

# LONG - SPAN BRIDGES

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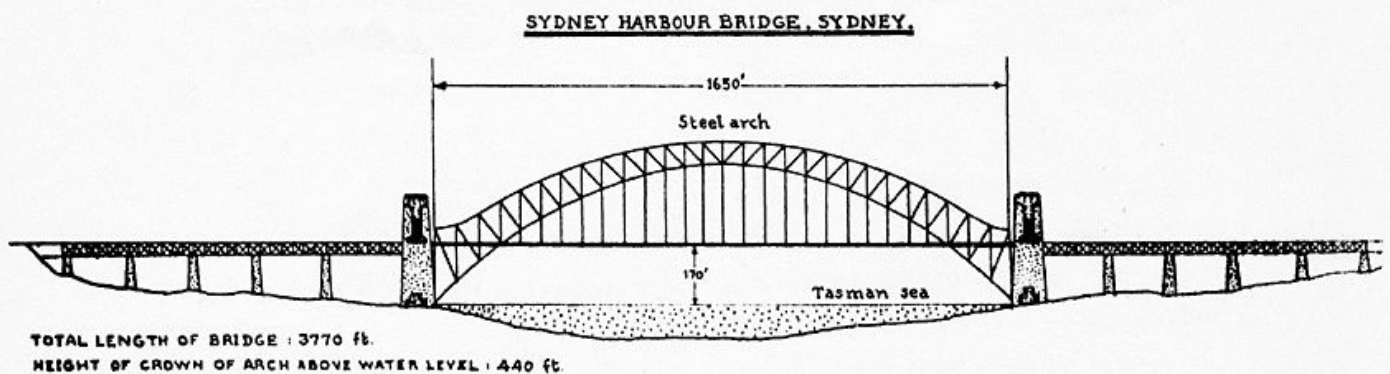
Long-span Bridges, which span a river or canyon without any intermediate piers or supports, represent one of the more daring accomplishments of Civil Engineers. Though there is no standard definition, a long span, in this context, may be taken to be one exceeding 300 m. With this definition, long-span bridges generally fall in the following categories:

1. Arch bridges
2. Double-cantilever Bridges
3. Suspension bridges

Most long-span bridges are of steel, though quite a few elegant long-span concrete arch bridges have been built.

## ARCH BRIDGES.

The arch bridge having the longest span in the world is the New River Gorge bridge in West Virginia, USA. It is a steel arch bridge having a span of 518 m. However, the most famous and majestic arch bridge is the Sydney Harbour bridge having a span of 503 m; this steel arch bridge was completed in 1932.

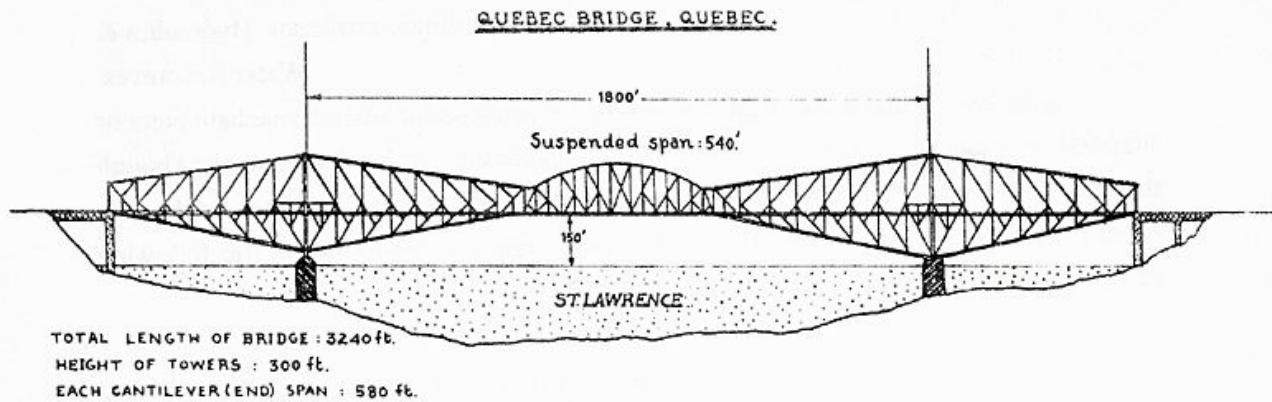


One of the longest span concrete arch bridges is the 305 m span Gladesville bridge, also in Sydney. This bridge has precast segmental arch ribs, which appear in cross section as four boxes held together by nominal reinforcement, and which function essentially as an unreinforced concrete arch.

