M.R.O. 1—77,006—8-6-37.

(1) Number of pages 1 N 4 3

(2) Date of repair 2 3 1 4 8

(3) Initials of the Referencer

MADRAS RECORD OFFICE.

Government of Madras.

Public works **DEPARTMENT.**

G.O. No. 3961 Press ~~Mis.~~

299-300

Dated 15 - 12 - 1866.

Not to be folded or roughly handled

No. 299. Read the following Circular from the Government of India, Public Works Department, (Civil Works, Communications,) dated Simla, 17th October 1866, No. 91:—

Description of Girder for Wrought-iron Bridges best suited for India.

Read:—

The annexed papers containing Tenders for, and general description of, the the above Bridges.

Governments of Madras, Bengal, North-Western Provinces, and Punjab.
Chief Commissioners of Oudh, British Burmah, and Central Provinces.
Commissioners of Mysore and Coorg.
Resident at Hyderabad.
Governor General's Agents, Central India, and Rajpootana.
Governor, Straits Settlements.

ORDER.—Ordered, that the above papers, with sets of the drawings referred to, be forwarded to the Local Governments and Administrations marginally noted, for information, in continuation of Public Works Circular No. 41 of 1864.

(Signed) C. H. DICKENS, Lieut.-Colonel, R. A.,
Secy. to the Government of India.

Description of Girder for Wrought-iron Bridges best suited for India.

From Colonel P. L. HART, Engineers (Retired List), Bombay, to the Under Secretary of State for India, dated 12th January 1864.

In acknowledging the receipt of the correspondence as per margin, relative to the supply of wrought-iron bridges required by the Bombay Government, I have the honor to report, for the information of Her Majesty's Principal Secretary of State for India, that I addressed a letter, with a printed general description of these bridges (a copy of which is annexed), to the following principal Manufacturers:—

Letter from the Under Secretary of State for India, dated 13th November 1863.
Letter No. 1,775 of 1863, dated 14th September, from the Secretary, Bombay Government, Public Works Department.
Letter No. 42 of 1863, dated 14th September, (copy of) from the Bombay Government, to Her Majesty's Principal Secretary of State for India.

R. Brotherwood, Railway Works, Chippenham, Wilts,
Harry Grissell, Regents Canal Iron Works, City Road,
Cochrane & Co., Woodside Iron Works, near Dudley,
Fairbairn & Co., Manchester,
Bray, Waddington & Co., New Dock Works, Leeds,
Kennard Brothers, Crumlin Works, Monmouthshire,
The Horseley Company, Tipton, Staffordshire,

and that I subsequently had interviews with either the Principals or their Agents at their several works and offices.

2. The result is, that I now beg to submit tenders numbered from 1 to 7, and drawings and tracings in a (tin case) numbered from 1 to 20, for wrought-iron bridges on screw-piles of 100, 60, and 30 feet spans, each tender being for two spans and one pier complete. An abstract for easy reference is annexed, showing the cost of the various bridges, and other information in connection with them.

3. It will be seen from the tenders that, generally speaking, with the increase of span, how greatly the cost is increased; and, as I am sure, there are few rivers in Western India which cannot safely be bridged with spans of 60 feet, I would earnestly recommend the Bombay Government not to exceed that span, except in special cases.

4. The drawings and tenders now submitted will, I trust, enable the Bombay Government to select any design which they may consider the best adapted; they are all very simple, and have been prepared in strict conformity with the Government instructions, which I embodied on the printed description forwarded to the different Manufacturers. After a very careful consideration of these designs, with due regard to their cost, I am of opinion that the following will be found best suited to the purpose required:—

1st.—*For the* 100 *feet spans,* Mr. Brotherwood's design (plan No. 1, tender No. 1) being a wrought-iron lattice girder; the amount of estimate for two complete spans and one pier landed at Bombay, being ... ... £ 1,826

2nd.—*For the* 60 *feet spans,* Mr. Brotherwood's design (plan No. 1, tender No. 1) being a wrought-iron lattice girder, precisely similar to the above; the amount of estimate for two complete spans, and one pier, landed at Bombay, being 958

3rd.—*For the* 60 *feet spans,* I would request particular attention to the Horseley Company's design (plan No. 19, tender No. 7) of a wrought-iron girder of segmental form; and would recommend that, with any order given, a few of this span should be sent. It is easily put together, and the cost very moderate, being, for two continuous spans, with screw-pile, pier, tracing, &c., complete, landed at Bombay 660

4th.—*For the* 30 *feet spans,* Bray, Waddington & Co.'s design (plan No. 11, tender No. 5) being wrought-iron plate girders; the amount of estimate being, for two complete spans and one pier, with spare materials, landed at Bombay 394

5. I would observe that the amounts now tendered for these bridges are subject to such variations as may exist in the prices of iron, freight, &c., and the general state of the trade at the time the order is given; and that some slight modifications will require to be made when the working drawings are prepared.

6. I would further observe that it was explicitly explained to the Manufacturers that their estimates were to include no commission or per-centage of any description, they are therefore the *bona fide* prices for the work tendered.

Abstract showing the amount of Tenders, Manufacturers' names, &c., &c.

