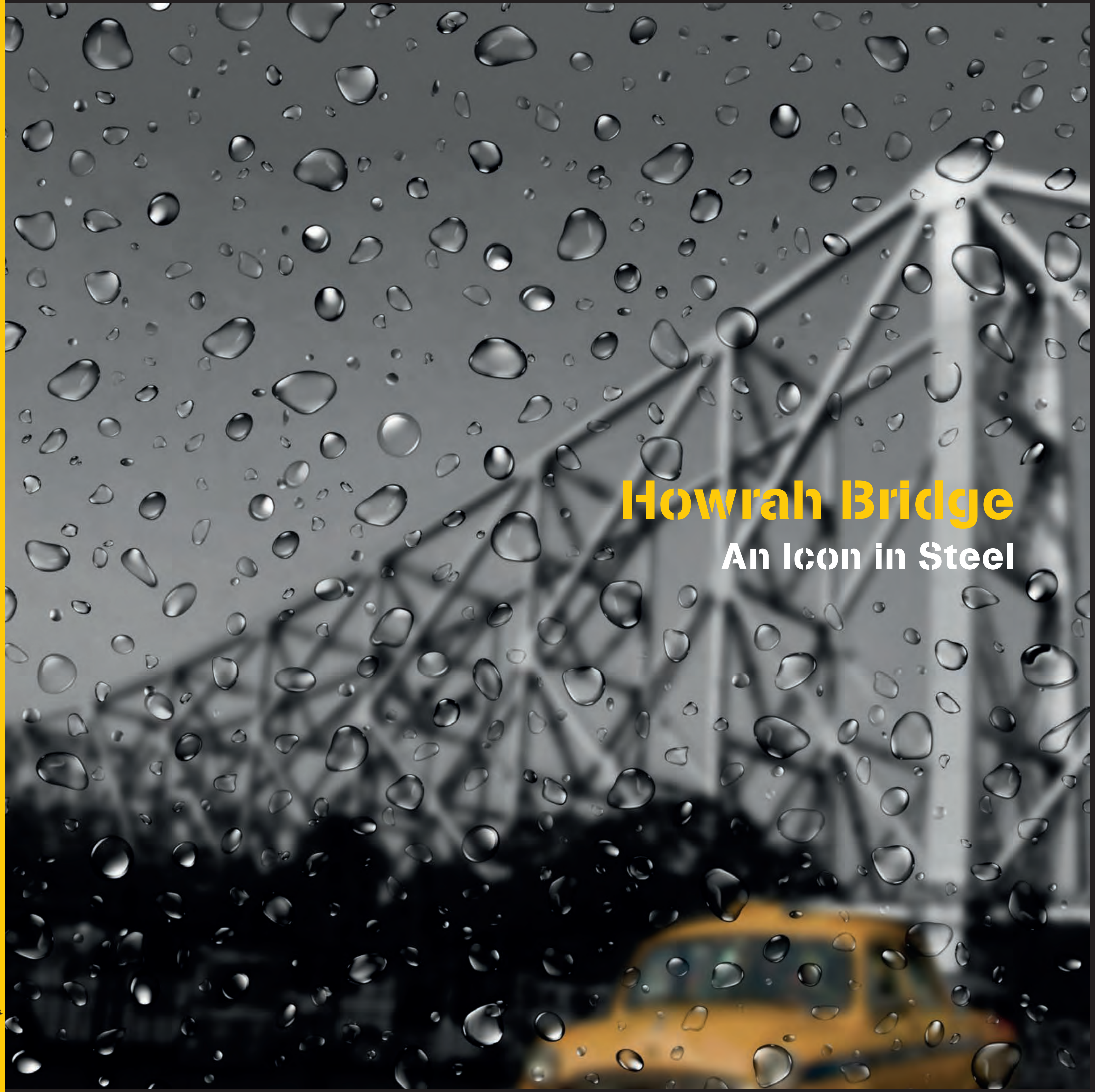
TATA

TATA STEEL

Howrah Bridge An Icon in Steel

CELEBRATING 75 YEARS



Howrah Bridge

An Icon in Steel

CELEBRATING 75 YEARS

Seventy-five years ago on this day, February 3, 1943, the Howrah Bridge was opened to the public. In those dark days of World War II, there was no opportunity to celebrate the marvellous piece of engineering; a bridge of steel made in India; almost the entire steel produced by Tata Steel and fabricated by Indian engineering firms and built by Indians to a sophisticated international design.

For all purposes, 'Make in India' was born in that era.

It is the amazing foresight, visionary investment in research and development by the early leaders in Tata Steel; India's technical competence and the confidence in the country's ability to deliver the fabulous cantilever structure that Tata Steel celebrates today as it rededicates itself to the task of 21st century nation-building.

"The city of Calcutta is situated on the left bank of the river Hoogly, whereas the Howrah station which is the terminus of the two important railway systems serving the city is on its right bank. In addition, the right bank of the river is highly industrialised as most of the jute mills are located there. As such, there has been a very great need for road and railway bridges. The bridge under description carries vehicular and pedestrian traffic as well as two tramway tracks. Of the two railway bridges which cross the river higher up, one also carries vehicular and pedestrian traffic.

Before the present bridge was built there was floating bridge designed by the late Sir Bradford Leslie for carrying road traffic across the river. The bridge was opened in 1874 and remained in use till 1943, when the new bridge was put into commission. It had a total length of 1528 feet between centres of abutments and provided a 48 feet roadway and two 7 feet footways."

Brochure on the New Howrah Bridge

Dedicated to the City of Kolkata

Year of publication: 2018

All measures have been taken to ensure accuracy of data contained in this publication.

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Photo © Satyaki Ghosh

The shimmering silver of the water is matched by the shining steel of the understructure

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Delivering the Cantilever

Hawkeyes that spot every potential sign of harm

Three young lads, Sangram, Tapas and Bishu, sure-footed as arboreals, traverse the majestic latticed expanse…for this bridge is theirs for safe-keeping

Three young lads, Sangram, Tapas and Bishu, sure-footed as arboreals, traverse the majestic latticed expanse of over 457.50 metres. They are checking the pulse of this lifeline to the city of Kolkata, its iconic Howrah Bridge. They inspect every nook and corner for any tell-tale sign of potential harm to the bridge; from bird nests to any suspicious corrosive 'brownish red' stain. For this bridge is theirs for safekeeping; it is not merely a bridge for passing but an emotion writ in shining silver.

Made in India; skill India...it all began with the Howrah Bridge, says Ashoke Chatterjee the design guru and the acknowledged master of India's creative space, who has literally "experienced" the bridge since the age of 10. For most of 21st century Bengal, focused on its "glorious past", this is the 20th century engineering marvel that could only have been possible in 'Calcutta'; the colossus, straddling the Hooghly, a distributary of the mighty Ganges. For such others as the celebrated but irreverent Geoffrey Moorhouse, it was something of a monstrosity: "There never was a bridge that dominated a landscape as much and in so ungainly a fashion as this one". Yet other equally discerning European observers have been quite wonderstuck by its majesty with a Frenchman likening it to a supine Eiffel Tower. The sight of the bridge deck hanging from 39 pairs of hangers suspended from the main trusses is quite mind blowing.

For the average citizen of this passionate city, it is a magnificent obsession; as it is for the global aficionado. Even Herge's Tintin finds himself placed before the Howrah Bridge, on the Facebook page of the Belgian Embassy, without the boy detective ever having visited the city. In its early years, any Bollywood depiction of "Kullkutta" had to include the silver festoon across the city's skyline.

Technology apart, the Howrah Bridge was built in an environment of religious bonhomie between Hindus, Muslims and Sikhs. There were also the Nepalis,

Religious and communal harmony marked the construction

An emotion writ in silver *Photo © Satyaki Ghosh*

The bridge was thrown open to the public of 'Calcutta', in the dead of the night on February 3, 1943, a tramcar rolling down from the city end to the station end

Gurkhas and even Pathans making valiant contributions. Every festival was celebrated with great gusto, bringing work to a halt. It was all taken in good spirit and never was a day lost to labour trouble of which the city was beginning to get a taste. They were the unheralded heroes working under the overall supervision of Britain's technology masters.

Today, the young trio is the unheralded hero of the bridge...

Almost unheralded as the bridge itself that was thrown open to the public of 'Calcutta', as it was then called, in the dead of the night on February 3, 1943, a tramcar rolling down from the city end to the station end. Not even the registers of the Port Commissioners dared log an entry.

For a technological marvel that had given rise to much discussion in technology circles the world over, ever since the designs—for what was then to be the longest cantilever bridge—were being worked on, the eerie silence upon completion was a testament to the terrifying oppressiveness of war. The Howrah Bridge was the targeted bridge for bombing. The Pearl Harbour experience weighed heavily on every mind.

1943 'Calcutta' was in the vortex of World War II and the Imperial Japanese Army Air Force was eyeing the looming silver structure. Japan had taken Burma some nine months ago and 'Calcutta' was as lucrative a target as any other. Bombard the city they did on December 20, 1942 and again but, destined for great glories, the set-to-be-inaugurated Howrah Bridge managed to stay out of the air-raiders' radar. "I remember the bombing of Calcutta by the Japanese, the target being Howrah Bridge", said Katyum Randhawa, then a young Parsi girl, in a later submission to WW2 People's War.

Coming into 'Calcutta' in 1945, Ashoke Chatterjee, now 83, found this incredible structure with what seemed to have "dirigibles" flying above it. These were barrage balloons, large kite balloon, used to defend installations against aircraft attack by raising aloft cables that created a collision risk and stymied the bomber's intentions. By 1938, the British Balloon Command was set to work to protect industrial areas and cities, ports and harbours. The Howrah Bridge was thus decked up in protective gear for war. "They looked like Zeppelins to a child", recalls Ashoke Chatterjee.

Some who can speak with authority regard the defences of Calcutta as the best outside Britain. However, this may be, the Japanese evidently had sufficient respect for them to come at night and flying high. This has disadvantages as well as advantages. They are unlikely to hit what they are aiming for, but they may hit what are very certainly not military objectives

The Statesman. Calcutta/Delhi, December 22, 1942
writing on the Japanese miss


HOWRAH
SIBPUR
GRAND TRUNK ROAD SOUTH
UPPER FORESHORE ROAD
DUKE ROAD
SHALIMAR ROAD
FORESHORE ROAD
RAILWAY
FORT WILLIAM
EDEN GARDENS
KINGSWAY
KIDDERPORE ROAD
RED ROAD
HASTINGS
RACE COURSE
VICTORIA MEMORIAL
HOWRAH FLOATING BRIDGE
HOWRAH R.S.
TAGORE ST.
COTTON ST.
BANSTALA STREET
TELKAL GHAT ROAD
GARDEN REACH


KING'S RD.
DOBSON RD
HOWRAH
HARI MOHAN BASU RD
CULLEN PLACE
GRUNDY
HOWRAH R.S.
BUCKLAND BRIDGE
HOWRAH FLOATING BRIDGE
TILLAND RD.
TELKAL GHAT ROAD
TELKAL GHAT
BANK ROAD
KALI KRISHNA
TAGORE ST.
BANSTALA STREET
COTTON ST.
CROSS ST.
ARMENIAN ST.
CLIVE ST.
CLIVE ROW
FAIRLIE PLACE
ROYAL ST.
LYONS PLACE
EZRA ST.
WING ST.

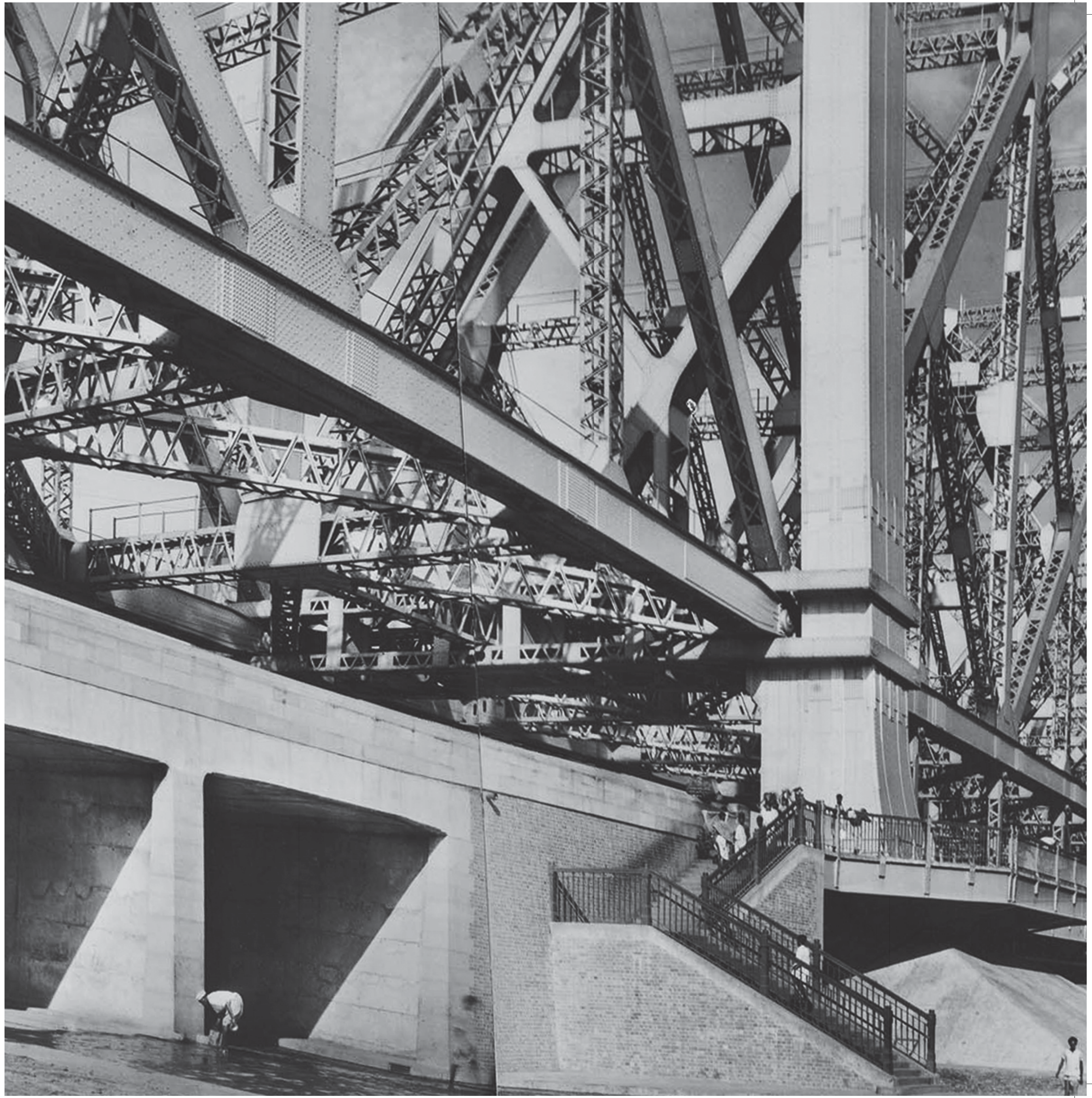
A New Act for a New Bridge

The bridge now and then

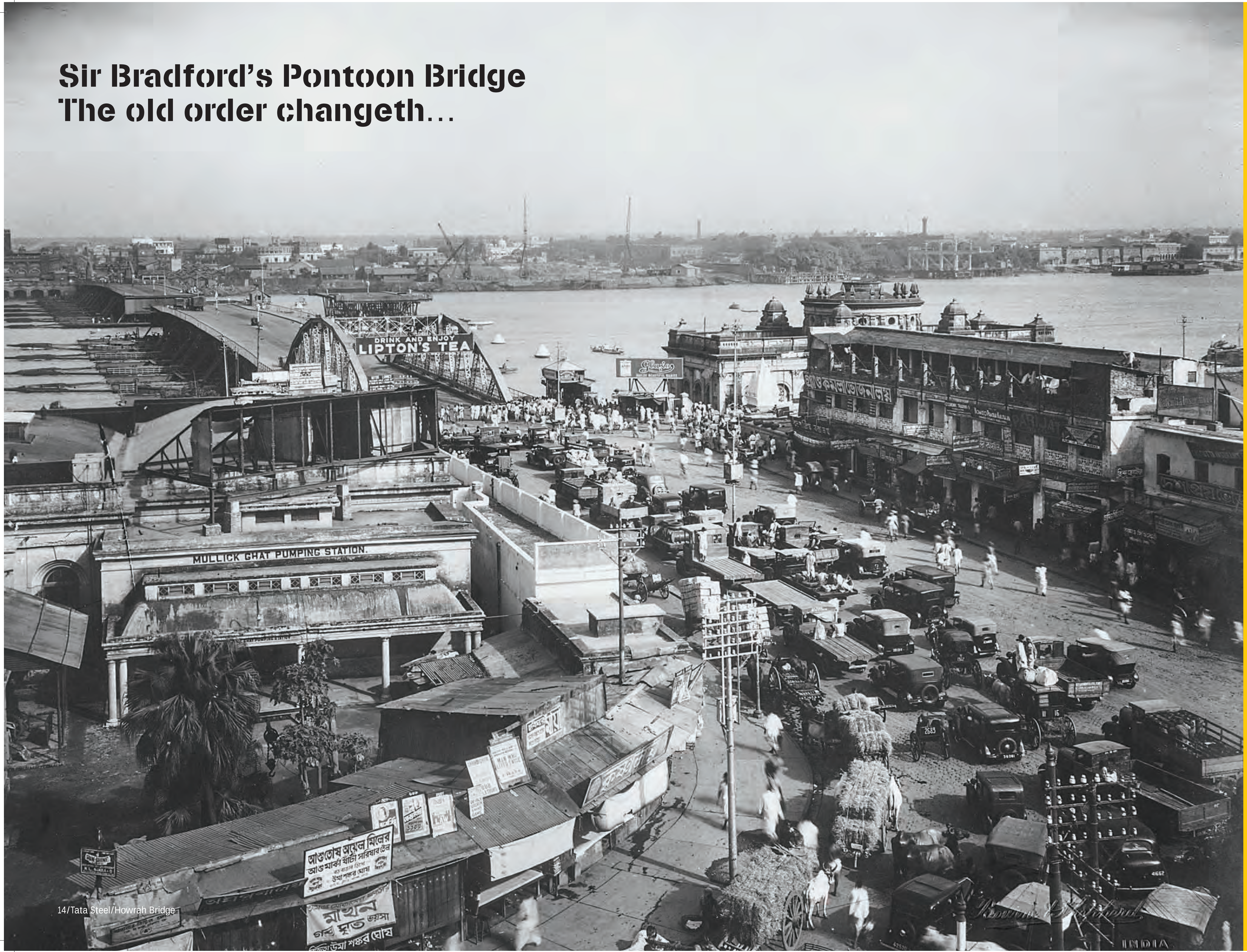
Everything about the proposed bridge aroused interest; it needed a special legislation to begin with: The Howrah Bridge Act, 1926... "An Act to provide for the construction, maintenance and control of a new bridge across the river Hooghly between Calcutta and Howrah" because it was "expedient that a new bridge across the river Hooghly...be constructed and maintained...". It involved a plethora of laws to acquire land, levy taxes, employ people...

It was, after all, the longest cantilever construction contemplated in those times and even stalwarts were sceptical. The Engineer—which was even then the voice of authority on all matters around engineering, technology and innovation—followed and reported every major discussion on the upcoming structure.

"An Act to provide for the construction, maintenance and control of a new bridge across the river Hooghly between Calcutta and Howrah"



Sir Bradford's Pontoon Bridge
The old order changeth...



