Sydney Harbour Bridge

The bridge walk is about 1.5 km. It starts at Milsons Point Railway Station, a short distance from the north end of the bridge, and ends at the stairs leading down to Cumberland Street in the city, a short distance from Circular Quay and Wynyard Station. There are stairs leading to the footway at each end of the bridge, with no wheelchair access. Allow two hours for the walk, including a visit to the pylon lookout and museum at the southern end of the bridge. There is no charge to walk across the bridge by the footway, but there is a charge for the optional visit to the lookout and museum.

Self-guided walk

ASHET

The Proud Arch

In 1791, Dr Erasmus Darwin, grandfather of the famous Charles, wrote a poem 'Visit of Hope to Sydney Cove' containing the following prophetic words which Chief Engineer J J C Bradfield later quoted:

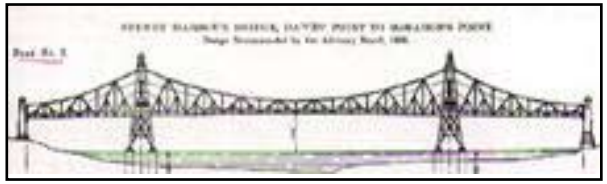
> There, the Proud Arch, Colossus-like bestride
> Yon glittering stream and bound the chafing tide.

The bridge as we now see it became the crowning achievement of Bradfield's career and of his vision for Sydney.

During the 1880s and 1890s there had been many proposals for crossing the harbour by a bridge or tunnel. In 1900 the Government called tenders for a bridge and after two rounds of tendering, the Advisory Board recommended a cantilever bridge. The 30-year old Bradfield participated in the analysis of tenders for the Advisory Board, thus starting his long association with the project. Several tenders were for arch bridges, one very similar to the one now standing, but without pylons. It was rejected on aesthetic grounds as 'too huge', an 'eyesore' and 'objectionable'.

The government then became short of money, rejected all the tenders, and allowed the project to lapse for over ten years. After the First World War, the bridge campaign, led by Bradfield, reached a climax. In 1921 tenders were called for a cantilever bridge, to his specification.

In 1923 Bradfield was sent overseas to talk to prospective tenderers and review current practice for major bridge works. He found that both American and British firms were preparing proposals for arch bridges, as a cheaper alternative design to a cantilever bridge. He also visited the 1916 Hell Gate Bridge, a massive steel arch bridge over the East River, New York.



Cantilever bridge. This is the design, by Sydney engineer Norman Selfe and the MAN Company of Germany, recommended by the Advisory Board in

Bradfield cabled instructions from England to postpone closing of tenders, worked on the specifications for an arch bridge on his sea trip home, and included it as an option in a revised call for tenders. The Minister for Works signed a contract to build the bridge with the British firm Dorman Long on 24 March 1924. Almost eight years later the bridge was opened.

Hell Gate Bridge, New York

Starting the walk

After passing through the ticket barrier at Milsons Point Station, turn left to reach Broughton Street then turn right and walk towards the city and up the stairs on to the eastern footway of the bridge. If you have time you can walk down to the harbour and look at the approach trusses from below, then return to the stairs.

The two traffic lanes immediately on your right as you walk across the bridge were completed in June 1959 replacing two original railway tracks. These were planned to serve the north east suburbs towards Manly but were used instead by trams serving the inner North Shore suburbs. The trams terminated underground at Wynyard in the city.

A view from the northern end

The first part of the walk is on the curved northern approach spans. From here, the closest suburb on the left is Kirribilli, with Neutral Bay, Cremorne, Mosman and Taronga Zoo further away.

At the southern tip of Kirribilli is Admiralty House, formerly Wotonga. Parts of the house date back to around 1842, Substantial additions were mostly complete by the time the NSW Government purchased it in 1885 as a residence for the Royal Navy's Admiral of the Pacific Fleet. In 1913 it became the Sydney residence of the Governor General. Next door to it is Kirribilli House, now the residence of the Prime Minister.

Ahead are the northern pylons with the southern pair in the distance. These granite faced concrete boxes serve no structural purpose. The Commissioner for Railways, James Fraser, recommended they be omitted to save money and the journal *Engineering* called them a 'meaningless mass of masonry'. However, Bradfield's view that they were an essential architectural feature prevailed.

The part completed arches with anchor cables

Who designed the bridge?

On the inside wall of the northern pylon is a bronze plaque giving credits for the design and construction of the bridge. It was carefully worded after negotiations between the New South Wales Government and the British company Dorman Long, constructors of the bridge, with the Institution of Engineers, Australia acting as arbitrator..

