately 13.5 million Australian dollars. Around 2,000 workers, mostly Australians, were employed during the project.

Sixteen workers lost their lives during the construction process.

The toll for crossing the Sydney Harbour Bridge ranges from $2.50 to $4.00 USD, depending on the vehicle type and time of day.There is no toll for northbound traffic.However, taxis traveling northbound may still charge passengers a toll, anticipating the fee the taxi will need to pay on the return (southbound) trip.

TECHNICAL PARAMETERS

1. The total weight of the bridge is approximately 53,800 tons
2. The steel arch alone weighing 39,000 tons.
3. The arch rises to a height of 134 meters above sea level, while the clearance under the bridge is 49 meters, allowing unrestricted passage of large ocean-going vessels beneath it.On hot days, thermal expansion of the steel can increase the arch’s height by approximately 18 centimeters.
4. The steel components of the bridge are fastened with over six million rivets.
5. To support the structure, massive granite-faced pylons nearly 100 meters tall were built on both shores.



6. Since October 1, 1998, guided bridge climbs have been offered to visitors aged 10 and above.Participants ascend the outer arch to reach the summit, offering breathtaking panoramic views of the city.
6.1 All that’s required is rubber-soled footwear; climbers are provided with a safety harness and special climbing suit.Trained instructors assist throughout the entire experience.
7. The bridge is crossed by over 200,000 vehicles daily.
8. Over 500 houses were demolished to make way for the bridge’s construction.
9. Any modification to the arch design requires a full structural recalculation.The original calculations filled 28 large volumes.
10. Painting the steel arch with three protective layers required nearly 300,000 liters of paint.

Got questions?

Thank you