Early morning traffic hold up on the Calcutta approach

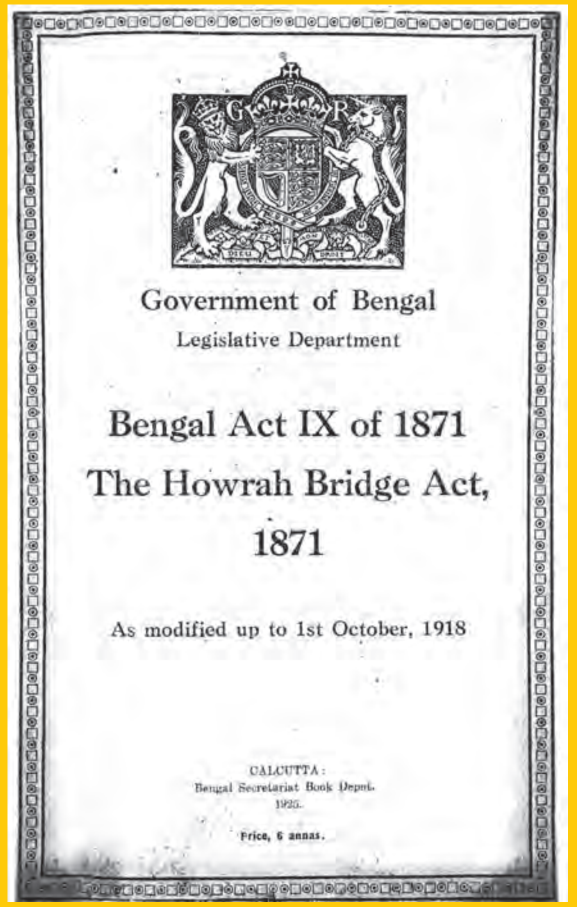
'HOWRAH' BY L. S. S. O'MALLEY AND M. CHAKRAVARTI IN THE BENGAL DISTRICT GAZETTEER SERIES, BENGAL SECRETARIAT BOOK DEPOT, CALCUTTA (1909)

"In Howrah town several bridges have been built over the East Indian Railway and the Bengal-Nagpur Railway lines, the finest being the Buckland Bridge leading to Howrah station, which is more than a quarter mile long.

By far the most important bridge, however, is the Howrah Bridge over the river Hooghly, which connects Howrah with Calcutta. This is a floating bridge, the middle section of which is movable so as to allow of the passage of vessels up and down the river. It is 1,528 feet between abutments and has a roadway for carriages, 48 feet in width, with footpaths, 7 feet wide, on either side. The construction of a bridge over the Hooghly at or near Calcutta was mooted over half a century ago, a committee being appointed to consider the project in 1855–56; but the idea was given up in 1859–60. The question was revived in 1868, and it was eventually decided that Government should construct the bridge and that its management should be handed over to a Trust. In 1871 an Act was passed empowering the Lieutenant-Governor to have the bridge constructed with...(Page 121 continued on Page 122) Government capital, to make and maintain ways and approaches, to authorise the levy of tolls and to appoint Port Commissioners to carry out the purposes of the Act.

A contract was entered into with Sir Bradford Leslie for its construction, and the work was forthwith commenced in England, the different portions of the bridge being sent out and put together in Calcutta. The work of construction was completed in 1874; and the bridge having been opened to traffic in October of that year, was made over to the Port Commissioners for management under Act IX of 1871, the cost, 22 lakhs of rupees with interest at Rs 4 1/2 per cent being made, the first charge to be repaid in thirty instalments. The total net revenue of the bridge since it was opened in 1874 amounts to Rs 34,11,410. The main item in the receipts consists of a small toll on railway traffic at the rate of Re 1 per 100 maunds of goods, which is paid by the East Indian Railway. The income from this toll has been growing steadily, rising from Rs 1,46,695 in 1899–1900 to Rs 2,16,360 in 1907–08. In that year the total receipts amounted to Rs 2,40,593 and the expenditure to Rs 2,21,111. Of the latter Rs 62,603 were spent on establishment and Rs 90,847 on repairs while Rs 13,000 were paid as a contribution to the Calcutta Port Trust on account of management. Before 1906, the bridge was opened for the passage of vessels only in the daytime, but since June of that year it has been opened at night for all vessels except ocean steamers, which have to pass through by day. The number of openings was thus raised to 24, while the average number of day openings was reduced from 13 to 4 in a month, with much less inconvenience to general traffic. In 1907–08, 130 sea-going vessels, 2,033 flats and inland steamers, 715 launches and steam tugs, 133 Port Commissioners' vessels, and 9 Government steamers with flats passed through the bridge, in all 3,020.

www.archive.org/details/howrahomalley01omal
Source: Library of the University of California, San Diego


Government of Bengal
Legislative Department

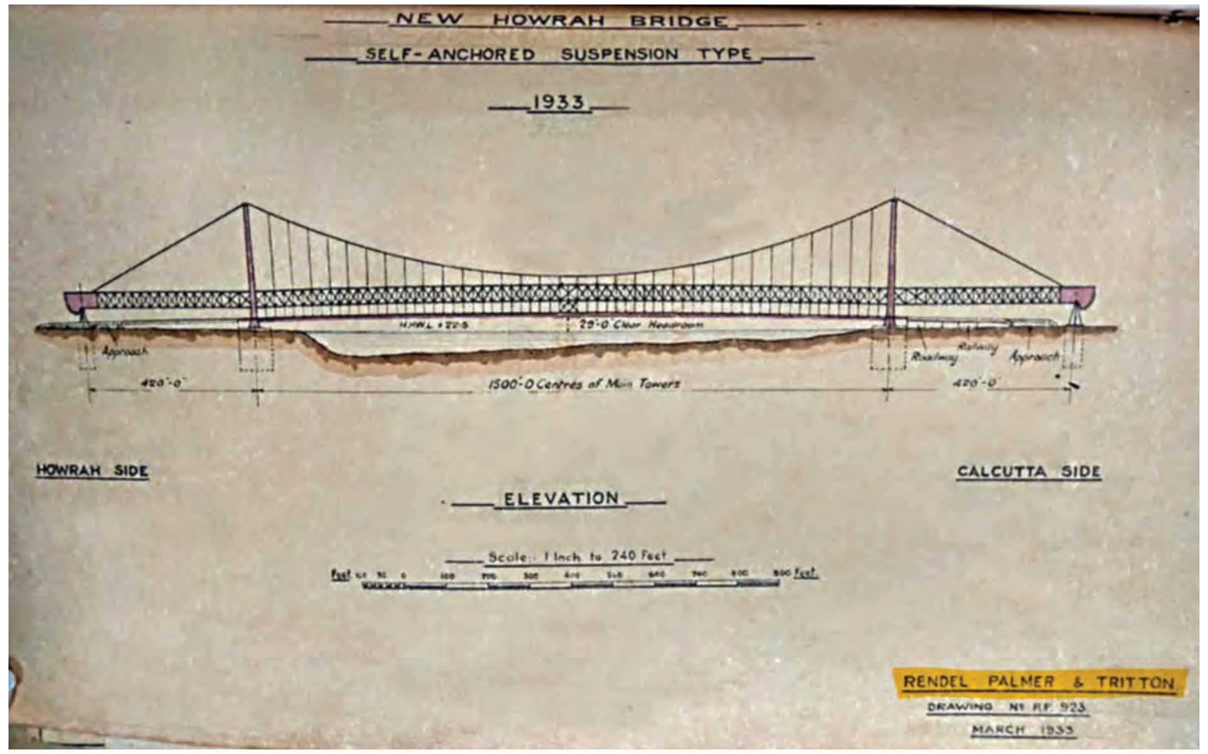
Bengal Act IX of 1871
The Howrah Bridge Act, 1871

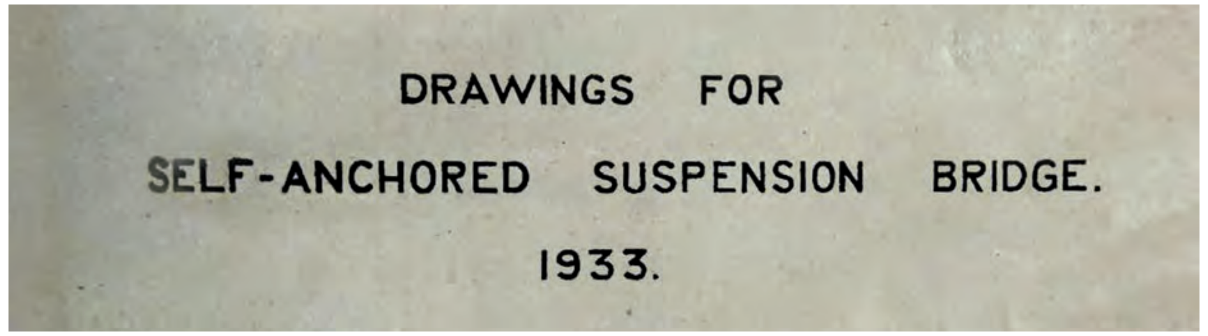
As modified up to 1st October, 1918

CALCUTTA:
Bengal Secretariat Book Depot.
1925.

Price, 6 annas.

On Board; Rendel, Palmer & Tritton



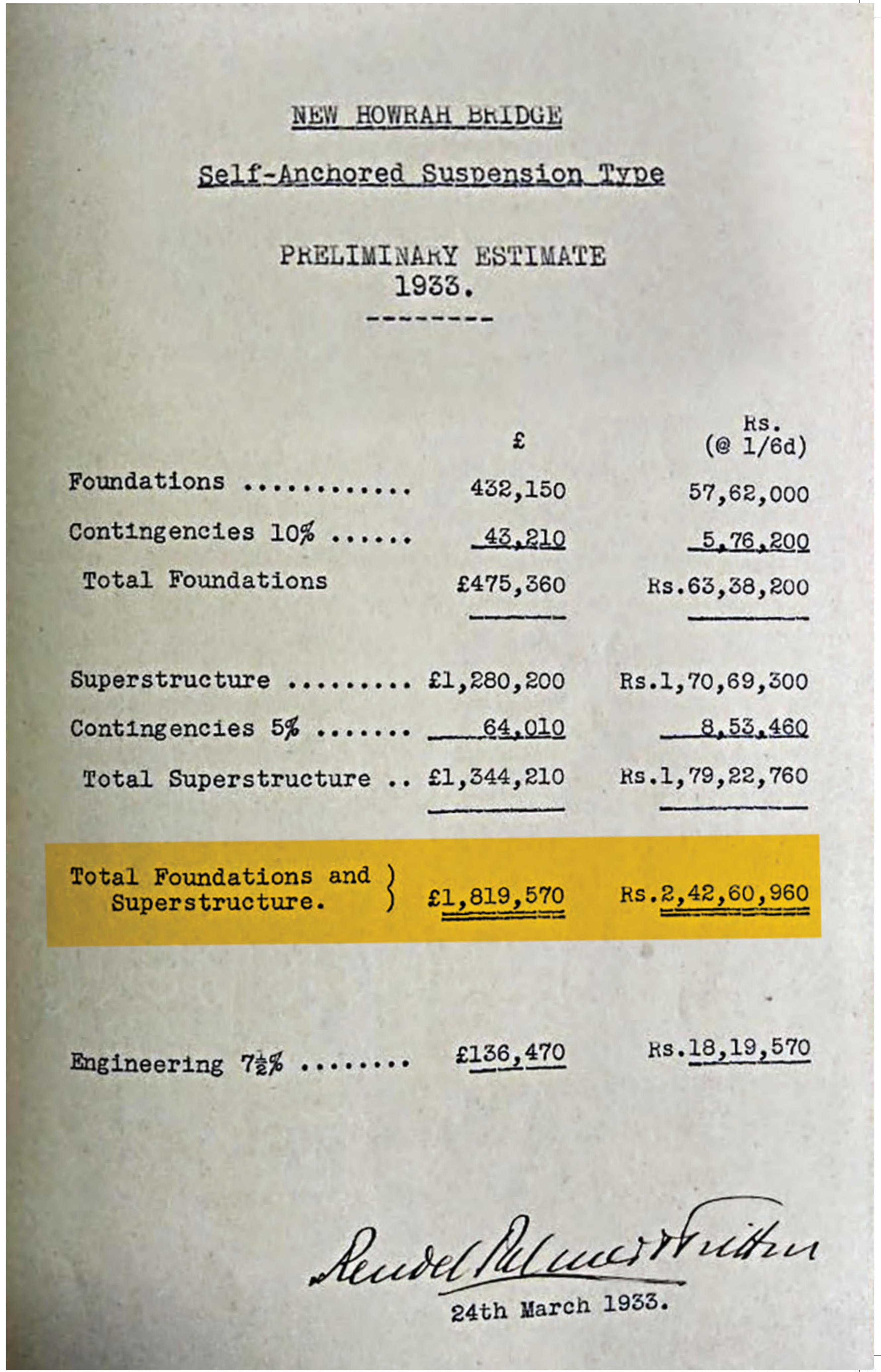

DRAWINGS FOR
SELF-ANCHORED SUSPENSION BRIDGE.
1933.

Deliberations on the bridge were held under the august supervision of the Governor General himself and the details duly communicated to the right circles. "A conference was held at Government House, Calcutta, on March 15th under the presidency of the Governor of Bengal, to consider the subject of the proposed Howrah Bridge across the Hooghly. The majority of the engineers favoured a cantilever bridge but the chairman of the Port Commission favoured a floating bridge. It was finally decided to appoint a small committee to advise on the nature of the tests necessary to determine the effect of a pier upon the river regime. The estimated cost of a cantilever bridge will be £2.650,000 and of a floating bridge £1,530,000", wrote the Engineer on March 31, 1930 (Page 325), under the column, Miscellanea.

The debate continued with everything hotly contested; from the design to the contractors, the fabricators and the raw material suppliers. The first thoughts about a new bridge were aired within the first decade of the 20th century. Sir Bradford Leslie, the redoubtable chief engineer of the East India Railway, "one of the most distinguished, as well as the most daring bridge builders that this country (Great Britain) has ever produced" to go by his obituary, had his own design in contention.

Much feted in 'Calcutta' for putting in the floating pontoon bridge in 1874—with a removable central portion that could be floated out to provide a clear opening of 200 feet for large vessels—Sir Bradford was clearly against the cantilever design of which no more than three had been built in different parts of the world. The 'Calcutta' soil was untried and importing new technology from Great Britain was perhaps a trifle daunting. After all, the cantilever Pont De Quebec bridge in Quebec, Canada (1917) had crashed. There was, however, no stopping an idea whose time had come though the first designs were for another floating bridge.

In the last quarter of the 19th century, the Commissioners of the Port of Calcutta had a meeting convened under John Scott, chief engineer of the port. The other members included RS Highet, chief engineer, East Indian Railway and WB MacCabe, chief engineer, Calcutta Corporation. Traffic flow over the bridge was amongst their main considerations and, as the records of the Port Commissioner reveal, the committee assessed that "bullock carts formed the 8/13th of the vehicular traffic", which was based on movements on August 27, 1906, when the traffic was the heaviest over a 16-day period. Given that the road on the pontoon bridge was 48 feet wide, save for the shore spans where it narrowed to 43 feet in road width, it was pointed out that the "roadway on the new bridge would be wide enough to take at least two lines of vehicular traffic and one line of trams in each direction and two roadways each 30 feet wide, giving a total width of 60 feet of road way which are quite sufficient..."


NEW HOWRAH BRIDGE

Self-Anchored Suspension Type

PRELIMINARY ESTIMATE
1933.

	£	Rs. (@ 1/6d)
Foundations	432,150	57,62,000
Contingencies 10%	43,210	5,76,200
Total Foundations	£475,360	Rs.63,38,200
Superstructure	£1,280,200	Rs.1,70,69,300
Contingencies 5%	64,010	8,53,460
Total Superstructure ..	£1,344,210	Rs.1,79,22,760
Total Foundations and Superstructure.	£1,819,570	Rs.2,42,60,960
Engineering 7½%	£136,470	Rs.18,19,570

Rendel Palmer Tritton

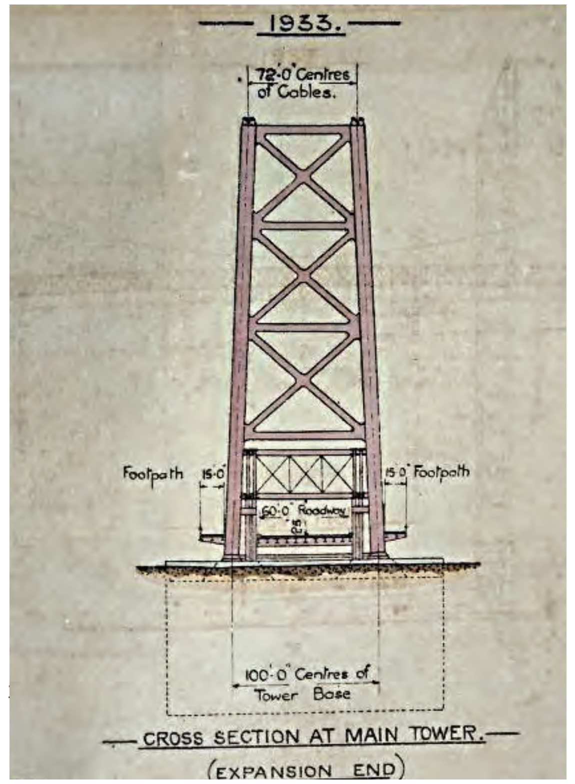
24th March 1933.

A design…submitted by the Maschinenfabrik Augsburg-Nurnberg (M.A.N.) was considered the best. Owing to the first World War, however, the scheme…was dropped

There was much deliberation about how traffic would be managed while the new bridge was being constructed and where indeed the new one would be located. Various options were discussed to address the emerging issues that included large ferry steamers capable of taking vehicular traffic, for which a one-time cost of Rs 29 lakh and an annual cost of Rs 4.37 lakh was estimated.

Also considered were a transporters' bridge that would cost Rs 20 lakh; a tunnel, that would involve an investment of Rs 3,382.58 lakh and an annual cost of Rs 17.79 lakh; a bridge on piers that could cost an estimated Rs 225 lakh; a floating bridge, at an estimated one time cost of Rs 21.40 lakh with annual maintenance accounting for another Rs 2 lakh; and an arched bridge, the cost for which was not readily ascertainable.

It was not till 1911 that notice inviting competitive designs for the new bridge was issued. In their paper on 'The New Howrah Bridge, Calcutta: Design of the Structure Foundations, and Approaches', Arthur Maurice and Ernest Bateson talk about the competitive designs for the floating bridge invited in 1911 with a cash award of £3,000. Sure enough, designs came in from all over the world; 18 of them came from nine firms by 1912. "A design with an opening span of the bascule type, submitted by Maschinenfabrik Augsburg-Nurnberg (M.A.N.) was considered the best. Owing to the first World War, however, the scheme for a new bridge was dropped for the time being". No activity of great import took place between 1917 and 1927, though papers started moving again from 1921.



Panoramic view of the site, station end

On February 7, 1930, The Engineer reported on Page 152 an early story about the "Proposed New Howrah Bridge, Calcutta". It said: "Still another Report has been made regarding the construction of a bridge across the River Hooghly between Calcutta and Howrah. It was presented to the Commissioners for the Port of Calcutta towards the end of last year by Messrs Rendel, Palmer and Tritton, of Westminster. The Report, of which a copy lies before us, is divided into two sections, each dealing with the alternative design, the first being concerned with a bridge of the cantilever type, while the other discusses a floating non-opening bridge. In each case a preliminary estimate of cost is given".

There were factors that were conducive and some not so. From the cost angle there was great joy when the original designs, prepared for a floating bridge, with an opening span giving a clear waterway of 200 ft, could be altered after the Port Commissioners checked with the Inland Steamer Companies about the headroom that would be required if a floating bridge did not have an opening span.

At first it was stated that not more than 35 ft would be required and it was decided to do without an opening span. That altered the whole of the conditions and made it possible considerably to decrease the cost of the bridge.

Later the height was raised to 38 ft to accommodate a bucket dredger. "Rendel, Palmer and Tritton looked into the question and found that a headroom of 37 ft for a loaded span and of 39.5 ft for an unloaded span could be obtained by allowing for a gradient of 1 in 40 "towards both ends of the centre span", reported The Engineer in February, 1930.

Never mind the frequent breaks...