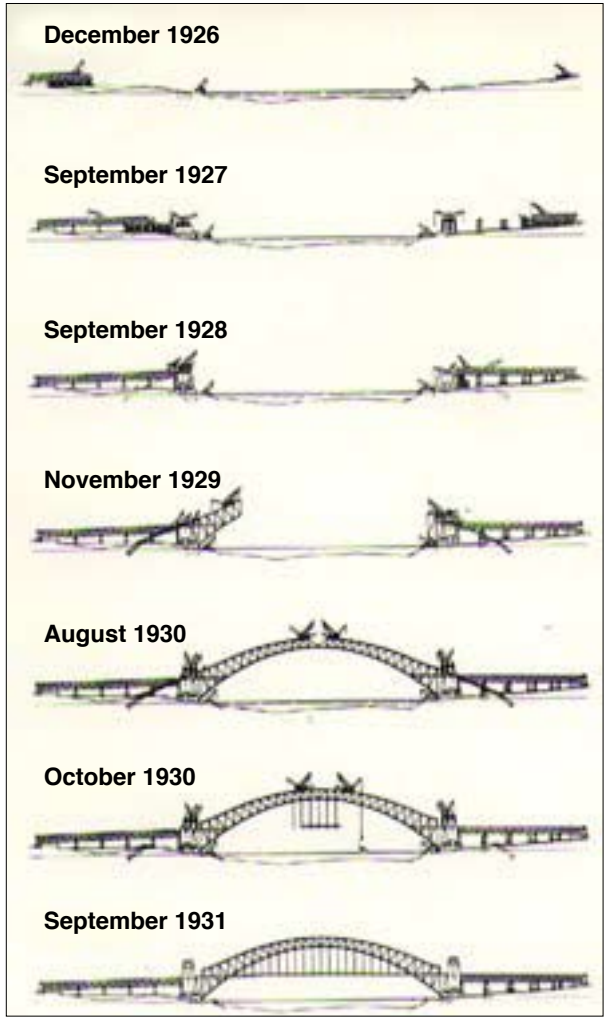
At issue was who should take credit for the bridge design. J J C Bradfield, Chief Engineer for the Government with a 30-year association with the project, claimed it was 'my design'. But Dorman Long had engaged the famous British engineer Ralph Freeman to prepare the detailed design for their successful tender, including all the drawings for fabrication and erection. Freeman objected to Bradfield's claim and the row became very public through the pages of the *Sydney Morning Herald* which supported Freeman.

Some bridge details

Stand at the city side of the north pylon and look up at the northern end of the bridge steelwork. Near the top you will see one circular and three narrow rectangular riveted plates. These cover openings that were used during construction of the bridge to allow the cradle of the anchor cables to attach to the anchor pin inside. The cables then passed over the half-completed pylon and down to a U-shaped tunnel deep in the rock, then up to the western end of the cantilevering arch.

Below you at this point, down at shore level, are two huge steel hinges which, along with the pair on the city side, support the arch. These hinges are better seen from the roads under the bridge on both shores.

One of the conditions of the contract was that as much as possible of the materials and work should be Australian. The granite facing of the pylons came from Moruya, 240 km south of Sydney. To minimise the weight of the steel arch, high strength silicon steel was specified, and this was supplied by Dorman Long from its steelworks in England. Most of the plain carbon steel, mainly in the deck and the approach spans, was produced locally at the BHP steelworks in Newcastle. Fabrication of the steelwork was carried out in two large temporary workshops on the north side of the harbour where the Olympic Pool and Luna Park now stand.



Construction stages

Building the bridge

As you walk towards the centre of the bridge, notice that the deck of the bridge is suspended from the arch by hangers that get progressively longer towards the centre of the arch. The bridge was constructed by first completing the arch and then adding the hangers and desk.

Traditionally, arches were built on timber falsework. Even if it were made of steel, it was not a practical method of building arches over a wide, busy waterway. The solution was to build the arch in two halves cantilevering from each shore and tying each half back by steel cables. The series of drawings illustrates the procedure.

On 7 August 1930 the crowns of each half were only a metre apart and then the process of slackening the anchor cables started. The gap slowly narrowed and finally closed at 10 pm on 19th August. After a few more days the crown members were installed and the structure became a self-supporting arch. Then the cables were fully slackened and dismantled.

With the creeper cranes at the crown, construction of the hangers and deck started there and worked towards the pylons where the creeper cranes were dismantled and the pylons completed to their full height.

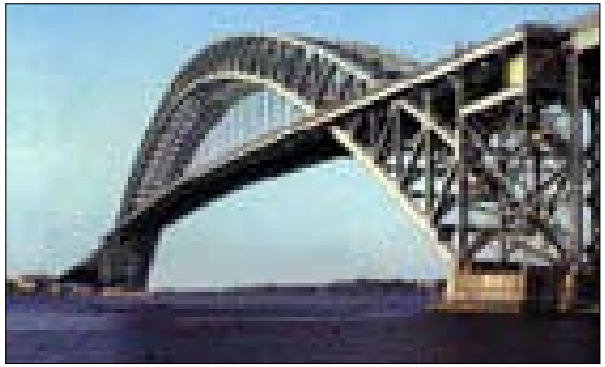
On completion of the bridge, a load test was carried out. The test load was 96 steam locomotives lined up on the four railway tracks. Engineers took measurements and compared them with the design calculations. The bridge easily passed the load test of 8,000 tons.