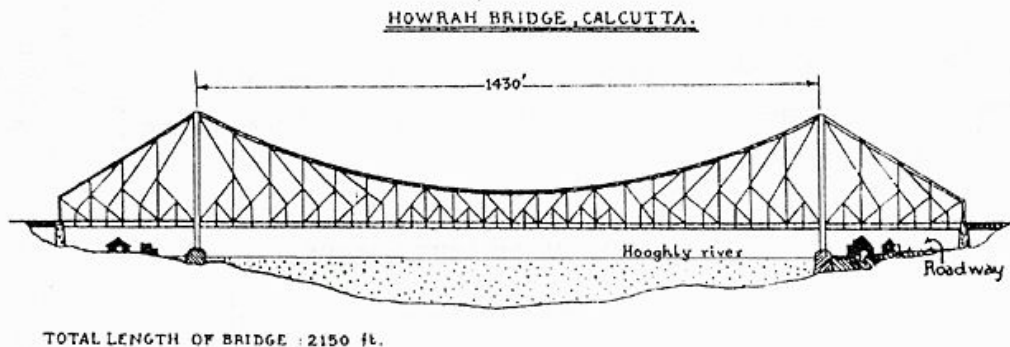
## DOUBLE CANTILEVER BRIDGES.

For a bridge other than the suspension type, the longest clear span in the world is

549 m for the Quebec bridge in Canada. This elegant double cantilever steel bridge was completed in 1917.



In India, the bridge with the longest clear span was, till recently, the Howrah bridge over river Hooghly in Calcutta. This is also a double cantilever steel bridge with a centre-span of 436 m.

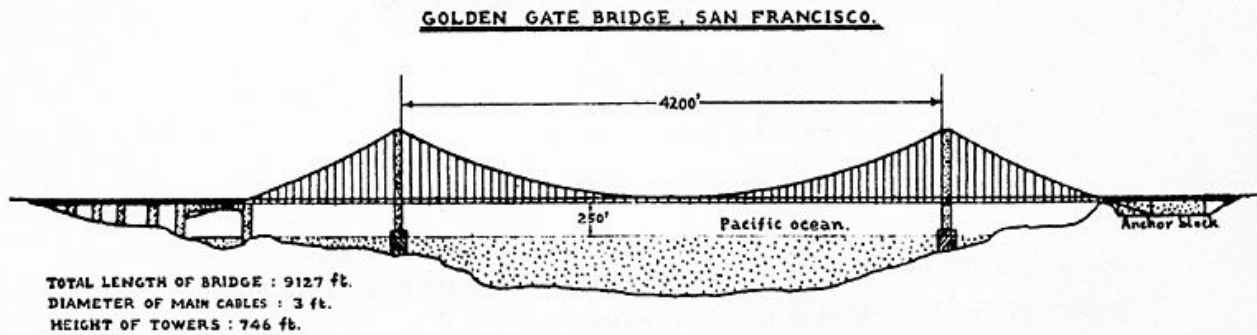


The recently completed Vidyasagar bridge across river Hooghly in Calcutta has the longest span in India, about 457 m.

### SUSPENSION BRIDGES.

Beyond spans of 500 m or so the suspension bridge reigns supreme. Suspension bridge engineering came of age with the construction of the Brooklyn bridge in New York in 1883, having a span of 486 m. In the decades that followed, magnificent suspension bridges of longer and longer spans were built in USA.

Early in the 20th century, a civil engineer proved in an article that the maximum possible span for a suspension bridge would be 1280 m, at which the suspension cables would bear no more than their self-weight! However, by 1937, the majestic Golden Gate bridge of exactly 1280 m span had been built in San Francisco. This bridge carries a roadway 76 m above the entrance to San Francisco harbour from the sea. Though its span has been exceeded by three later bridges, the Golden Gate bridge continues to retain its pride of place as the most famous long-span bridge in the world.