So important was Sir Bradford's contribution to railway engineering in India that even his obituary, retrieved from Graces Guide to British Industrial History, mentioned that: "The floating bridge over the Hooghly was at that time becoming inadequate to meet the demands of increased traffic, and he paid a brief visit to India in 1899 to gain consideration of his proposals for a new design. It was not until 1910, however, that a committee of engineers was formed to consider the question of renewing the bridge, and in 1915 he submitted, at their invitation, plans for a new bridge. This design, which consisted of twin floating bridges, was, however, not favoured. He was a vigorous critic of the cantilever design selected by the Committee". The Jubilee Bridge over Hooghly River between Naihati and Bandel in West Bengal, a cantilever truss bridge, constructed entirely by riveting, without any nuts or bolts used in the construction, was designed by him, of course.

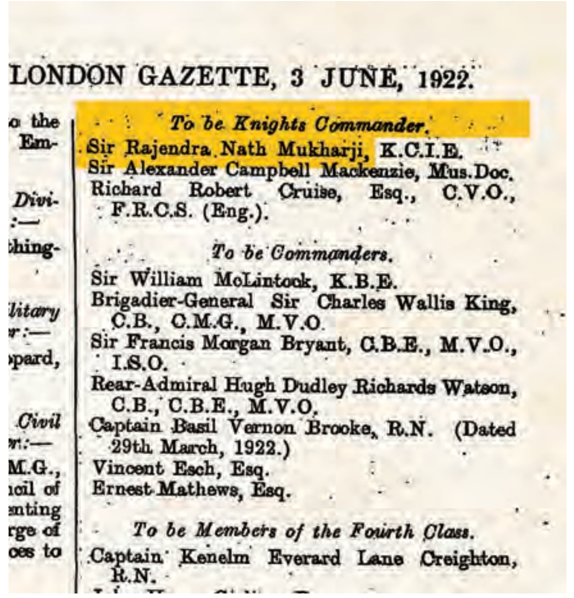
The 1921 committee of engineers was named after him and this ‘Mookerjee Committee’ comprised other distinguished engineers

Rajendra Nath Mookherjee

Not enough credit is given to Sir Rajendra Nath Mookherjee, amongst the most eminent engineers of the 20th century, for his guiding vision vis-a-vis the Howrah Bridge. Indeed, the knighthood followed his erudite chairmanship of the 1921 committee that finally got the Howrah Bridge under way.

Sir Rajendranath, better known as RN Mookherjee, had distinguished himself as an engineer and industrialist. His company, Martin & Co (set up in partnership with Sir Thomas Acquin Martin), had built the Victoria Memorial Hall, and Belur Math at Belur, Howrah, amongst other landmark buildings in the city. The 1921 committee of engineers was named after him and this ‘Mookerjee Committee’, comprised such other distinguished engineers as Sir Clement Hindley, chairman of the Commissioners for the Port of Calcutta and J McGlashan, chief engineer. They consulted Sir Basil Mott, an acknowledged expert on construction of the bridge on piers. Sir Basil proposed the construction of single span arched bridge in 1921.

Matters moved on a steady keel thereafter, with the (New) Howrah Bridge Commissioners to the Government of Bengal set up in 1922 and the ‘Mookerjee Committee’ submitting its report, whereupon the legal eagles got into the act to ensure that matters of land, labour and capital were adequately addressed to ensure a smooth passage of the bridge construction activity. The New Howrah Bridge Act was passed in 1926 and the Commissioners for the Port of Calcutta made the Commissioners for the new bridge.



LONDON GAZETTE, 3 JUNE, 1922.

To be Knights Commander.

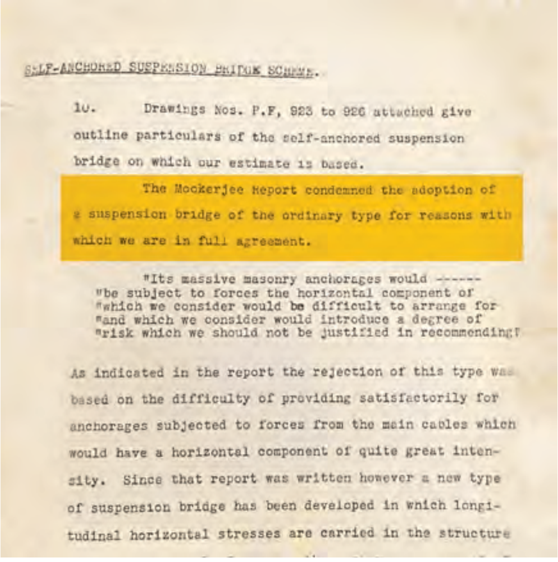
Sir Rajendra Nath Mukharji, K.C.I.E.
Sir Alexander Campbell Mackenzie, Mus.Doc.
Richard Robert Cruise, Esq., C.V.O., F.R.C.S. (Eng.).

To be Commanders.

Sir William McLintock, K.B.E.
Brigadier-General Sir Charles Wallis King, C.B., C.M.G., M.V.O.
Sir Francis Morgan Bryant, C.B.E., M.V.O., I.S.O.
Rear-Admiral Hugh Dudley Richards Watson, C.B., C.B.E., M.V.O.
Captain Basil Vernon Brooke, R.N. (Dated 29th March, 1922.)
Vincent Esch, Esq.
Ernest Mathews, Esq.

To be Members of the Fourth Class.

Captain Kenelm Everard Lane Creighton, R.N.



SELF-ANCHORED SUSPENSION BRIDGE SCHEME.

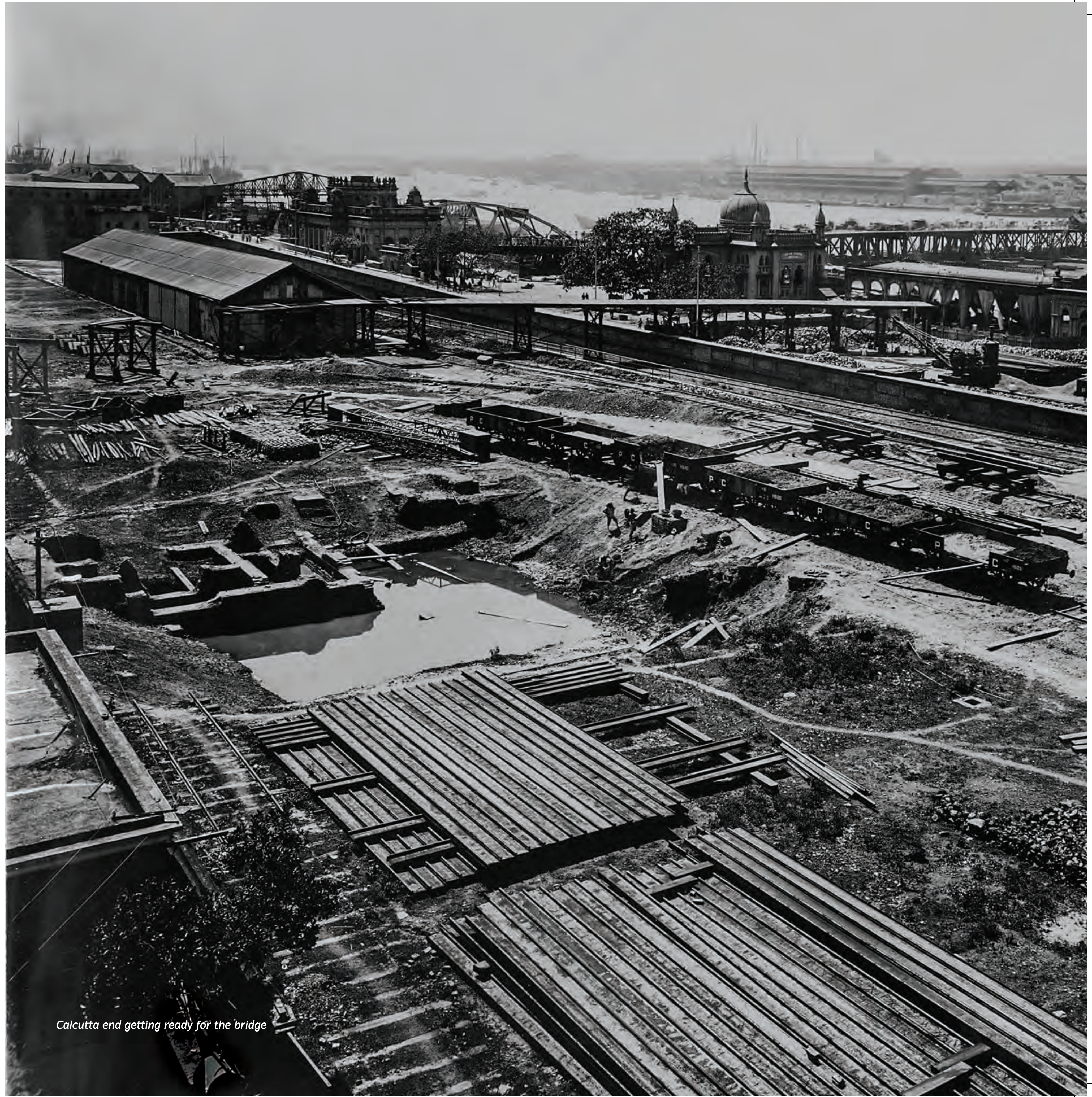
10. Drawings Nos. P.F, 923 to 926 attached give outline particulars of the self-anchored suspension bridge on which our estimate is based.

The Mookerjee Report condemned the adoption of a suspension bridge of the ordinary type for reasons with which we are in full agreement.

"Its massive masonry anchorages would ------
"be subject to forces the horizontal component of
"which we consider would be difficult to arrange for
"and which we consider would introduce a degree of
"risk which we should not be justified in recommending"

As indicated in the report the rejection of this type was based on the difficulty of providing satisfactorily for anchorages subjected to forces from the main cables which would have a horizontal component of quite great intensity. Since that report was written however a new type of suspension bridge has been developed in which longitudinal horizontal stresses are carried in the structure

Excerpts from the `Mookerjee´ Report



Calcutta end getting ready for the bridge

Enter Tata Steel

The significant aside here is that an Indian enterprise was ready with the ability to supply steel to the required specifications. It had earlier proved its credentials as had local engineering fabricators in the construction of the £450,000 (Rs 60 lakh) King George VI Bridge. Evidence of this is to be had on Page 12, of the Engineer of January 7, 1938.

Under the head, Asia, it recorded: "Late in the year a new railway bridge over the river Meghna at Bhairab Bazar, in Bengal, was formally opened and named the King George VI Bridge. All the steel work, amounting to some 3,400 tons, was manufactured by the Tata Iron and Steel Company". The fabricators were Braithwaite, Burn & Jessop Construction Company (BBJ) and the consulting engineers, Messrs Rendel, Palmer and Tritton, of Westminster.

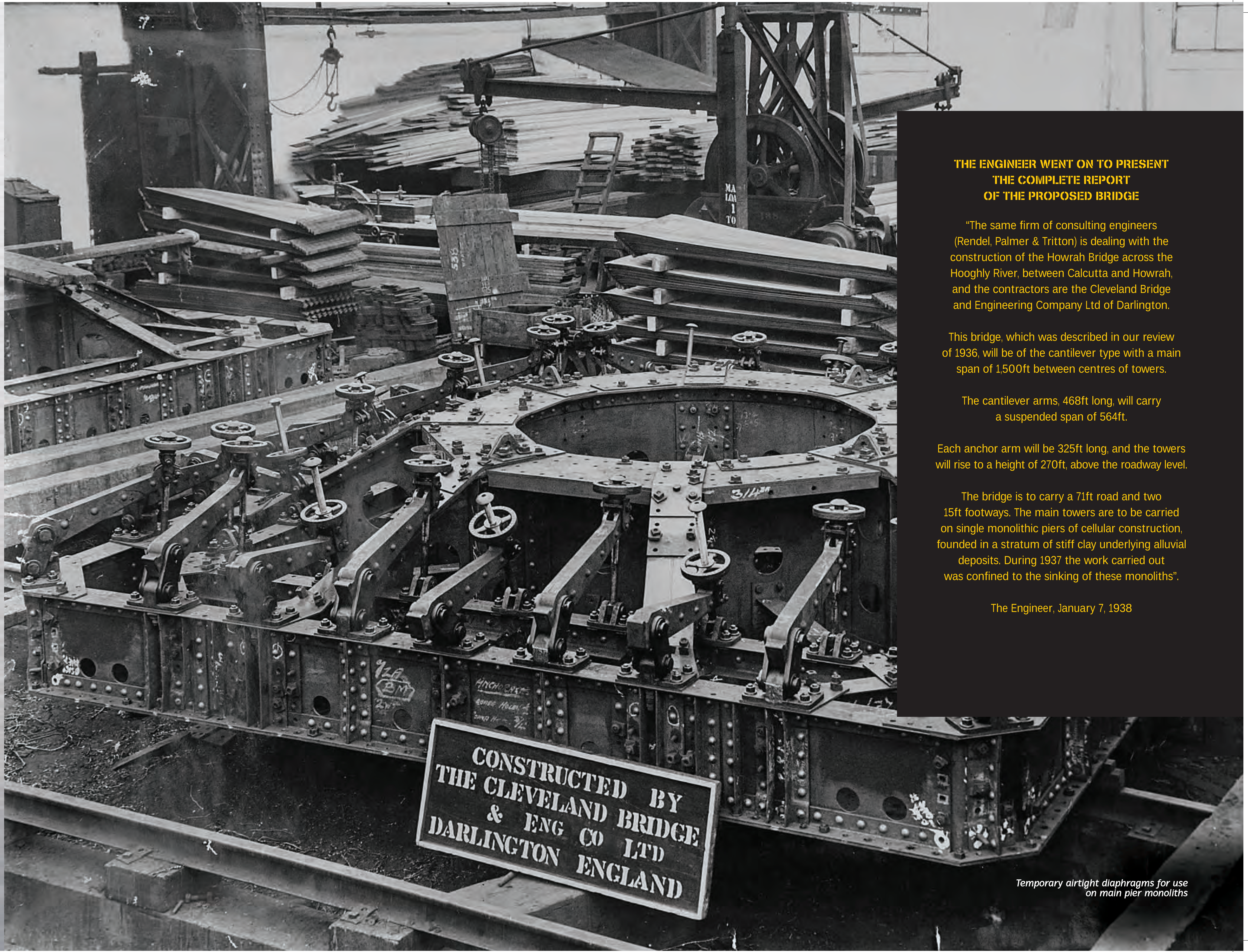
The archives of Rendel Palmer and Tritton say: "James Meadows Rendel, the 6th President of the Institution of Civil Engineers (ICE) 1851–1853 formed Rendel & Partners in 1838 in London, U.K. The company later changed its name to Rendel, Palmer & Tritton". This was the company that was asked to design the cantilever bridge of 1,500 feet span, with a fixed height, a 71 feet wide roadway with two 15 feet cantilever footways. In doing so, it also considered navigational aspects at the Hooghly, hydraulics and its tidal conditions. Its report was available by 1929 and commented upon by the technical media.

KING GEORGE VI BRIDGE

"Work on this structure was begun late in 1935, and the first trains passed over it last September. It has seven river spans, each 331ft long, and six approach spans of 105ft. The steelwork is supported upon masonry piers built on special foundations, which were formed by open dredging in 60ft of water and through 80ft of sand and clay below the bed of the river. The district being subject to earthquakes, the piers have been constructed in the manner shown in an accompanying engraving, so that a certain amount of angular distortion can occur without affecting the stability of the bridge".—The Engineer, January 7, 1938

Tata Steel had already presented its steel making credentials at the highest level with aplomb!

Steel work, amounting to some 3,400 tons, was manufactured by the Tata Iron and Steel Company



THE ENGINEER WENT ON TO PRESENT THE COMPLETE REPORT OF THE PROPOSED BRIDGE

"The same firm of consulting engineers (Rendel, Palmer & Tritton) is dealing with the construction of the Howrah Bridge across the Hooghly River, between Calcutta and Howrah, and the contractors are the Cleveland Bridge and Engineering Company Ltd of Darlington.

This bridge, which was described in our review of 1936, will be of the cantilever type with a main span of 1,500ft between centres of towers.

The cantilever arms, 468ft long, will carry a suspended span of 564ft.

Each anchor arm will be 325ft long, and the towers will rise to a height of 270ft, above the roadway level.

The bridge is to carry a 71ft road and two 15ft footways. The main towers are to be carried on single monolithic piers of cellular construction, founded in a stratum of stiff clay underlying alluvial deposits. During 1937 the work carried out was confined to the sinking of these monoliths".

The Engineer, January 7, 1938

Temporary airtight diaphragms for use on main pier monoliths

The Lay of the Land

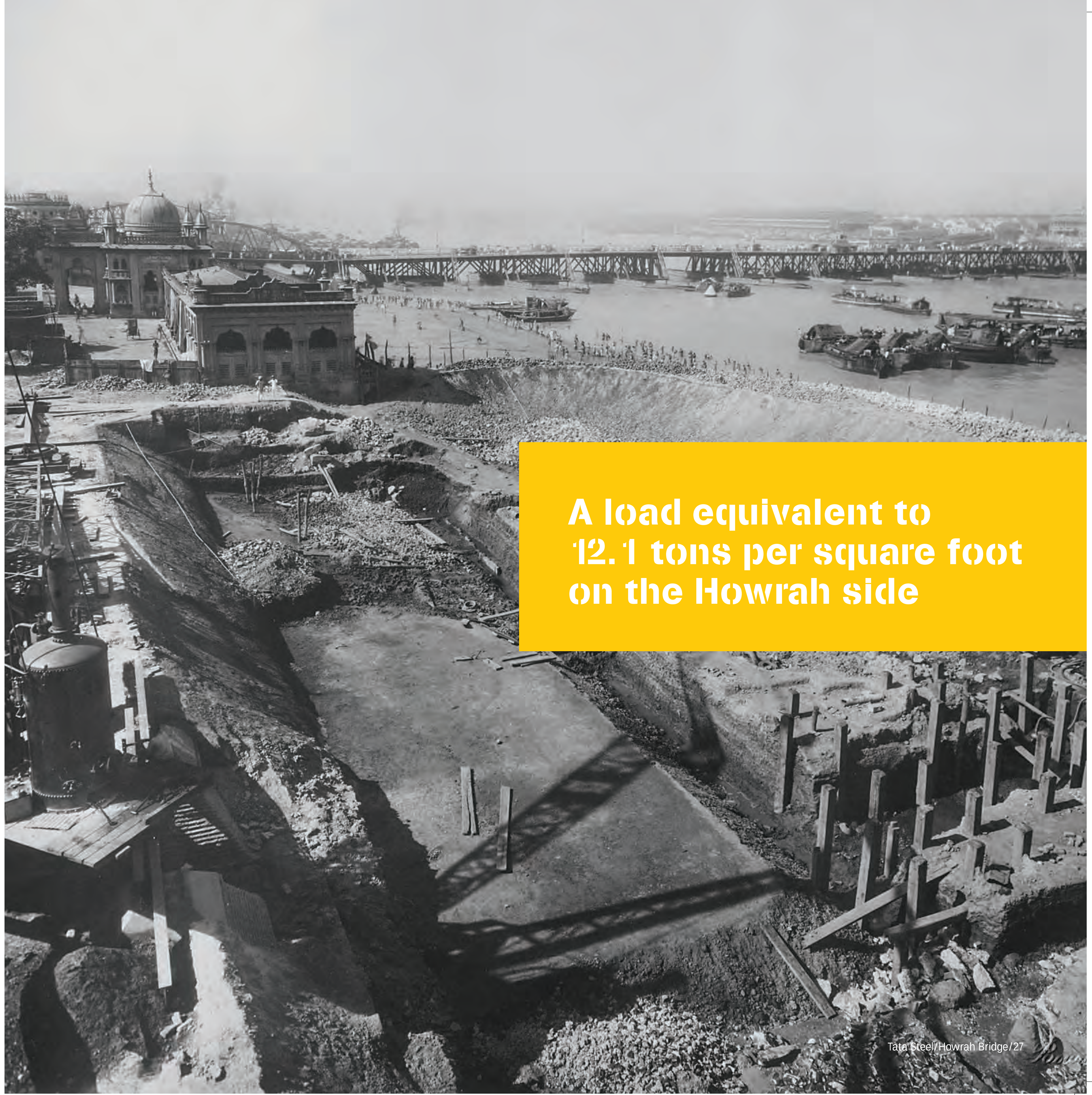
In 1921, the chief engineer, Port Commissioners, carried out tests to ascertain the bearing capacity of the clay bed at the Hooghly. The tests showed that, with a load of 5.5 tons per square foot, the settlement was almost negligible. Thereafter, there were confirmatory tests by Rendel, Palmer & Tritton, with cylinders sunk 10 feet into the hard clay. These proved that with a load equivalent to 12.1 tons per square foot, there was practically no sinking on the Howrah side. On the 'Calcutta' side, a load of 16 tons per square foot was supported without sinking, skin friction being eliminated in each case. Thus the load proposal for the Howrah abutment foundation of the bridge would amount to an average of 6.14 tons per square foot with a maximum toe pressure of 6.5 tons per square foot. On the 'Calcutta' side, the average load imposed on the abutment would be 7.3 tons per square foot, with a maximum toe pressure of 7.8 tons per square foot.