Load test, 1932

Largest but not longest

With 39,000 tonnes of steel, Sydney Harbour Bridge is the largest steel arch bridge in the world. In appearance it strongly resembles New York's Hell Gate Bridge which is about two-thirds the span and has about half the steel.

The distance between the base hinges of Sydney Harbour is 503 m. But it was never the longest arch span because the 1931 Bayonne Bridge over the Hudson River between New York and New Jersey is 60 cm longer. The world's longest span for an arch bridge is 518 m for the New River Gorge Bridge in West Virginia, USA, opened in 1977.



Bayonne Bridge, New York

The view from mid-span

The island fort in the middle of the harbour is Fort Denison, built in 1854 as a defence against a feared Russian invasion.

To the right is an island now joined to the southern shore, known as Garden Island. In 1857 the Royal Navy was granted permission to use the island as a naval base and during the 1880s and 1890s built workshops and administrative buildings. In 1911 it became the principal base for the Royal Australian Navy. During the Second World War the harbour between the island and the shore was reclaimed and one of the world's largest dry docks, the Captain Cook Graving Dock, was constructed and completed in 1946.

In the foreground is the Sydney Opera House, designed by Danish architect Jørn Utzon in association with engineers Ove Arup and Partners.

Further to the right is Circular Quay with its busy fleet of ferries.

The pylon lookout and museum

Continue to walk from the centre of the bridge towards the southern pylon. On the inside wall of the pylon is a plaque from the American Society of Civil Engineers and a repeat of the credits plaque on the northern pylon.

If you opt to enter the pylon you will need to pay to continue through the museum to the lookout. The museum has an excellent series of photographs of all aspects of the bridge and a small collection of memorabilia. Two videos, one about the bridge and the other about the tunnel, are showing continuously.

Immediately after leaving the pylon to continue to walk towards the city, look down at the shoreline below to see a rectangular ferry dock. Vehicular ferries and a horse-ferry for horse drawn transport used this dock up to the time the bridge was opened.

The Engineers

J J C Bradfield (1867–1943)

Bradfield graduated as a Gold Medallist at Sydney University in 1889, then joined the New South Wales Public Works Department. He was appointed Chief Engineer Metropolitan Railway Construction and Sydney Harbour Bridge in 1912. He received his Doctorate in 1924. After his retirement in 1933 he acted as consultant for the design of the Story Bridge in Brisbane.

Sir Ralph Freeman (1880–1950)

A graduate of the Central College, London, his first notable bridge design was for the 1907 Zambesi Gorge Bridge near the Victoria Falls in Zimbabwe. He was consulting engineer to Dorman Long for their successful tender for the Sydney Harbour Bridge. He designed many major bridges and received numerous awards. He was knighted in 1947.

Lawrence Ennis (1871–1938)

Born and trained in the USA, Ennis joined Dorman Long in 1903, and became General Manager in 1915 and a Director of the company in 1924. From 1924 to 1932 he was engineer in charge of construction of the Sydney Harbour Bridge.

Bradfield, Freeman and Ennis

Walk's end

When you reach the city end of the footway, look right to see the tunnel entrances down which the trams ran to and from Wynyard. The tunnels are now a car park.

Before going down the stairs to Cumberland Street, go the short distance up the stairs to see three commemorative plaques. One was unveiled by the Premier J T Lang, and another by the New South Wales Governor at the opening of the bridge on 19 March 1932. The third plaque is in memory of the 16 workmen who died accidentally during construction of the bridge, mainly due to falling objects.

Leaving the bridge

To reach Circular Quay, go down the stairs, turn left and cross Cumberland Street, then down the stairs to Argyle Street, turn left and walk towards Circular Quay. For Wynyard, turn right at the bottom of the Cumberland Street stairs and keep walking through to York Street.

ASHET self-guided tour brochures

This brochure is one of a series describing self-guided tours to places of engineering and technological interest in the Sydney area. All of the brochures are published in pdf form on the ASHET website www.ashet.org.au where they may be viewed and downloaded for printing on a desktop printer.

The full set of brochures is as follows:

The Sydney Harbour islands
Self-guided tours by fery

Ryde to Tempe: discovering the history and industrial heritage of Rhodes, Concord, Canterbury and the Cooks River
Self-guided cycle tour

Sydney's colonial fortifications
Self-guided tours

Sydney Harbour Bridge
Self-guided walk

The engineering heritage of Sydney's maritime industries
Self-guided tour by ferry

Steam at the Powerhouse
Self-guided visit to the museum

Parramatta River bridges
Self-guided tour by RiverCat

Sydney Water: A day tour of the water supply dams south of Sydney
Self-guided tour by car

Engineering and industry on three Sydney Harbour islands
Self-guided tours of Fort Denison, Cockatoo and Goat Islands

An engineering walk around the Sydney Opera House
Self-guided walk

ASHET, the Australian Society for History of Engineering and Technology, was formed in June 2003. Its objects are to encourage and promote community interest and education in the history of engineering and technology in Australia. For more about ASHET, visit the website www.ashet.org.au .