The following table lists suspension bridges throughout the world having spans exceeding 1000 m :

Name of the bridge	Country	Year of completion	Span in metres
George Washington	USA	1931	1067
Golden Gate	USA	1937	1280
Mackinac	USA	1957	1158
Verrazano Narrows	USA	1957	1298
April 25th	Portugal	1966	1013
Bosporus	Turkey	1973	1074
Humber	England	1981	1410
South Bisan-Seto	Japan	1988	1100
Akashi Kaikyo	Japan	under construction	1990

In a suspension bridge, the entire weight of the bridge is borne and transmitted by two or four multi-strand steel cables to the two towers at the end of the main central span.

These cables are spun in-situ by an automatic cable-spinning machine which traverses the entire length of the bridge to and fro. In the case of the Golden Gate bridge, there are two cables of three feet diameter, each made of 27572 high-tensile steel wires (in 61 strands of 452 wires each) of 0.2 inch in diameter.

In the case of the Verrazano Narrows bridge, there are four cables of three feet diameter, each made up of 26108 high-tensile steelwires (61 x 428) of 0.2 inch dia. At the allowable tensile strength of 39 T per sq. inch, each cable can withstand a pull of 32000 tons. Substituting in the well-known formula for cable tension

$$H = w \times l / 8 \times d$$

where  $l$  = span of the bridge (4260 ft.)

and  $d$  = sag of the cable (385 ft.).

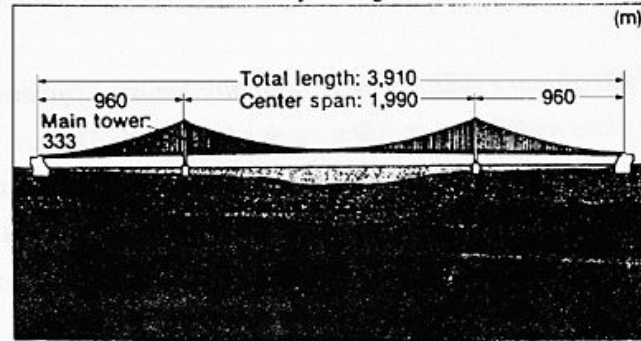
We find that the four cables can carry a total span load of 92000 tons. Roughly a quarter of this is accounted for by the cables, and a half by the hangers, deck truss and roadway.

Till 1940, suspension bridges were designed only for the static loads (dead load plus live load). That year, the newly built Tacoma Narrows bridge in USA, which was a daringly slender suspension bridge of 853 m span, collapsed due to resonant oscillations in a sustained wind of moderate speed ( which was well within the maximum ~~within the maximum~~ windspeed assumed in the static design ). At the time of failure, the road deck of the bridge was having a violent vertical oscillation of amplitude 6 ft. along with a superimposed torsional oscillation. The failure led to the emergence of an entirely new design aspect -- the aerodynamic instability of suspension bridges. As a sequel to the investigations, several existing bridges, including the Golden Gate bridge were stiffened and the Tacoma Narrows was eventually rebuilt in 1950.

Long-span bridges are viewed as symbols of engineering supremacy of a country. It is interesting to note that the Humber estuary bridge of 1410 m span, located on a minor highway in England and dubbed as 'the bridge that leads nowhere', was designed and built by the British with the clear objective of beating the record for the longest span!

And now it is the turn of the Japanese to demonstrate their growing engineering prowess. Japan has made a great leap forward in bridge engineering, and several elegant long-span suspension bridges have been built or are under construction. The most spectacular of these is the Akashi Kaikyo suspension bridge, now under construction, which will have the world's longest clear span of 1990 m .

Elevation of the Akashi Kaikyo Bridge



Its towers are 333 m high, with the roadway 65 m above the Akashi strait. Construction began in 1988 and is expected to be completed by 1998. When completed, the Akashi Kaikyo suspension bridge will stand as a majestic symbol of the human spirit of defiance and the conquest of nature.

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Dr. Jayaraman is presently a visiting professor in the Dept. of Hydraulics and Water Resources Engg. Apart from being an expert in his own speciality, he maintains an active interest in all fields of science and contributes to leading periodicals of a similar nature.

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