"These tests show that on both sides of the river the clay bed will have a factor of safety of almost exactly 2 under the worst condition of load and wind pressure—a combination which can never come about in actual practice, as, in a wind of the velocity required to give the maximum wind pressure, there can be little (if any) live load crossing the bridge", said Rendel, Palmer & Tritton.
In dealing with the proposed cantilever bridge, with a main span of 1,500 feet between centres of towers and two anchor spans, each of 446 feet, the location was determined by two important factors. One, that it was unnecessary "for ocean-going steamers to proceed above the bridge" and the discovery of a bed of hard clay of 97 feet below the surface on the 'Calcutta' side and 79 feet below the surface on the Howrah side.

Rendel, Palmer & Tritton said that: "The first of these factors, eliminating the necessity for an opening span generally simplifies the design for a single-span bridge, while the second entirely revolutionises the previously held opinions as to the permissible foundation loads in the neighbourhood of Calcutta".

Prior to the discovery of this stratum of hard clay, Rendel, Palmer & Tritton held that the difficulties in regard to a single-span bridge were almost insuperable, because of the enormous loads, "which would have to be carried by the abutment foundations-loads far in excess of anything previously attempted in this locality".

It was not all muck…coins dating back to the East India Company were amongst the finds



A load equivalent to 12.1 tons per square foot on the Howrah side

The Foundations

Cut to the abutment foundations. The designers thought hard and finally proposed to enclose the whole area with steel sheet piling driven from above the highest high water level down into the clay, so as to avoid such 'blows' and inrushes of water that made sinking the test cylinders such a troublesome affair. The monoliths or wells to be sunk to form the foundation would, in the aggregate, cover an area of 116 feet by 196 feet or 22,736 square feet for each abutment. There would be 15 monoliths on each side, each 36 feet square, spaced four feet apart.

The Engineer wrote, "It is evidently the intention to arrange the monoliths as shown in the accompanying sketch Fig.3 the twelve monoliths sunk being shown unhatched. It is explained that the estimates provide sinking only twelve of the total number". The designers intended "to excavate, in the dry, the area enclosed by the 12 monoliths and thus save the cost of well sinking".

The core issue while designing the foundation was to keep the load down to the minimum possible. Reinforced concrete was chosen to reduce the thickness of the walls and the idea was to form a practically cellular construction with a bed of concrete at the bottom to spread the load of monoliths and over the whole area excavated. The foundations for the anchor arms of the cantilever too would be constructed in the same manner and approximately, to the same depths, to provide practically the same unit load on the clay as in the abutments. Rendel, Palmer & Tritton believed that this would be essential for construction purposes.

However, once the bridge was up, the weight of the superstructure between the main abutments would more than counterbalance the weight of the anchor arms; the excess taken by the the weight of those anchor foundations, with an ample margin of safety.

There would be 15 monoliths on each side, each 36 feet square, spaced four feet apart

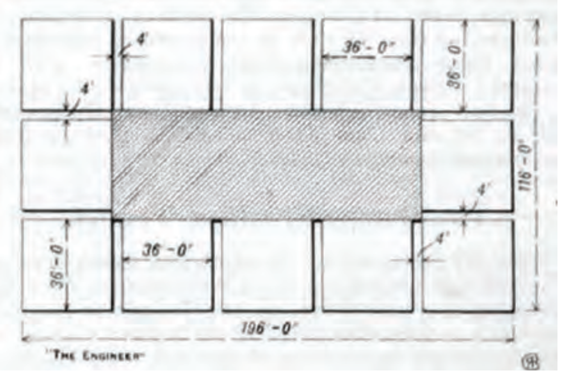
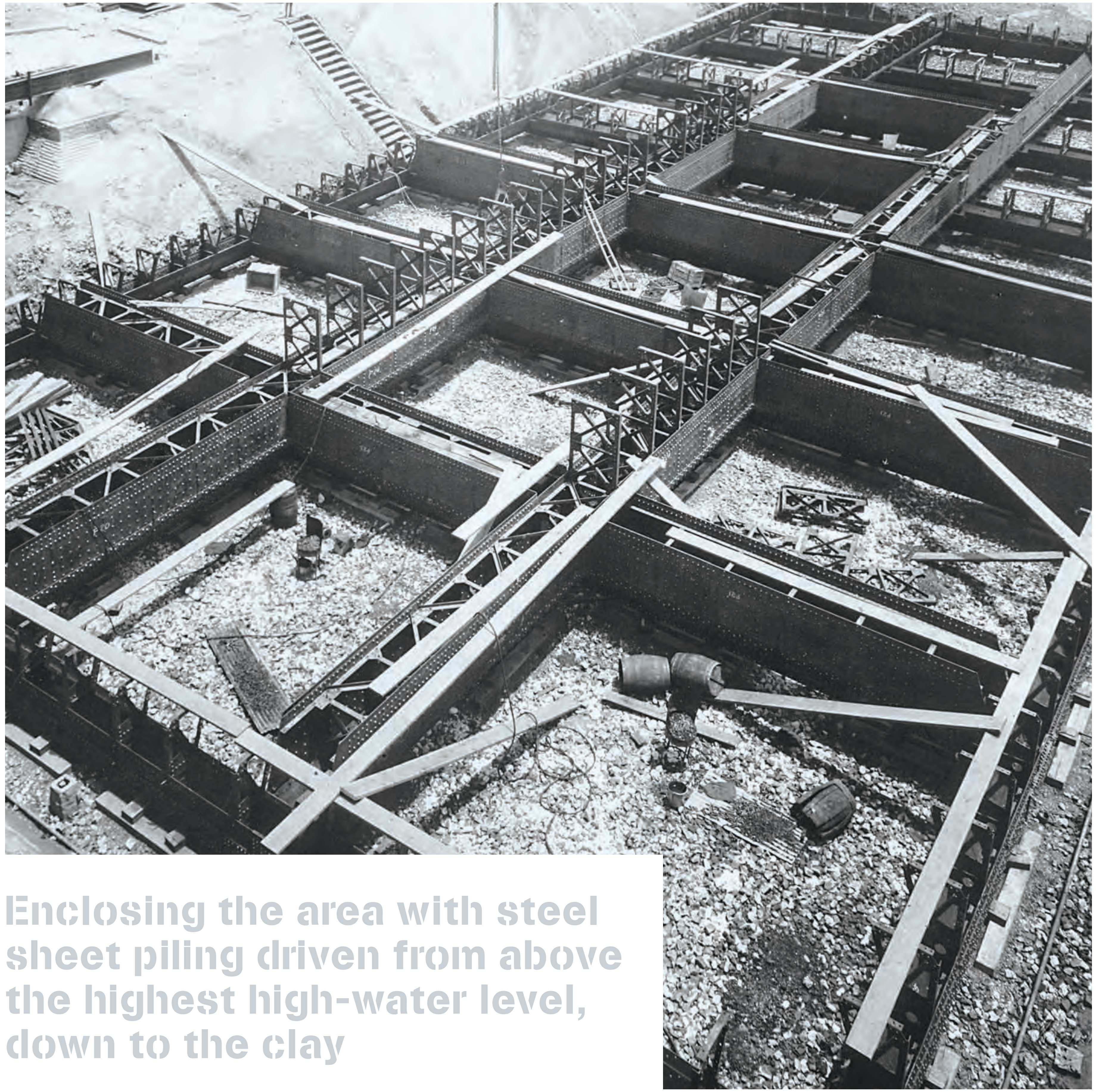


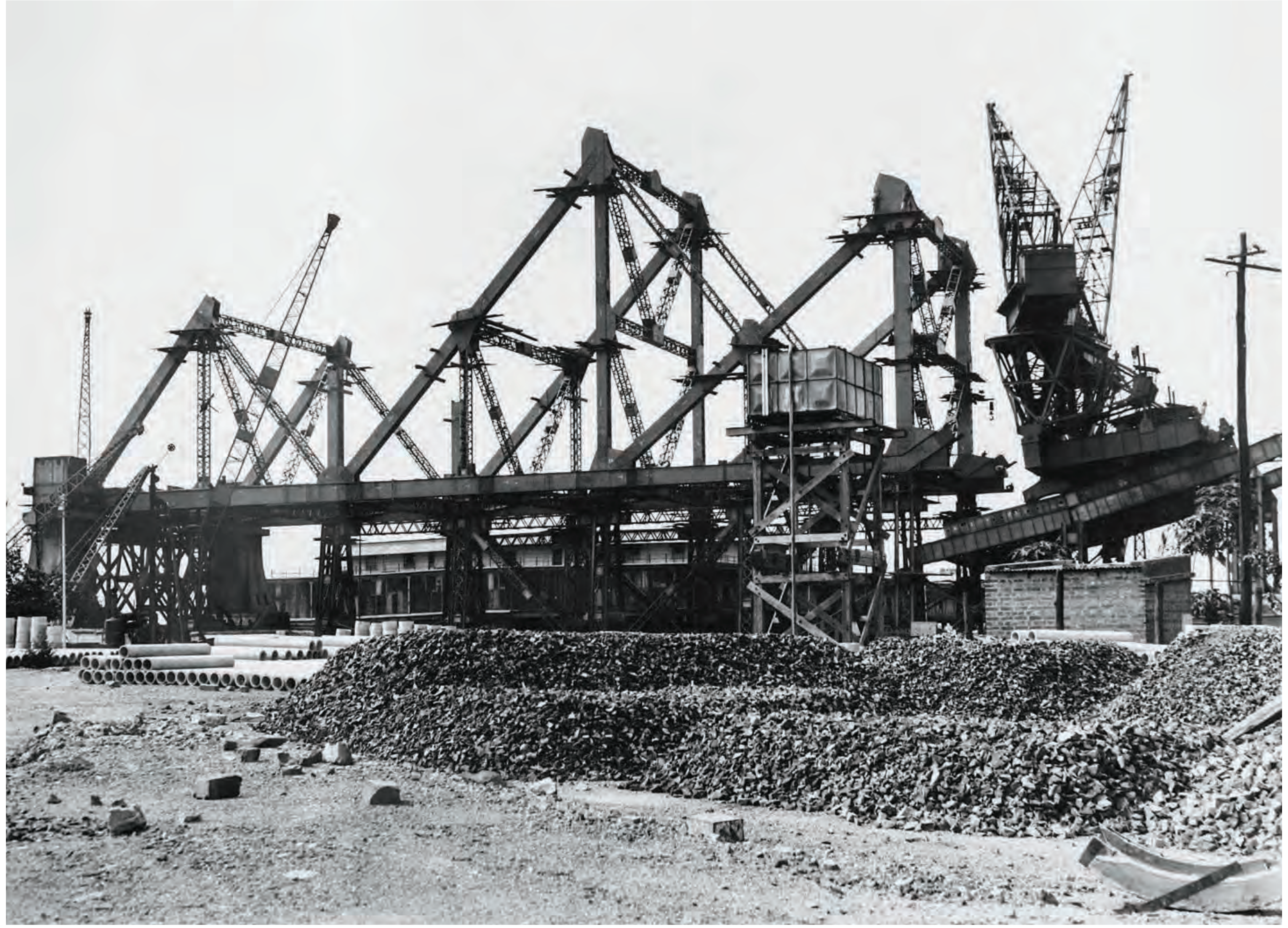
Fig.3 Arrangement of monoliths in Abutment Foundation

The core issue while designing the foundation was to keep the load down to the minimum possible



Enclosing the area with steel sheet piling driven from above the highest high-water level, down to the clay

*Building upon solid foundation.
General site view in July 1937*



‘It was originally proposed that tramways should be taken across the bridge but the idea was given up, and it is now suggested that there should be a clear roadway…’

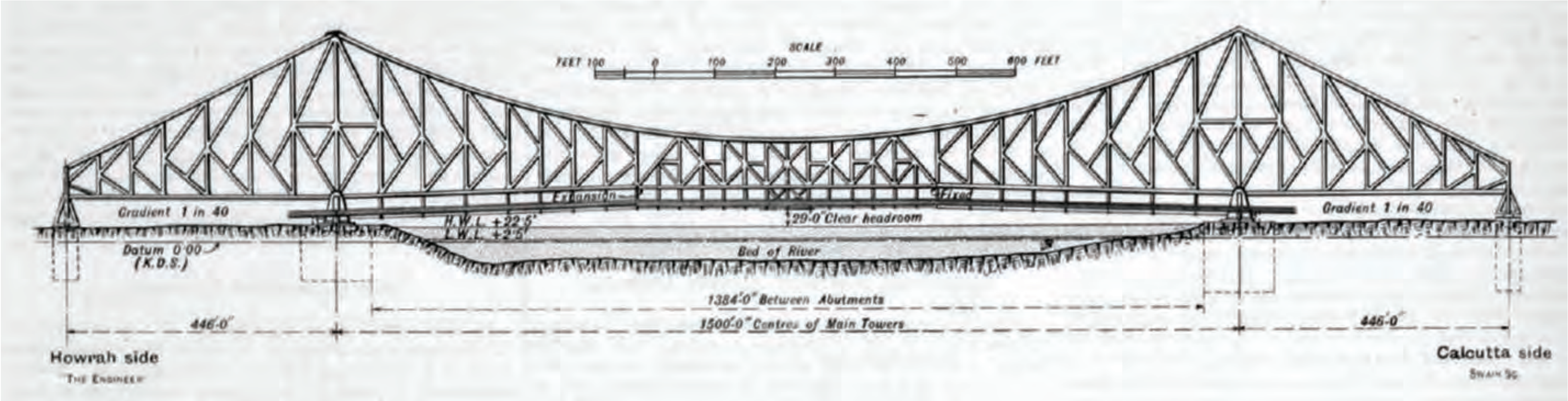


Fig.1 Side elevation of proposed cantilever bridge

The Engineer explained, “The form of superstructure proposed is shown in Fig.1 while a cross section through the centre of the suspended span is given in Fig.2. It was originally proposed that tramways should be taken across the bridge but the idea was given up, and it is now suggested that there should be a clear roadway, 80ft wide and a footway 15ft wide, outside each main girder these footways being carried on extensions of the cross girders. The overall width of the bridge would be about 130ft. It is suggested that the two arms of the main span should be built outwards until they met in the centre, when they would be joined up, the central portion being thus changed from the cantilever form to a suspended span”.

How would this construction help? It would obviate the risk to building the suspended span girders separately and then floating out such heavy loads and lifting them into position. The floor system would be carried on hangers and a clear headway of 25 feet given for vehicular traffic. The lower chord of the bridge as designed, would be at a height of 64 feet above the highest water level in the fairway of the river. “In the extremely unlikely event of an ocean-going vessel colliding with the bridge, only the masts and possibly the funnels of vessels could reach the main structure”, the designers explained. The main structure itself would be further protected on each side by the projections—about 20 feet wide, carrying the footways.

Thus, any damage to the floor system would be quite local and easily repaired and it would not affect the stability of the main structure. The carrying of the bridge floor on hangers from the main girders would have the additional advantages. First, those girders could be completely erected before the weight of the floor system was added. Second, during the erection of the main structure there would be the clear headway of 64 feet for navigation.

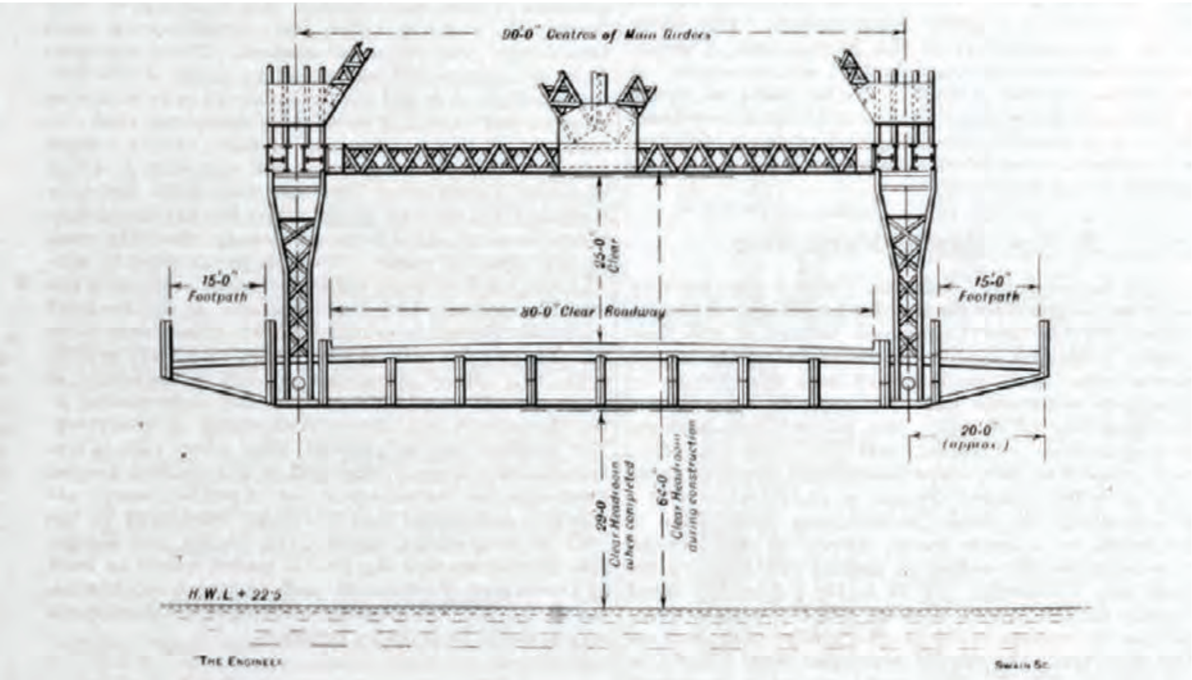


Fig.2 Cross section of proposed cantilever bridge

The work was supervised by the engineers, who had resident inspectors at the sites

The preliminary estimated cost of the entire structure was £2,656,999 or Rs 315,426,659. The cantilever bridge would cost around one and three-quarter times as much as a floating bridge. The final estimates from Rendel, Palmer and Tritton included charges for insurance, freight, import duty, and landing dues for all steel work plant and other material that may be shipped from England. In the charges for plant, allowances were made for the amounts recoverable by the sale of such portion of it as might be disposable at the termination of the work of erection.

To go by the account of Maurice and Bateson, the Commissioners for the New Howrah Bridge permitted the tenderers to submit alternative offers with complete design or design specification, full particulars and controlling dimensions of the required bridge, the loading to be provided for and the permissible working stresses in the materials. Advance information, including the design specification and draft conditions of contract, was placed at the disposal of all interested firms, who sent their engineers to 'Calcutta' to inspect the site and obtain the necessary local information required for preparing their tenders.

In the intervening period, yet another committee, the 'Goode Committee', comprising SW Goode, as president, SN Mallick and WH Thompson, was constituted to 'investigate and report on the advisability of constructing a pier bridge between Calcutta and Howrah'. The bureaucracy seemed endless and opinions poles apart as Geoffrey Moorhouse's, 'Calcutta', talks of the angst of an EP Richards, chief engineer of the Calcutta Improvement Trust, who rued (in 1914) that the proposed new bridge as tendered for would be "too narrow even from the first day it was opened to traffic".

These observations were probably taken on board when the complete tender documents were finally issued in December 1934. The deadline for the receipt of tenders, at the Commissioners' Office in 'Calcutta' or at the Consulting Engineer's Office in London, was March 26, 1935. The date was subsequently altered to April 30, 1935. There was concern that the bureaucracy would ensure that the bridge never came up. Moorhouse suspected that "it might still have been in the building if the military had not required a proper crossing at that point for fighting their war against the Japanese".

The preliminary estimated cost of the entire structure was £2,656,999 or Rs 315,426,659. The cantilever bridge would cost around one and three-quarter times as much as a floating bridge

General view of construction 1939

Bidding for the Bridge

Post-event scepticism notwithstanding, four firms tendered; three in London—one English, one Scottish and one German—and one in 'Calcutta'; a combine of three leading Indian structural firms, Braithwaite, Burn & Jessop (BBJ). The three London tenders were for the complete official scheme only, while the Indian combine also submitted offers for six alternative schemes. The four tenders for the complete official scheme ranged from Rs 209,73,099 to Rs 232,72,918 of which the German tender was the lowest. Those for the alternatives ranged from Rs 181,83,317 to Rs 228,04,980.

Three of the alternative tenders were for the official design of the superstructure. One had the official design of foundations but modified vis-à-vis methods of construction and material. Two offered alternative types of foundations. Only one of these tenders was lower than the lowest offer for the complete official scheme but the proposed alternative foundations were considered unacceptable, said Maurice and Bateson. There were then other design issues.

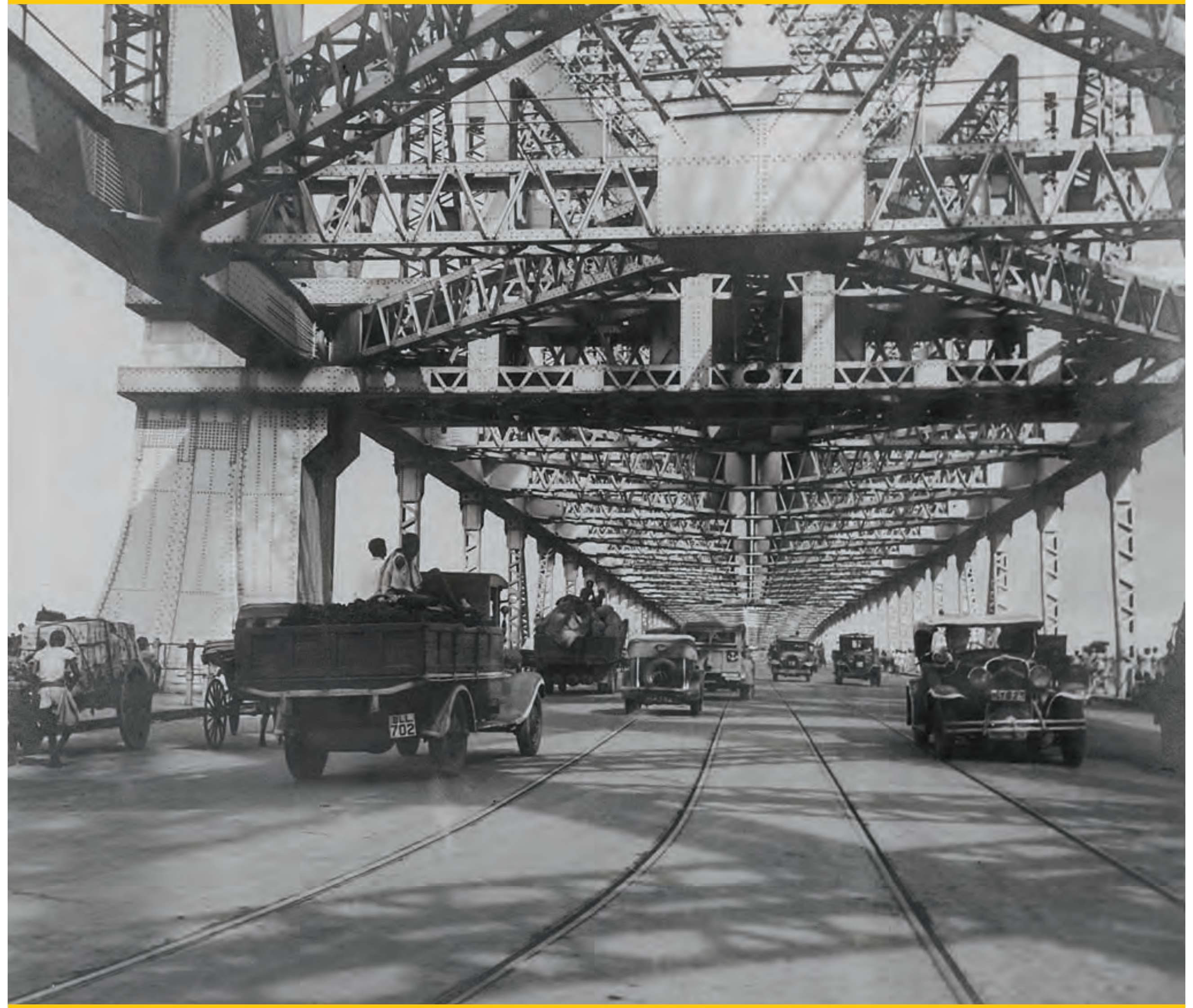
Of the three remaining alternative tenders for a modified design of superstructure in combination with three alternative types of foundations, none could satisfy the stringent demands of the assessors. The proposed modified design of the superstructure was about 46 feet shorter than the specified span of 1,500 feet and had an inferior deck. This did not make much of a difference to the cost that was essentially contributed by the alternative type of foundations.

"Neither the modified design of superstructure nor any of the alternative of foundations was considered acceptable for the proposed bridge and all the alternative tenders were therefore ruled out". There was then no option but to look at the four tenders for the official scheme, all of which were from constructing companies of repute.

Krupp's from Germany was, as expected, the most competitive and should have got the contract but the British were already suspicious of Germany and thought the better of giving a contract to a German firm, work for which would probably take at least five years to complete. "Therefore, the German tender was passed over and the decision was justified by subsequent events", as Maurice and Bateson pointed out.

It was then the turn of the Cleveland Bridge and Engineering Co Ltd to be considered, being the second lowest bid. Again the Indian bureaucracy intervened—and rightly so—insisting that a job of such import should engage the Indian steel industry to the extent possible. Both BBJ and Tata Steel had proven credentials and could hardly be deprived of the opportunity to prove themselves all over again. Fortunately, the Cleveland Company saw merit in the argument and was convinced about the local expertise, agreeing to "purchase in India the whole of the structural steelwork obtainable in that country if they could agree to reasonable terms of Indian manufacturers".

Cleveland agreed to "purchase in India the whole of the structural steel work obtainable in that country if they could agree to reasonable terms of Indian manufacturers"

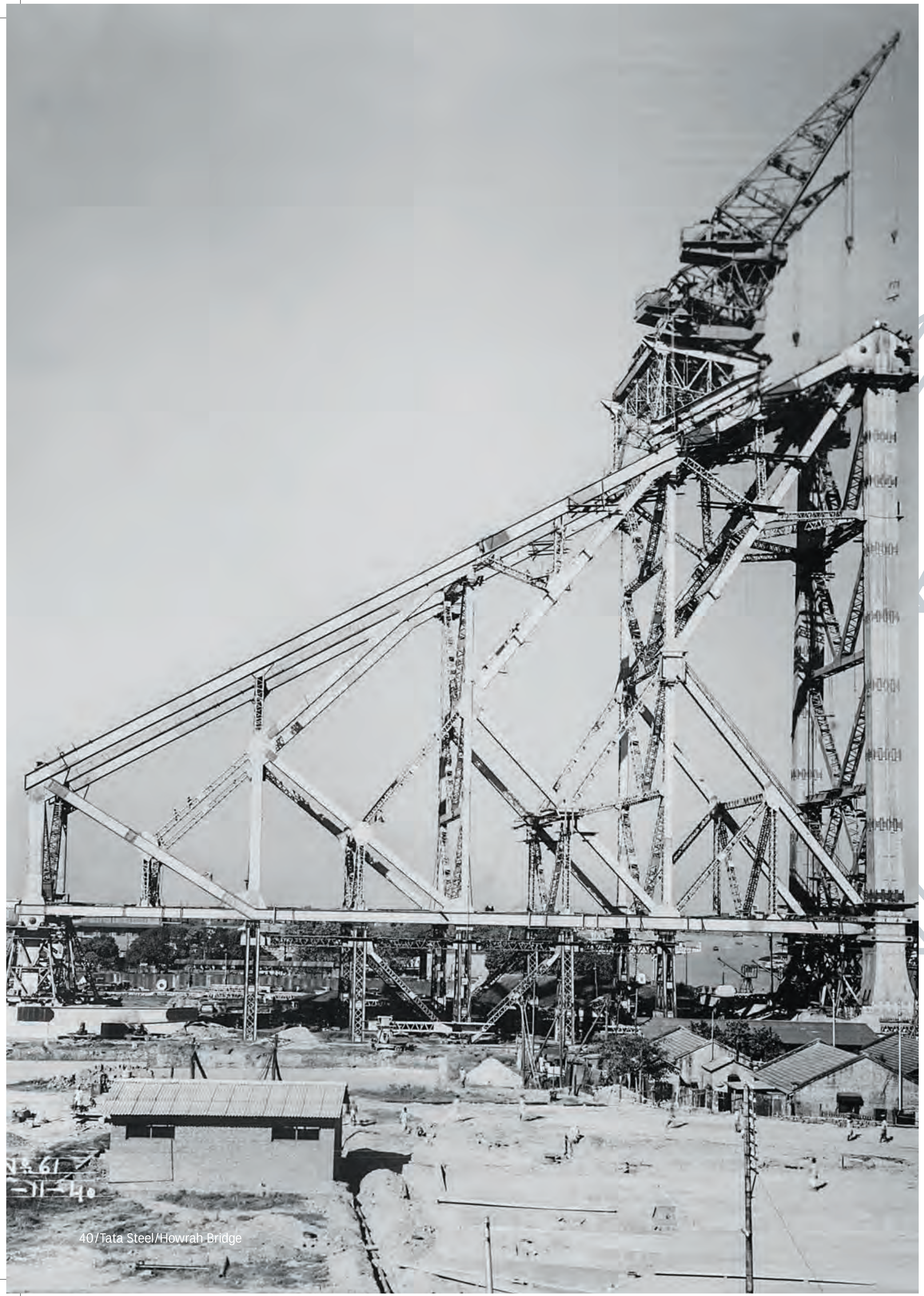


Both BBJ and Tata Steel had proven credentials and proved themselves all over again

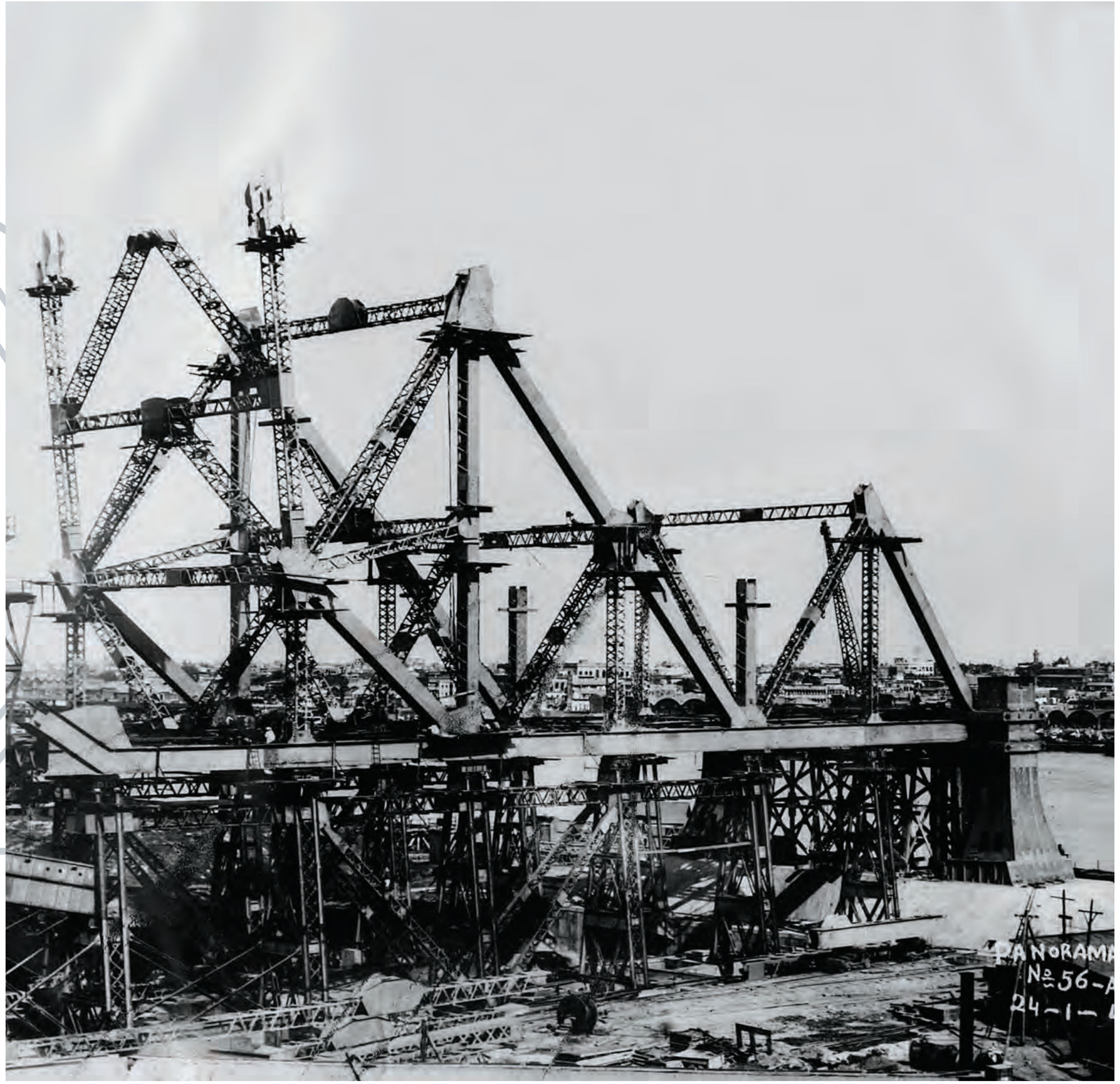
Cleveland secured the contract for the whole work in 1936 and managed the erection at site while BBJ became the sub-contractors for the fabricated steel work. The fabrication specifications were as stringent as they were interesting and challenging.

Fabrication Specifications

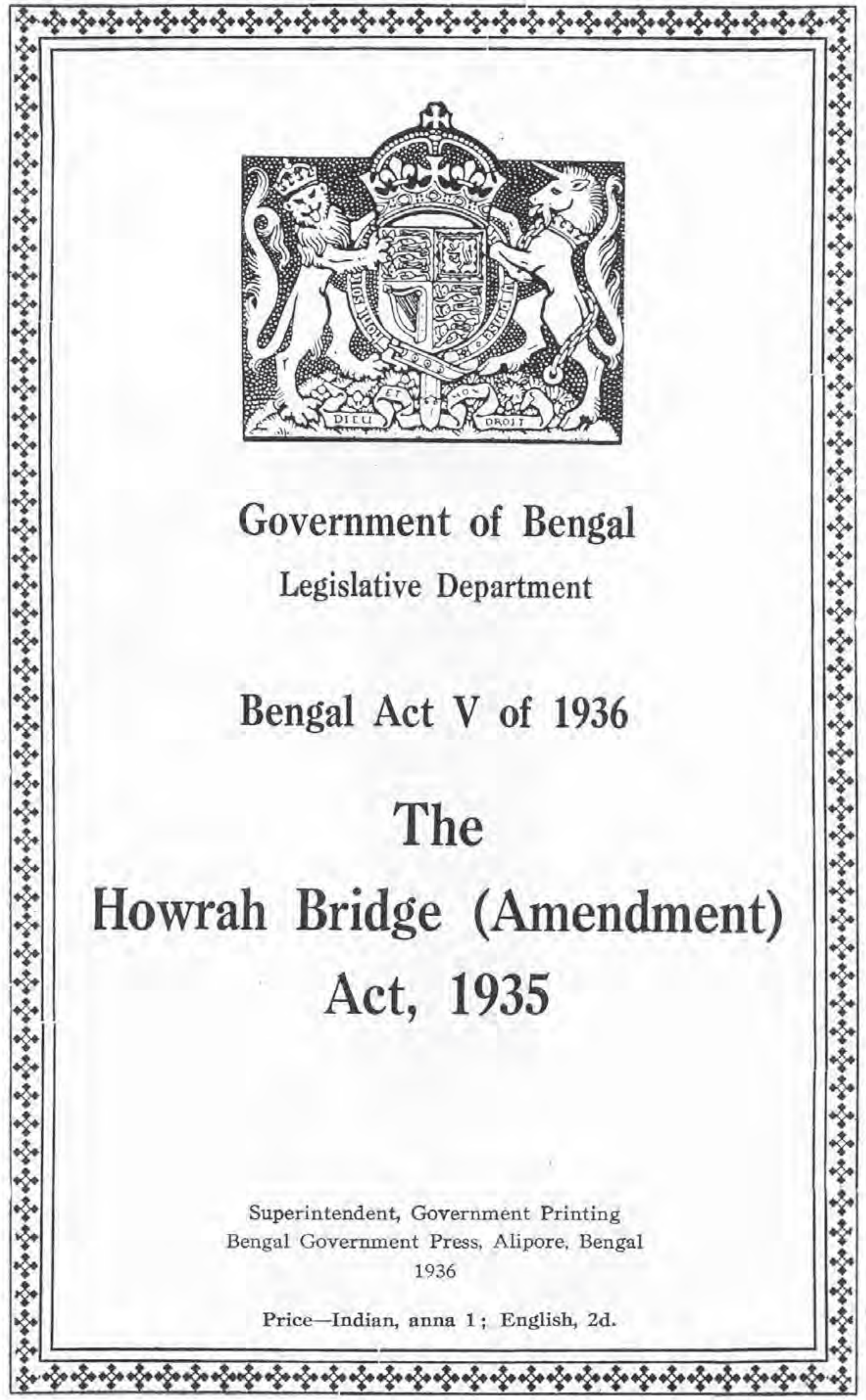
- All members meeting at intersection points had to be set up on a horizontal bed with the members accurately laid out and securely fixed at the correct intersection angles, with all the connection-plates and covers in position.
- The previously drilled small holes were then to be opened up through all thicknesses, at one operation, to the required final diameters for the site connection rivets.
- The intersection angle at which the various members were to be laid out were to be accurately determined to correspond with the loaded profile of the bridge, thereby eliminating secondary stresses as far as possible.
- Butt-joints in permanent compression members were designed to transmit load by direct bearing of the abutting ends. Such joints were only covered and riveted to a value of 50 per cent of the strength of the member. Such joints demanded sophisticated workmanship because the abutting ends of such members had to be accurately machined to give absolute contact over the full cross-section of the member.
- Special tapered holes, to suit the tapered plugs appropriately, were called for at all intersection points to facilitate setting out of the members at the correct intersection angles and to provide datum-points for measuring the lengths of members.
- This specified accuracy of the length of each section of a member, measured over machined ends or from intersection point to machined end, as the case might be, was plus or minus 1/64 inch.
- All measurements were to be made with steel tapes graduated at a temperature of 68° Fahrenheit and under a tension of 4 lb, for 50 feet by 5/8 inch tapes or 10 lb for 100 feet by 3/4 inch tapes.
- Certificates for accuracy for all tapes used were obtained from the National Physical Laboratory, Teddington.
- The design had to be such as to obviate direct sunlight from falling on a part of a member being marked out or machined, in order to ensure that the temperature of such members should be uniform throughout.
- The fabrication of the steel work was supervised throughout by the engineers, who had resident inspectors at all the works.



Howrah cantilever during construction



And the twain begin to meet



Government of Bengal
Legislative Department

Bengal Act V of 1936

The
Howrah Bridge (Amendment)
Act, 1935

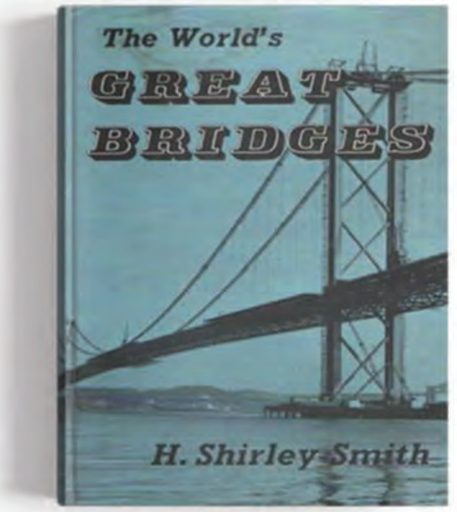
Superintendent, Government Printing
Bengal Government Press, Alipore, Bengal
1936

Price—Indian, anna 1; English, 2d.

Once all was finalised, there was need to amend the Howrah Bridge Act of 1926 and replace it with the 1935 New Howrah Bridge Act

Sir Hubert Shirley-Smith

Yet another person who seems to feature nowhere in popular literature on the Howrah Bridge is a British civil engineer. Sir Hubert Shirley-Smith (born October 13, 1901, London, England—died February 10, 1981, London), designed steel bridges the world over but is arguably the most famous for "helping to design the Howrah Bridge in Calcutta for the Indian Public Works Department in 1943", to go by Sir Banister Fletcher's, 'A History of Architecture'. Evidence of his contribution is to be found in a paper on the construction of the bridge that he wrote along with GE Howorth. Sir Hubert presented a detailed account of how the bridge was actually made, beginning with being accommodative of the local engineering skills and steel, although there was no contractual obligation to do so.

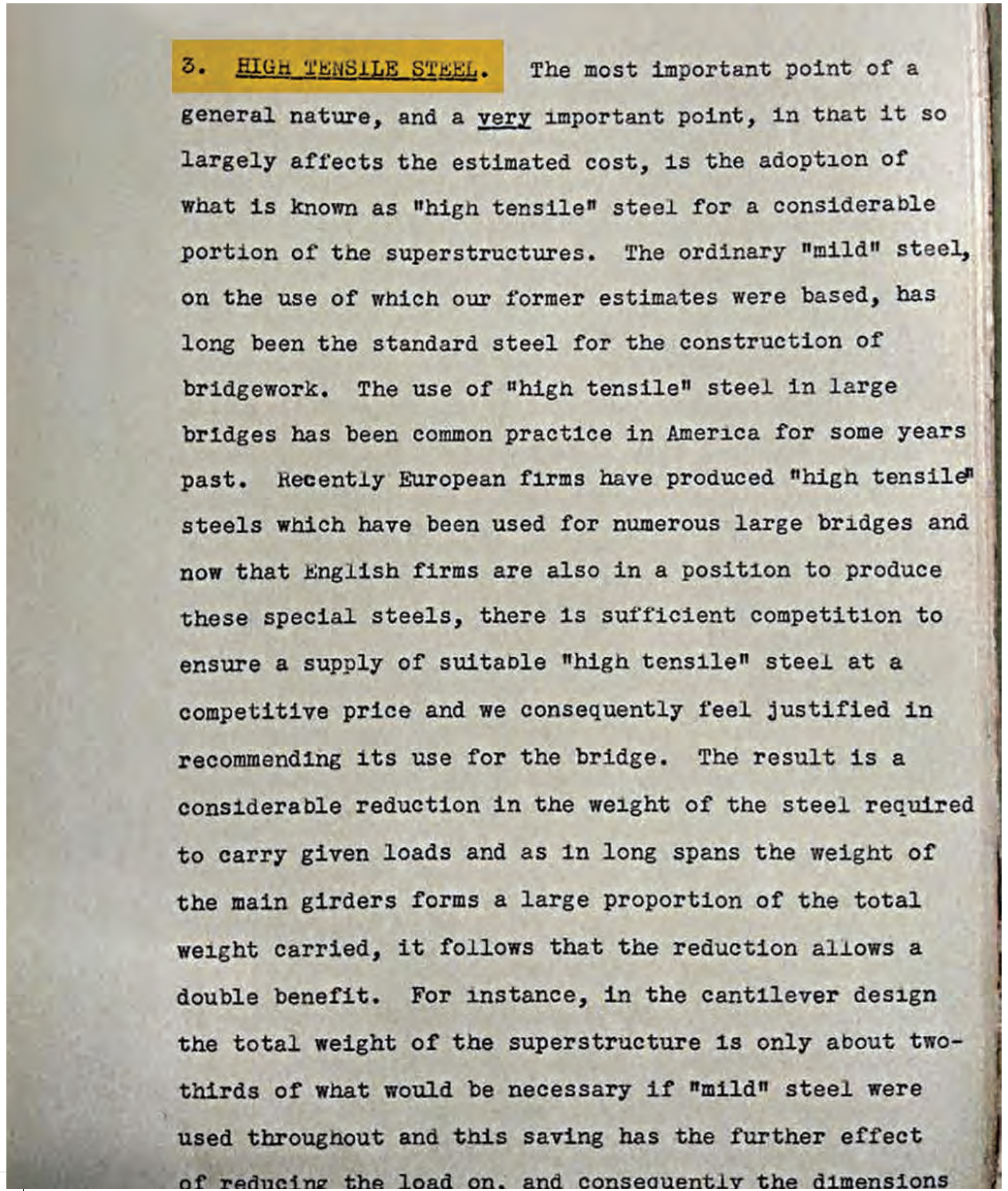


MAKE IN INDIA

"Strong representations were made to the contractors that as far as might be found practicable they should do so (use Indian steel for the permanent work). The contractors' tender was based on steel fabrication in their own works in England but, after re-examination of the whole position, it was found possible to sublet the supply and fabrication of about 23,500 tons out of a total weight of 26,500 tons of permanent steel work in India. This steel was supplied by the Tata Iron & Steel Company Limited, Jamshedpur and fabrication was undertaken by the Braithwaite, Burn & Jessop Construction Company at four different shops in Calcutta. The remaining 3,000 tons, including wide plates and a number of special items such as the universal joints at the end of the suspended span, all the heavy pins and bushes and the assemblies of hydraulic and screw jacks used for closing the span were made in England. The creeper cranes, all major items of plant, and a further 2,500 tons of steel work for temporary structures were also made in England".

GE Howorth and Hubert Shirley-Smith

How did Tata Steel Manage to Deliver?



3. HIGH TENSILE STEEL. The most important point of a general nature, and a very important point, in that it so largely affects the estimated cost, is the adoption of what is known as "high tensile" steel for a considerable portion of the superstructures. The ordinary "mild" steel, on the use of which our former estimates were based, has long been the standard steel for the construction of bridgework. The use of "high tensile" steel in large bridges has been common practice in America for some years past. Recently European firms have produced "high tensile" steels which have been used for numerous large bridges and now that English firms are also in a position to produce these special steels, there is sufficient competition to ensure a supply of suitable "high tensile" steel at a competitive price and we consequently feel justified in recommending its use for the bridge. The result is a considerable reduction in the weight of the steel required to carry given loads and as in long spans the weight of the main girders forms a large proportion of the total weight carried, it follows that the reduction allows a double benefit. For instance, in the cantilever design the total weight of the superstructure is only about two-thirds of what would be necessary if "mild" steel were used throughout and this saving has the further effect of reducing the load on, and consequently the dimensions

From the Rendell, Palmer & Tritton Report 1933

High-tensile structured steel had by then proven itself. The 1933 estimates for a self-anchored suspension bridge and, optionally, for a comparable cantilever bridge, clearly demonstrated their faith in the strength and value for money propositions of high-tensile structured steel. The official cantilever design made use of such high-tensile steel wherever it would deliver lower costs. Nevertheless, the design specification was effectively drawn up to cover the use of both ordinary structural steel to BSS 153 and high-tensile structural steel having an ultimate tensile strength of from 37 tons to 43 tons per square inch, "a yield-point of not less than 23 tons per square inch, and an elongation of not less than 18 per cent", said Maurice and Bateson. These values for high-tensile structural steel are the same as those subsequently adopted in BSS No 548, in 1934. High-tensile rivet steel was specified to have an ultimate sheer strength, on driven rivets, of 26 tons per square inch.

Sir M Visvesvaraya

How did Tata Steel manage to deliver to the required specifications? Of course, the participation became possible thanks to the metallurgical department for process control started by the company in 1925, which was constantly improving steel quality and addressing customer feedback. By the time the bridge was being built it had a fully-fledged research and control laboratory that was formally inaugurated on September 14, 1937 by Chairman, Sir Nowroji Saklatvala, and Sir M Visvesvaraya. Such guiding visionaries were inspiration enough but the department received further impetus when the company was tasked with making a suitable low-alloy structural steel for the New Howrah Bridge.

Sir Nowroji Saklatvala

Tata Steel records show that the final specification called for the use of high-tensile structural steel having a specified tensile strength between 5.82 and 6.77 metric tons per square millimetre (37 and 43 tons per square inch—1 kilogram is equal to 0.001 metric tonnes, or 0.00110231 tons) and it had to launch a comprehensive R&D initiative to produce steel that would comply with the specifications. The going was not easy and there were difficulties galore though none that its metallurgists and engineers could not overcome. There were problems with the rolling of sections in the mills.

The degree of spread of the steel under the rolls was different from the plain carbon steel. Roll pass designers had to step in and to modify the pass design so that it was possible to roll sections in this special alloy steel quality as well as in plain carbon quality on the same roll-setting. "If they had to rely on import of steel, the construction would have been enormously delayed. Even during this period, Tata Steel had to sell steel to support the war effort; steel was sold at controlled prices! Sir Jehanghir Ghandy was knighted because of this contribution", says Dr Tridibesh Mukherjee, former Deputy Managing Director, Tata Steel. "The name Tata Iron and Steel Co is embossed on the steel structural", he says.

Rolling out the New Howrah Bridge (Source: Howorth & Shirley-Smith)		
	Calcutta	**Howrah**
Work commenced at site	October 1936	
Main Monoliths: Well curbs laid	May 1937	
Concreting started	September 1937	
Sinking commenced	November 1937	
Plugging commenced	April 1938	July 1938
Plugging completed	May 1938	November 1938
Anchoring steel work erected	May 1938	February 1939
Erection of Towers begun	April 1939	July 1939
Erection of anchor arm begun	October 1939	March 1940
Erection of anchor arm and tower completed	November 1940	February 1941
Erection of cantilever arm completed	June 1941	August 1941
Erection of suspended span completed	December 1941	
Closure and swinging of suspended span	December 1941	
Deck steelwork completed	March 1942	
Bridge ready for traffic	August 1942	

The bridge as it looked in November 1940

Photo © Satyaki Ghosh

TATA IRON & STEEL COMPANY LIMITED, JAMSHEDPUR, SUPPLIED

23,500

TONS OUT OF A TOTAL WEIGHT OF 26,500 TONS OF PERMANENT STEEL WORK

Coming up with Tiscrom

The solution was found in the newly developed Tiscrom which, by the nature of the alloying elements present, produced a hard scale that is not easily removed from the surface during rolling as is the case with rolling plain carbon steel

There was yet another problem with the removal of the tightly adhering scale in order to prevent its being rolled in. The solution was found in the newly developed Tiscrom which, by the nature of the alloying elements present, produced a hard scale that is not easily removed from the surface during rolling as is the case with rolling plain carbon steel. The team introduced high-pressure steam on every pass that broke off the scale and produced a clean section. The metallurgists also had to address the peculiar property of surface cracking due to the presence of copper.

There was fresh drama as the company had to successfully defend itself against a patents suit and satisfy the consulting engineers before it could establish its ability to substitute steel that the contractors might have wanted to import. Recalls Tridibesh Mukherjee: "Tata Steel had a Bolts Nuts and Rivets Mill that was shut down long before I joined. In fact, the steel melting shop, SMS 1, where the steel was made and all the mills in which the steel ingots were processed into products for the bridge have since been closed down". Even as technology advances, the former excellence survives and continues to serve.

By October 1936 everything was settled and work commenced at the site. Shirley-Smith and Howorth wrote that plant provision and methods of working employed on the building and sinking of the monoliths were based on normal standard practice. The monoliths were served by 10-ton steam derricks with 120-foot-gibs, four cranes being required at each of the main monoliths. Dredging was done by 60-cubic-foot grabs and, in accordance with the terms of contract, spoil was removed from the works by rail under arrangements made by the Port Commissioners. Concrete was mixed in two-cubic-yard batches at central batching-plants, one on each side of the river.

Standing in riveted attention

Making the Superstructure

The BBJ archives provide interesting trivia around the team of British senior engineers and foremen with Indian assistants working at the site. Muslims, Hindus, Sikhs and Pathans comprised the labour, including the skilled riveters. Most steel erection was done by Punjabis and Bombay khalassies, while Nepalis and Gurkhas kept vigil on the proceedings. There were 40 Indian crane drivers besides, trained on the job, working in three eight-hour shifts as the sinking of the monoliths—the biggest ever sunk on land, some 180 feet x 81 feet—was carried out day and night at a steady rate of a foot or more a day.

Erection of caisson steel work and sinking the monoliths were matters of great sophistication. The monolith curbs were assembled and riveted on adjustable steel packings on timber sleepers laid on prepared beds of broken brick 12 inches thick in the bottom of open excavations. These had been taken out for the removal of existing shallow foundations and obstructions.

On the 'Calcutta' side, the sinking was accompanied by interesting finds: parts of old country boats and their cargoes, bundles of flat and round iron bar, which had become embedded in very soft mud and silt, were dredged up from all shafts of the main monolith. This did not delay progress as much as might be expected; the weight of the monolith and of the heavy grabs broke up the obstructions quite effectively without the assistance of divers or explosives.

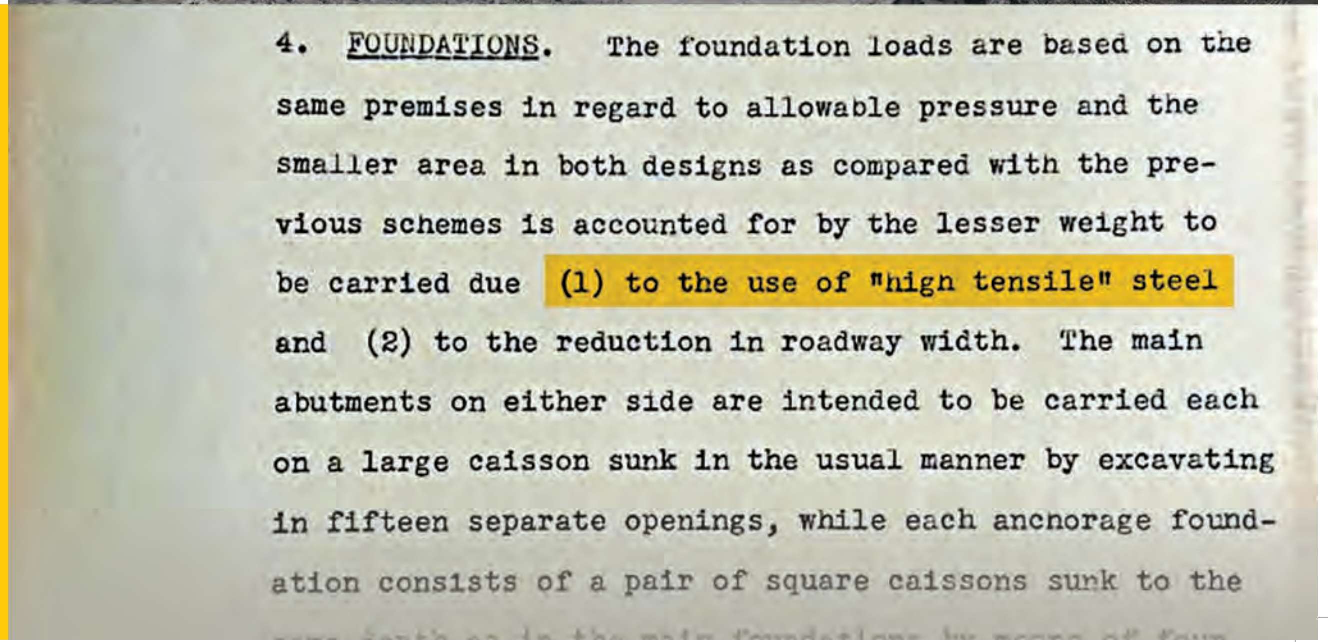
The BBJ archives talk of one night, while removing the muck to enable the caisson to move, the ground below it yielded, and the entire mass plunged two feet, shaking the ground. The impact of this was so intense that the seismograph at Kidderpore registered it as an earthquake and a Hindu temple on the shore was destroyed, although it was subsequently rebuilt. While muck was being cleared, a variety of objects were brought up, including anchors, grappling irons, cannons, cannonballs, brass vessels, and coins dating back to the East India Company.

As far as the sinking of the monoliths was concerned, Shirley-Smith and Howorth explained that both the main monoliths and a pair of anchor monoliths was sunk to the full depth by open dredging. The other pair of anchor monoliths on the 'Calcutta' side ran into a thick bed of fine sand.

To make matters worse, one of them was very close to the main office building, forcing the resident engineer to discontinue dredging. He opted for pneumatic sinking. The Howrah monoliths presented an easier task, given the more or less impervious materials that they were sunk through. It ranged from a soft, spongy consistency near the surface to a stiff yellow clay at founding-level, 87 feet below ground-level. "A good penetration (about seven feet into the stiff clay) was obtained and all the shafts were plugged in the open, after individual dewatering with about 15 feet of back-filling in adjacent shafts". The foundations were in place by 1930. The chief engineer for the bridge was AM Ward and the resident engineers, A Webster (1936–1939) and WT Wheeler (1930–1943).

'The floor beams, toughing and kerb were run out on decauville tracks laid on the rail bearers of the deck and skidded into position. The spot welding of the stirrups of the troughs, involving more than one million welds, was completed on special jigs at site before the troughs were erected. After the riveting was finished the reinforcement was placed and the roadway concrete was poured.'—Shirley-Smith and Howorth

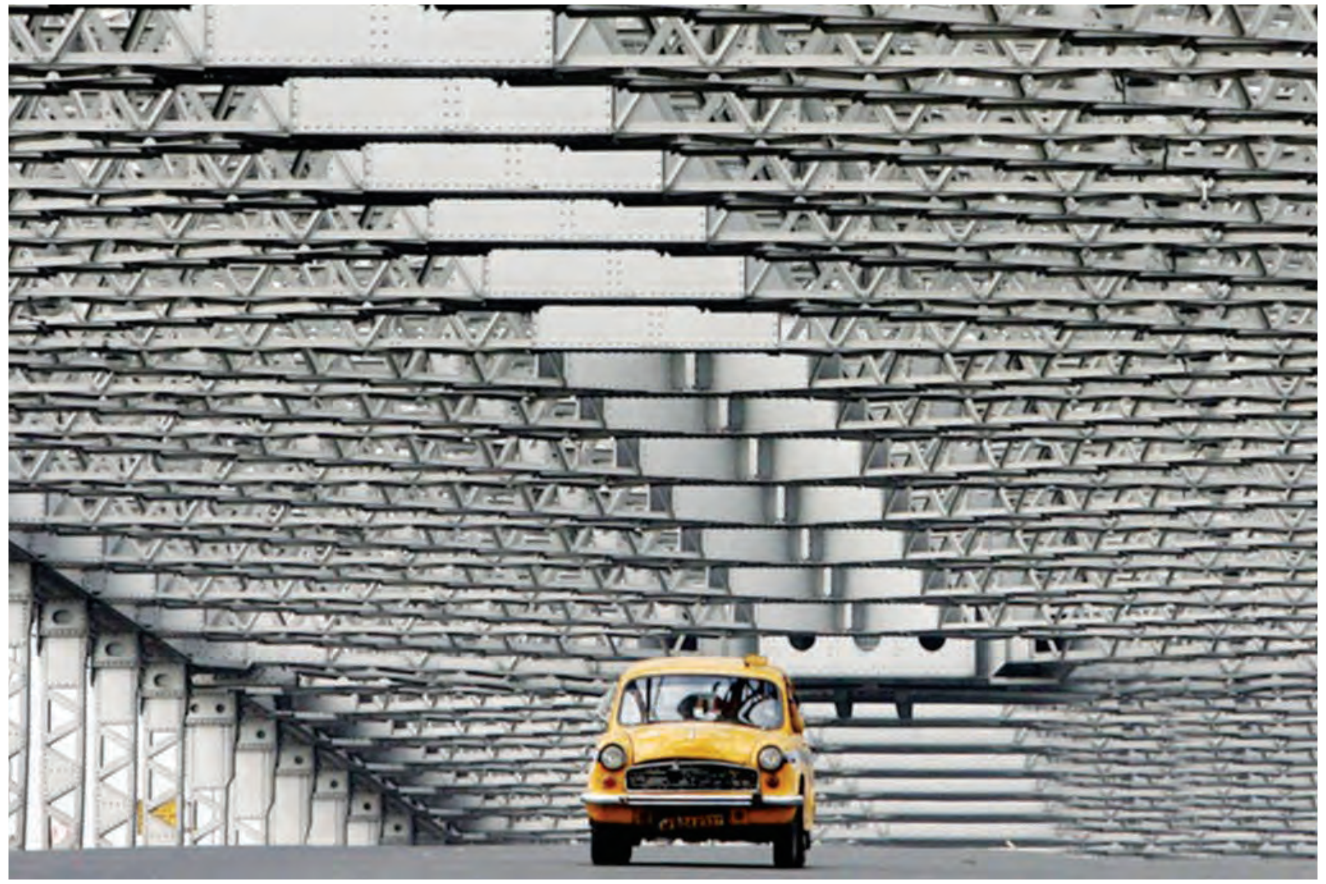
The earth ranged from a soft, spongy consistency near the surface to a stiff yellow clay at founding level



4. FOUNDATIONS. The foundation loads are based on the same premises in regard to allowable pressure and the smaller area in both designs as compared with the previous schemes is accounted for by the lesser weight to be carried due (1) to the use of "high tensile" steel and (2) to the reduction in roadway width. The main abutments on either side are intended to be carried each on a large caisson sunk in the usual manner by excavating in fifteen separate openings, while each anchorage foundation consists of a pair of square caissons sunk to the

While muck was being cleared, a variety of objects were brought up, including anchors, grappling irons, cannons, cannonballs, brass vessels, and coins dating back to the East India Company

The Bridge is Up



All doubts about India's ability to fabricate the bridge disappeared. The fabricators worked in four different shops and must have delighted the inspectors. Says Shirley-Smith: "A careful check of the full length of the lower chord of the anchor arm, comprising eight members, showed that it was correct to within 5/64 inch of an overall length of 325 feet".

In fabricating the members, web-plates were "batch-drilled to templet", the holes for end connections being left 1/8 inch smaller. The steel templates had case-hardened steel bushes that were sent to the different shops as and when they needed them. The chord members were boxed on rectangular cast-steel diaphragms, machined all over and connected by turned bolts to pilot holes drilled in the member.

Once ready for finishing of the main connections, the members were assembled and levelled at the Victoria Works in 'Calcutta's' Garden Reach area. The gussets and covers were in position with butt joints drawn up tight. The angles of intersection were then checked by theodolite, after which the rivet holes were drilled out full size and the covers were marked out for position. The steel work was cleaned out by chipping and wire brushing, so that all loose scale and rust were removed. Finally, one coat of red lead paint was applied and the material delivered.

It opened to busy traffic

Shirley-Smith and Howorth have fascinating tales to tell about the erection of the deck. Hand winches were pressed into service to lift the hangers, cross girders and stringers "on the deck or bottom laterals working through tackles suspended from the superstructure overhead. This method proved quick and simple; a routine was soon established by means of which two panels were erected per week, and within three months after closure all the deck steel work had been assembled and riveting was well advanced".

The cross girders were assembled in pairs and then riveted on one of the pontoons moored close to the shore on the Howrah side. Painting a vivid picture Shirley-Smith and Howorth say: "The pontoon was taken out by two tugs and held immediately below each pair of hangers in turn. Each girder, weighing 22 tons, was hoisted by two hand winches working through 5-to-1 tackles hung from the lower lateral cross member immediately over it. By this means two cross girders could be erected and their pin connections to the hanger completed in a morning".

The floor beams, toughing and kerbs were run out on decauville tracks laid on the rail bearers of the deck and skidded into position. The spot welding of the stirrups of the troughs, involving more than one million welds, was completed on special jigs at site before the troughs were erected. After the riveting was completed the reinforcement was placed and the roadway concrete was poured.

By the end of 1942, the steel work was up and the roadways were ready. The 'Calcutta' skyline had changed forever courtesy this riveted structure with not a nut or a bolt used. No city-based quiz is held without a question asked on the number of nuts and bolts used in the Howrah Bridge. Some visitors hit by the palpable penury of the indigent in the city looked upon it as a sign of oppression but the 'Calcuttan's' heart brimmed with pride. "Not even the increasingly belligerent communist trade unions of the time opposed the bridge", recalls Jolly Mohan Kaul, now going on 97, who was then in his mid-twenties and gradually assuming charge of the port unions under the Communist Party of India. He had seen the bridge being built bit by bit, his father, Shyam Nath Kaul, having been brought to 'Calcutta' by the East Indian Railways to manage the accounts of the New Howrah Bridge in 1925.

The regret about not being able to celebrate one of the top technology achievements of the era was evident in The Engineer's comment: "It is for us one of the sad paradoxes of war that, in reviewing a year when work of great interest to civil engineers was being carried out under conditions of urgency in many parts of the world, we can only devote so few pages to it and, owing to the necessary activities of the censorship, would indeed find it difficult to fill a greater number of columns!

In addition, wartime difficulties of communication with distant places and the stress of work thrown upon depleted staffs of firms and organisations, that formerly might have provided us with information, make it impossible for us to cover as completely as we could wish the work of civil engineers during the year.

Civil Engineering in 1943;
No. I; The Engineer, January 14, 1944, Page 22

A cacophony of people and vehicles

The 'Calcutta' skyline had changed forever

Photo © Satyaki Ghosh

Flashback

Was there ever a doubt in anyone's mind about the bridge ever becoming a reality?

"No, never"

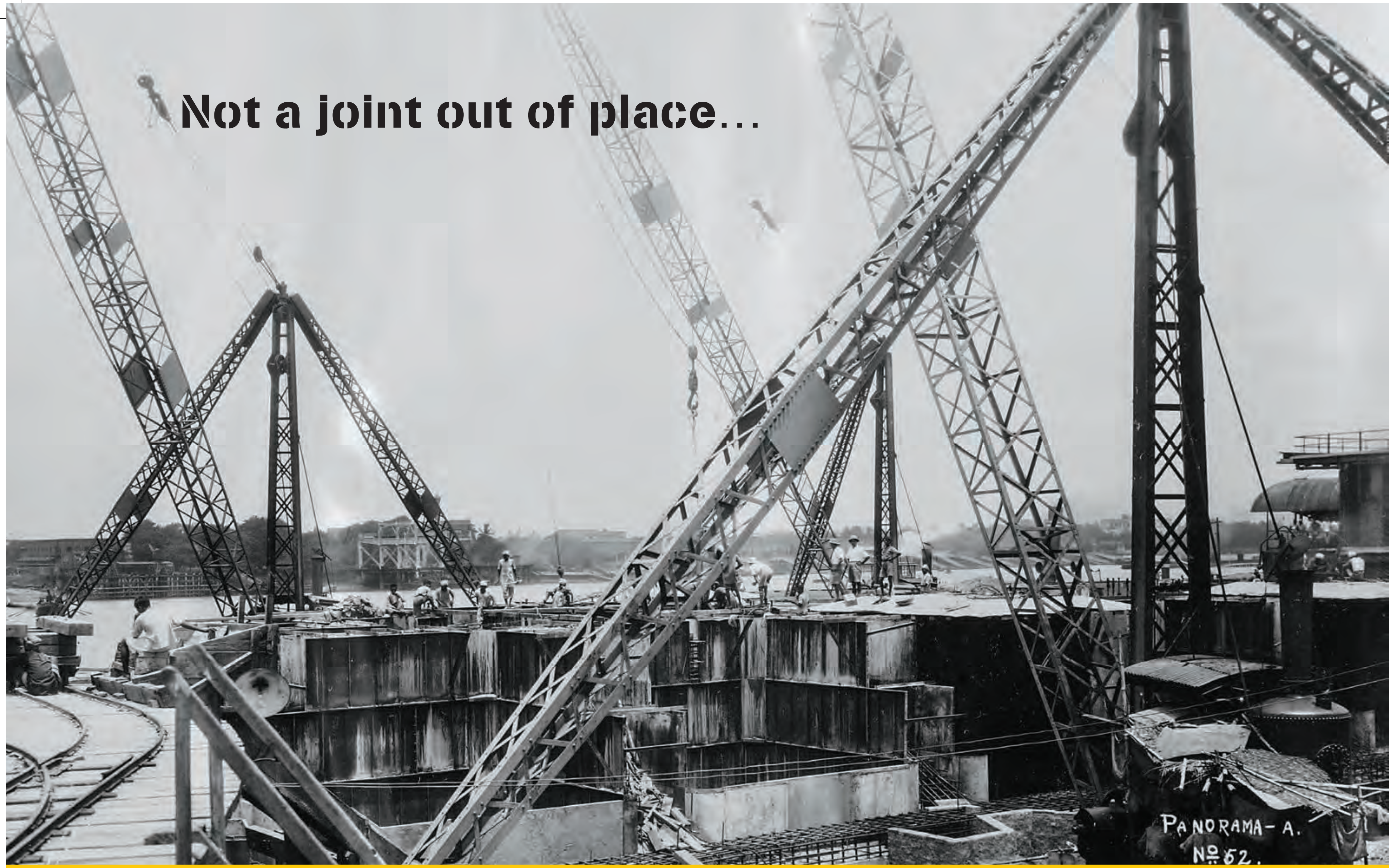
"The Howrah Bridge was a matter of great excitement in the family. Not a day passed when the proposed construction did not come up in the discussions at home", recalls the nonagenarian Kaul. Hardly 10 or 11, for him it was a matter of great adventure to accompany his father to the site; first travelling over the pontoon bridge from where they watched the gigantic structure come up. Long before completion, "I accompanied a maternal uncle, Shambhubhai Hukku, who must have been an engineer working on site, and often had a ring-side view of things that most people did not. Once the bridge came up, we rode the tram right up to the Howrah Station, which was a delight because there was no need to wait for the bridge to open and close—as was often the case with the pontoon bridge—which could be tiring for a youngster".

His mind goes back to the "agent", one Mr Haymen, an Anglo-India gentleman, whom he met over dinner at the Chungwah along with his father. Was there ever a doubt in anyone's mind about the bridge ever becoming a reality? "No, never", is the emphatic response from Jolly Kaul. His father was, after all, an aficionado of the Raj, its loyal servant, and a firm believer in its technological genius. It is another matter that Shyam Nath Kaul's youngest son, Jolly, turned out to be a communist activist, dedicating his youth to ending the Raj.

Yet another octogenarian, then in her teens, Ruby Palchoudhuri, recalls the open-jawed wonder with which she experienced the bridge for the first time. "We had seen the construction coming up whenever we visited the city from the districts, where my father was posted. But when I saw the Howrah "Pool" (pronounced pull in Hindi) as it was referred to in those days, I was struck with awe". To Ruby Palchoudhuri, an artist and specialist in the creative space, the bridge is a thing of beauty. "I recall coming out of the station, getting into a horse-drawn carriage and travelling clip clop over the bridge. I stuck my head out to take it all in. It was quite amazing"...and Howrah Pool it has been for the aam aadmi ever since. The Bengali is so happy with the "Howrah Bridge" that even after it was renamed on June 14, 1965, as Rabindra Setu after Kobiguru Rabindranath Tagore, the first Indian to win the Nobel prize, the old name tag survived.

General view at anchorage showing lateral windframe and anchor links

Not a joint out of place...



JOINT SYSTEM OF BRIDGE (EXPANSION JOINTS)

Longitudinal expansion and lateral sway movement of the deck are taken care of by expansion and articulation joints.

There are two main expansion joints, one at each interface between the suspended span and the cantilever arms.

There are expansion joints at the towers and at the interface of steel and concrete structures at both approaches.

ARTICULATION JOINTS

There are total 8 articulation joints.

3 at each of the cantilever arms.

2 in the suspended portions.

They divide the bridge into segments with vertical pin connection between them to facilitate rotational movements of the deck.

CAMBER AND TRAFFIC CLEARANCE

Bridge deck has longitudinal ruling gradient of 1 in 40 from either end.

They are joined by a vertical curve of radius 4,000 feet.

Cross gradient of the deck is 1 in 48 between kerbs and the central 4.9 mtr is level to provide tramway housing channel in between troughing and kerbs.

Belated Back-patting

To go back in time, after a silent, nocturnal inauguration, the Engineer wrote on January 14, 1944 (Page 22) under the Bridges and Tunnels column: “The Howrah structure, the third largest cantilever bridge in the world, was opened to traffic in February of the year under review. It carries a roadway 71ft wide and two footways, each 15ft wide, across the Hooghly River at Calcutta, and its central span has a length of 1,500ft. The anchor arms of this bridge, each 325ft long, do not carry the roadway, which turns in under them at each end to reach the roadway deck suspended under the main span from pier to pier. Each cantilever arm is 468ft long and they carry between them a suspended span, 564ft long. The engineers for this great bridge, work upon the erection of which started well before the war, are Rendel, Palmer and Tritton, of Westminster, and the contractors the Cleveland Bridge and Engineering Company, Ltd”.

Explaining the technological excellence, Tridibesh Mukherjee says: “There are cases of steel structures failing by ‘fatigue’. There is an endurance limit, below which the structure will not nucleate any crack on the surface, on repeated loading. The endurance limit is about 50 per cent of the steel’s tensile strength. So it appears that the safety factor of 2 took care of such an eventuality.

The other problem is corrosion, which is obviated by using corrosion resistant steel and proper paints and by denying access to corrodants, bolstered by regular inspection. There is probably no possibility of erosion but there is a possibility of brittle failure, which is normally assigned to low temperatures. The ‘chimney of a boat hitting the bridge’ experience shows that Kolkata’s temperature does not make the steel brittle in the Howrah Bridge”.

“The Howrah structure, the third largest cantilever bridge in the world, was opened to traffic in February of the year under review. It carries a roadway 71ft wide and two footways, each 15ft wide, across the Hooghly River at Calcutta, and its central span has a length of 1,500ft.”

—The Engineer, 1944

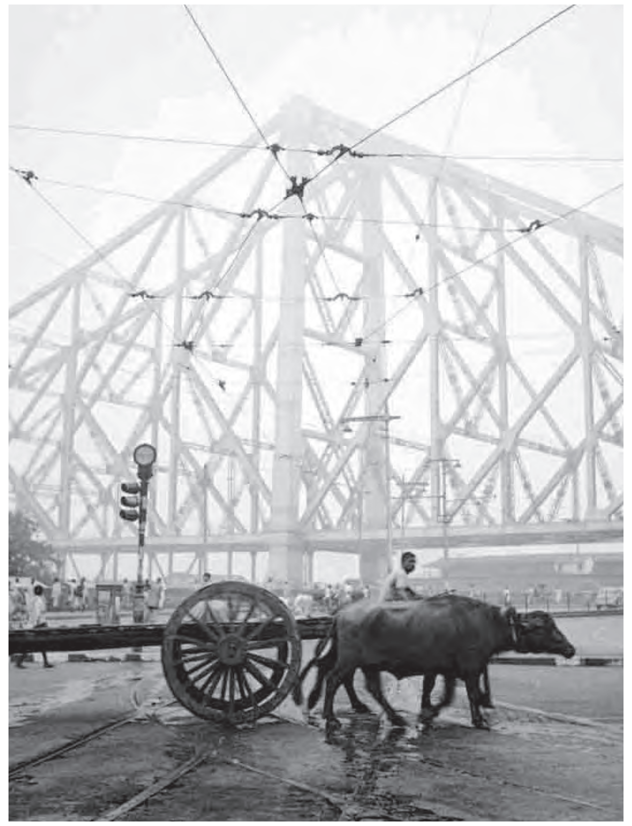
Structure of Steel; Heart of Gold

The Howrah Bridge was always one with a heart. Indeed, it was to spare the poor bullocks, who bore the brunt of the traffic that had to be carried across the bridge, that the designers reduced the curvature of the arch that would have made the construction easier. The bullocks would not be able to handle a steeper gradient. Not just that, the roadway provided for a special surfacing with metals to ensure an easier rolling of the bullock and horse drawn cart wheels. Tell-tale signs peep through the now bitumen surface. The brochure prepared on the "New Howrah Bridge" printed in the late 1930s said: "The up gradients of the approach roads has been limited to 1 in 40 and the down gradient to 1 in 36. These are considered the maximum safe values for bullock carts and hand carts".

The purposes of the war served, the Howrah Bridge became the people's bridge in more senses than one. Of course there was the traffic because 'Calcutta' was literally teeming with people. Not so charitable to the British, who he felt were responsible for the city's plight, Moorhouse went on a tirade in his book, 'Calcutta':

"To stand on the Howrah Bridge at any time is to feel that you are in the middle of some colossal refugee movement struggling to make headway against an impending doom; and these refugees are so bewildered by their plight that they are attempting to move in both directions at once. In 1947 it was estimated that 12,000 motor vehicles alone crossed the bridge everyday; by 1964 the figure had risen to 34,000; today it will be something over 40,000.

On top of the motor traffic there is the traffic in bullock-carts, handcarts, tramcars, bicycles and simply the endless stream of people; there are half a million pedestrians pushing, heaving their way over Howrah Bridge every day, very often everything just locks into a solid jam in which nothing can move for hours. It is now not unknown for the multitudinous traffic of Howrah Bridge to seize up before noon and to stay that way until late in the evening, by which time the police have been called out not only to disentangle everything, but to charge with their lathis and shields, to put down the riots that have broken out when there is enough room for civil disturbance at each end of the bridge".



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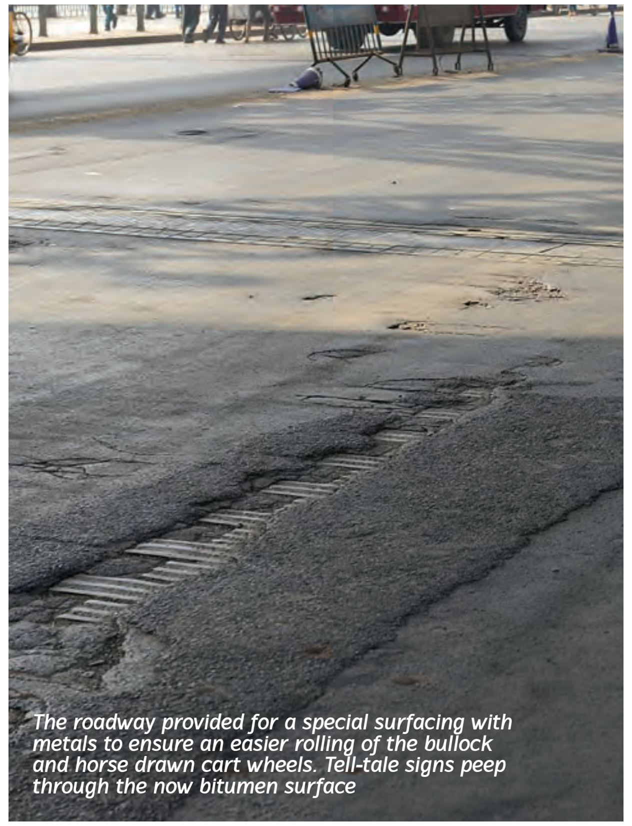


The roadway provided for a special surfacing with metals to ensure an easier rolling of the bullock and horse drawn cart wheels. Tell-tale signs peep through the now bitumen surface

Further down, the wholesale market at Barrabazar remained the hub of trade for the whole of eastern India

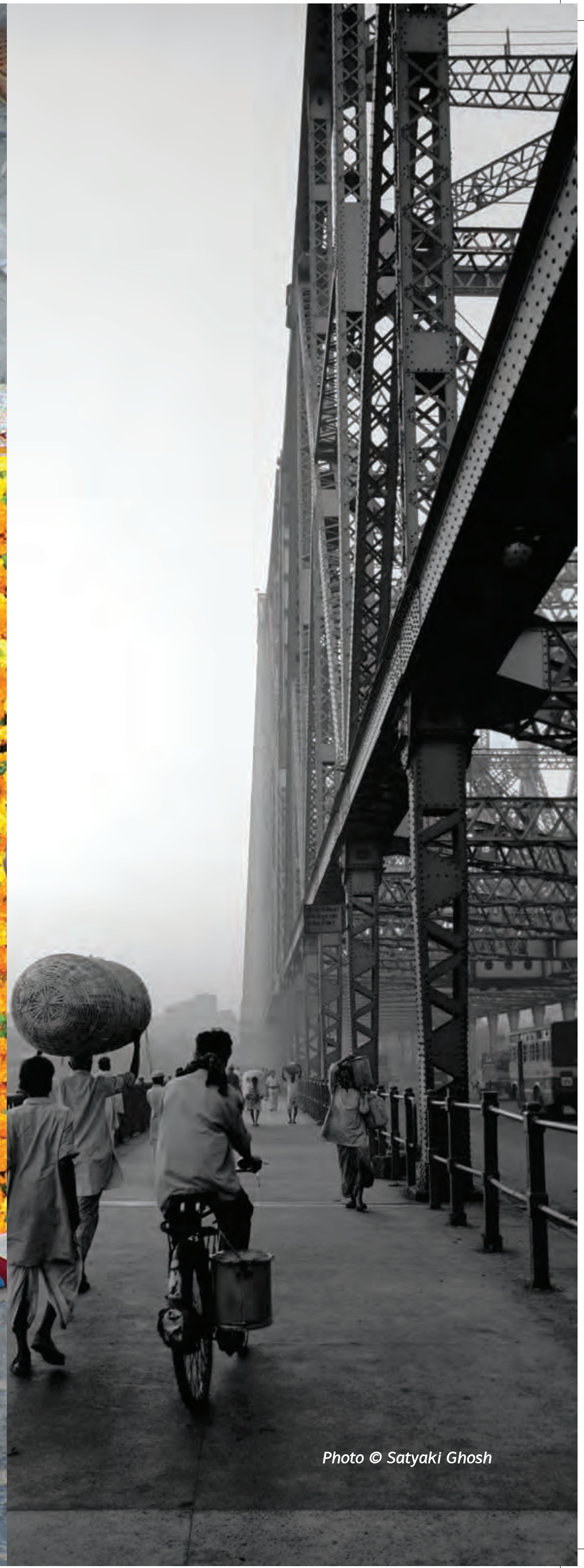
Times and circumstances changed. The city grew and was neither notorious for labour trouble or traffic jams; nor for riots; but it still favoured a more relaxed way of living than did much of the north and west of 21st century India, choosing cricket, football and the crafts to hectic commerce. Under the bridge though a gentler variety of commerce flourished—flowers, fruit, spices, fabrics and miscellany of a bewildering variety—while further down the wholesale market at Barrabazar remained the hub of trade for the whole of eastern India. Nothing seemed to have changed there; nor on the ghats that the bridge overlooks.

A gamut of religious gatherings, brides visiting the Holy Ganga on the wedding morn; young parents offering the first shavings of an infant's hair to the river; or just-bereaved sons asking the ever-obliging barber for a tonsure and many others taking a holy dip every morning alongside the wrestlers and maalish wallahs (masseurs). There is, of course, nothing to beat the spectacle of the multitudes assembling to offer tarpan (prayers and puja) to their forbears on the day of 'Mahalaya' just ahead of the Durga Puja, when the city launches into a near 10-day revelry. Festivities around praying to the goddess and to the god of gastronomy—most precious to the city—end with another trip to the waters under the bridge. It is time to immerse the "mother" in another humongous demonstration of emotion, excitement and environmental desecration.

Indeed, damaging the fragile ecology around the bridge is amongst the worst crimes committed by the city.

It was not before 1992 that the phenomenal increase in city traffic finally induced the authorities to relent and give the Howrah Bridge an equally majestic though more modern companion. It is the largest cable-stayed bridge in Asia, constructed by a consortium of Indian public sector undertakings and a private firm under the consultancy of S&P Germany & FFP of UK. The bridge was commissioned in the year 1992 under the aegis of Hooghly River Bridge Commissioners and named the "Vidyasagar Setu", after the eminent educationist-reformer and freedom fighter, Pandit Ishwar Chandra Vidyasagar.

Under the bridge a gentler variety of commerce flourished—flowers, fruit, spices, fabrics and miscellany of a bewildering variety



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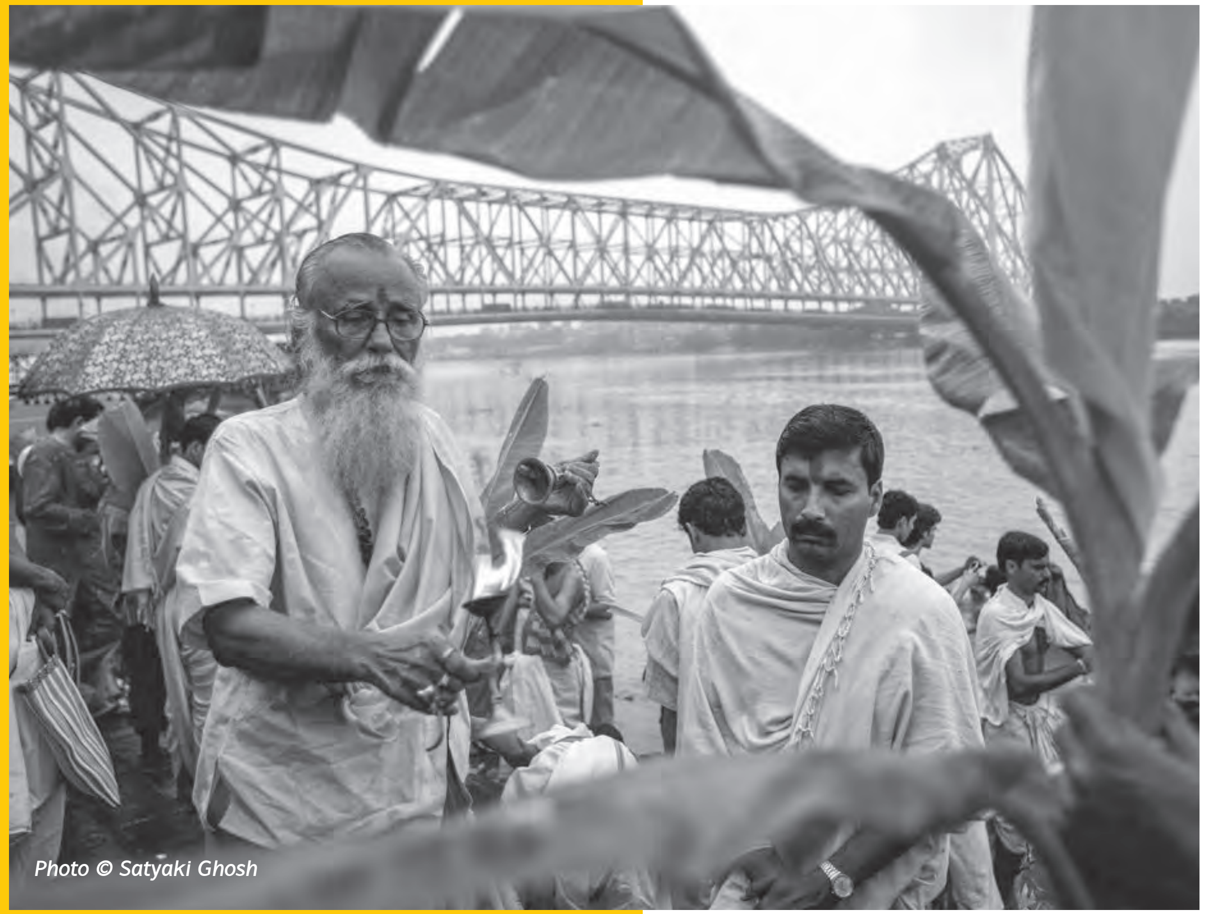


Photo © Satyaki Ghosh


Photo © Satyaki Ghosh

Researchers Arnab Chakraborty and Ritaja Ray talk about a technical inspection by Port Trust officials in 2011 that revealed that spitting had reduced the thickness of the steel hoods protecting the pillars from six to less than three millimetres since 2007 in their paper on 'Howrah Bridge and Second Hooghly Bridge: A Comprehensive Comparative Study'. These hoods are of critical importance for the hangers that need them at the base to prevent water seeping into the junction of the cross-girders and hangers, and damage to the hoods can jeopardise the safety of the bridge. Kolkata Port Trust announced a Rs 2 million spend on covering the base of the steel pillars with fibreglass casing to prevent spit from corroding them.

There were other depredations galore, including attacks on the structure by errant drivers of lorries, trucks, buses and other automobiles. Around half a century after it was built, in October 2008, six high-tech surveillance cameras were placed to monitor the entire 705 metre-long and 30 metre-wide structure from the control room. Two cameras were placed under the floor of the bridge to track the movement of barges, steamers and boats on the river, while the other four were fixed to the first layer of beams, one at each end and two in the middle, to monitor vehicle movements and potential human traffic. The idea was to address the extensive damage caused to the bridge from colliding vehicles over the years by nabbing the violators and demanding compensation of them.

The point is that the Howrah Bridge has constantly bettered expectations of it. With upwards of 100,000 vehicles plying over it every day apart from 150,000 pedestrians—much larger than it was designed for—it is not just a tribute to the pioneering engineers but to the quality of maintenance. Travel under the bridge on an inspection trolley and look up: there will be not a single unwanted speck on the beautifully aluminium paint coated bottom, layered over a primer of zinc chromate. Look below and there is the shimmering water of the Hooghly, gently massaging the foundations, as it were, exhorting it to go on for ever and ever. Indeed, the bridge provides for the massive change in temperature—on a hot summer day it is known to expand. "The colossal steel mesh of the Howrah Bridge is habitually four feet longer by day than by night", pointed out Moorhouse. The bridge had the technology to handle that as well.

"It is an engineering marvel that continues to evoke the same kind of curiosity and awe as it did seventy-five years ago, when it was unveiled to a war-torn city, primarily to aid supplies to British troops", says Vinit Kumar, Chairman of the Kolkata Port Trust (KPT), that was built by a "colonial government in 1943 and placed in the custody and maintenance of the Kolkata Port Trust since then". It is a task that the KPT does with diligence. "The Port takes pride in looking after this giant mega-structure, standing as a towering and permanent reminder to port-city synergy", says Vinit Kumar.

"It is an engineering marvel that continues to evoke the same kind of curiosity and awe as it did seventy-five years ago, when it was unveiled to a war-torn city, primarily to aid supplies to British troops"

"It is only appropriate that Tata Steel, an iconic entity in the world of steelmaking, should celebrate the 75th year of India's most glorious bridge of all time. The company, when the bridge was being built, owned the largest steel plant in India under the pioneering entrepreneurship of Jamsetji Tata.
The construction of this marvel consumed 26,500 tons of steel, out of which 23,500 tons of high-tensile alloy steel, known as Tiscrom, were supplied by Tata Steel. The Port of Kolkata, the only riverine port of the country and also the oldest, takes pride it associating itself once again with Tata Steel in commemorating and celebrating the beginning of a great epoch in the history of bridge construction".

Vinit Kumar, Chairman, Kolkata Port Trust

Maintaining the Marvel

An interesting hatch on the concrete foundations, takes one down the inspection tunnel. Into this go in the 'boys of the bridge' on regular checking missions. As enthusiastic a bunch as one will ever find in the city that is known to take work with languid contemplation.

The Kolkata Port Trust, erstwhile Commissioners of the Port of Calcutta and later Calcutta Port Trust, has been the custodian of the bridge. In the initial decades it meant regular painting about twice in a dozen years but today it means a constant vigil for corrosion that has been its bane—both the atmospheric conditions and biological waste have been the principal culprits. Worse, bird droppings and human paan-mingled spit were found to have been particularly damaging for the bridge in an investigation into the health of the structure in 2003.

Remedial measures followed and checking for bird droppings and cleaning them became an everyday routine. Painting too was regular; the KPT spent Rs 6.5 million to paint 2.2 million square metres of the bridge, that needed some 26,500 litres of paint. Bird droppings continued to wreak havoc. The 2011 inspection by the authorities showed that between 2007 and 2011, spitting had reduced the thickness of the steel hoods protecting the pillars from six millimetres to less than three millimetres. The Rabindra Setu division under the KPT's department of civil engineering, looks after the regular and special maintenance of the bridge. Between 2013 and 2016, the average annual expenditure on engineering maintenance was Rs 2.5 crore. Having kept it in shape for 75 years, the commissioners want this to be a bridge for eternity.

"This inspiring piece of engineering is a wonderful example of how superb function follows efficient form", says Ashoke Chatterjee philosophically.

Shining up like a new penny; above and under

Accessing the foundations: An interesting hatch takes the 'boys of the bridge' down the inspection tunnel

Inspection at the soffit of the top chord of the suspension span

HIT BY A VESSEL

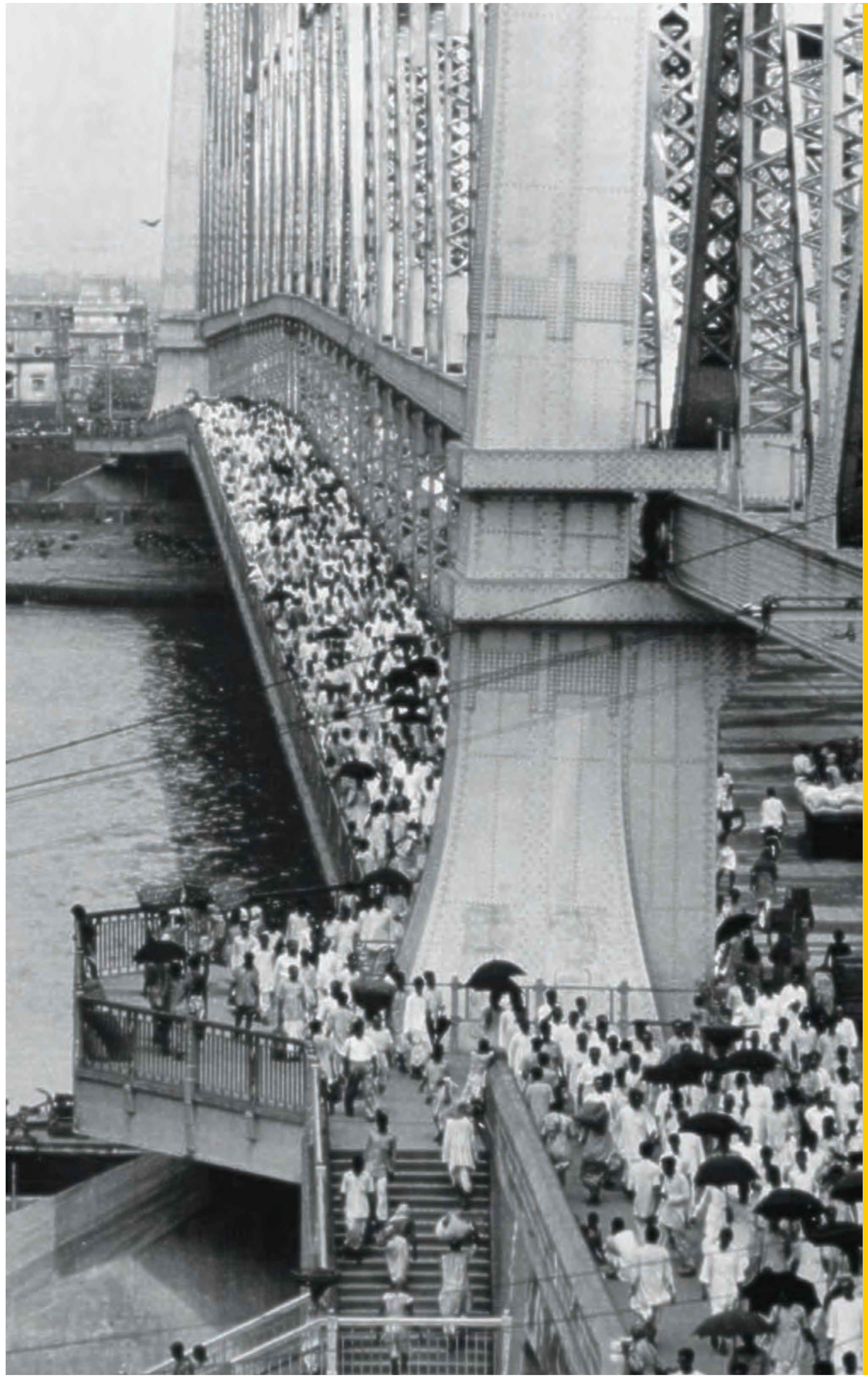
On June 24, 2005, a private cargo vessel, MV Mani, belonging to the Ganges Water Transport Pvt Ltd, had its funnel stuck underneath for three hours while trying to pass under the bridge during high tide. Much damage was caused; of Rs 15 million to the stringer and longitudinal girder of the bridge, BBJ reported. Some of the 40 cross-girders were also broken and two of four trolley guides, bolted and welded with the girders, were extensively damaged. Nearly 350 of 700 metres of the track were twisted beyond repair.

"The damage was so severe that KPT requested help from Rendel, Palmer & Tritton Limited, the original consultant on the bridge from UK. KPT also contacted SAIL to provide 'matching steel' used during its construction in 1943, for the repairs. For the repair costing around Rs 5 million, about 8 tons of steel was used. The repairs were completed in early 2006", said BBJ.

For TV Narendran, the CEO and Managing Director of Tata Steel, the bridge was amongst the pioneers in using Indian material to 'build' India "by a company set up 110 years back to help the nation. The Howrah Bridge is a great testimony to that ambition". Indeed, as he looks back at "all the wear and tear that the bridge has withstood over three-fourths of a century", TV Narendran cannot but "marvel at the confidence of the consulting engineers not only in their own abilities but in those of Tata Steel. The bridge was erected to minute tolerances during erection. It was constructed at heights of up to 300 feet in the air in a difficult climate, apart from being faced with other technical challenges. It is a tribute to Tata Steel's technological prowess even back then that this iconic structure is celebrating its 75th anniversary today".

The bridge was amongst the pioneers in using Indian material to 'build' India "by a company set up 110 years back to help the nation"

Commemorative stamp on the Howrah Bridge



Having kept it in shape for 75 years, the commissioners want this to be a bridge for eternity

“It is a tribute to Tata Steel’s technological prowess even back then that this iconic structure is celebrating its 75th anniversary today”

T V Narendran
CEO & MD, Tata Steel

Photo © Satyaki Ghosh

The city grows under the eternally watchful eye of the Devi and the Bridge

Photo © Satyaki Ghosh

CELEBRATING 75 YEARS

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