Number of drawings or tracing.	Number of Tender.	Name and Address of Manufacturer.	Amount of Tender for two Spans and one Pier complete. 100 feet.	60 feet.	30 feet.	Bridges where delivered.	Remarks.
			£	£	£		
1	1	R. Brotherwood, Railway Works, Chippenham, Wilts.	1,645	858	385	Free on boardship at London.	These amounts include sundry extra bolts. The cost of extra cast-iron columns and piles is shown in Mr. Brotherwood's tender.
			*1,826	958	431	At Bombay.	
2	2	Harry Grissell, Regents Canal Iron Works, Eagle Wharf Road, N.	2,210	1,160	490	At Bombay.	These amounts do not include the spare materials the cost of which is shown in Mr. Grissell's, tender.
3 4 5	3	Cochrane and Co., Woodside Iron Works, near Dudley.	2,518	1,157	400	Free on boardship at London or Liverpool.	These amounts do not include the cost of spare fittings; they are, however, shown in Cochrane and Co.'s tender. Cochrane and Co. do not undertake to deliver at Bombay.
			2,818	1,297	450	At Bombay.	
6 7 8	4	Messrs. Fairbairn and Co., Manchester.	3,905	1,617	585	At Bombay.	Messrs. Fairbairn and Co. undertake to deliver alongside a quay at Liverpool, though the cost is given, delivered at Bombay. The amounts include spare parts of piers, &c., and are based on the assumption that many bridges of these several spans will be required.
9 10 11	5	Bray, Waddington and Co., new Dock Works, Leeds,	3,161	1,085	345	At Liverpool.	In these amounts the spare screw-piles, bracings, &c., are included.
			3,592	1,236	394	At Bombay.	
12, 13 14, 15 16, 17	6	Kennard Brothers, Crumlin Works, Monmouthshire.	3,680	1,751	587	At Newport or Grangemouth.	In these amounts the spare fittings are included.
			†4,058	1,938	661	At Bombay.	
18 19 20	7	The Horseley Company, Tipton, Staffordshire.	2,155	575	700	At London or Liverpool.	In these amounts the spare materials are included.
			2,400	660	223	At Bombay.	

* This has been calculated with freight at 35s. per ton, insurance 40s. per cent. on the value of the work, and all other expenses (after the work has been delivered alongside the export ship) at 1s. per ton.

† Freight, insurance, and other charges have been calculated at the same rates as above to Mr. Brotherwood's bridges.

GENERAL DESCRIPTION OF WROUGHT-IRON GIRDER BRIDGES ON SCREW-PILES REQUIRED FOR INDIA.

Spans. 1. The following are the different spans required :—

Span.	From Bed of River to Roadway.	
One hundred feet.	About thirty feet.	Depth of piles below the bed of the river to be taken at ten feet deep.
Sixty feet.	,, twenty feet.	
Thirty feet.	,, ten feet.	

Bridges where required. 2. These bridges are required over such rivers and streams where ordinary building materials are very scarce, and where, owing to the alluvial character of the soil, founding heavy structures in the usual manner is a very expensive operation.

Screw-piles for Piers. 3. Screw-piles for piers could most easily be managed, and it is proposed to use cast-iron hollow piles, because they can be sent out in lengths, and be made applicable to any height of bridge, which would not be the case with wrought-iron piles.

Diameter of Pile. 4. It is not proposed to use piles of large diameter, and probably, for such bridges as are required, the outer diameter of the piles need not exceed ten or at most twelve inches for the smaller spans, and fifteen inches for the larger, but on this point the advice of the manufacturer will be required: all that is absolutely necessary is, that, without being unwieldy, the piles should be sufficiently strong, not only to carry the bridge, but to stand a reasonable amount of wear and tear.

Size of Screw. 5. The screws should be from twenty-four to thirty inches in diameter.

Spare fittings, &c. 6. A complete pier should accompany every two spans of bridging, and there should be a few spare screw-piles and fitings. Abutments will be provided in the usual manner.

Width of Roadway. 7. The width of roadway should not be less than twenty-two feet clear.

Strength of Girders. 8. The strength of the girders should be equal to one ton per foot run of line road on the complete bridge, the breaking weight being calculated at, at least, four times that amount.

Girders for small spans. 9. For the thirty feet span, plate girders would, perhaps be best, and for the larger spans some kind of lattice.

Girders for larger spans. 10. For the larger spans, where the depth of the lattices must be considerable, and the roadway must rest on the lower booms, two girders only in each span may be required, but for the small thirty feet spans there may be three, or even four, if it is considered an advantage; the great object being of course to obtain the requisite amount of strength with the safe minimum of metal. Of course all cross-girders, bed-plates, bracing, &c., must be arranged for, *and each span and pier sent out quite complete as to iron-work.*

Difficulty of transit, a most important point to remember. 11. Owing to the great difficulty of transport in the part of India where these bridges are required, *it is a most important point* that the component parts of the bridge spans and their supports should be as light and manageable as possible; an idea can be easily formed on this point when it is mentioned that the only means of transport are bullock carts of a very rough construction, without springs, drawn by either two or four bullocks, camels, and pack-bullocks, over roads, (the natural surface of the country) composed of either deep ruts in black alluvial soil or deep sand, which are always excessively heavy for draught. It would be advisable, therefore, if possible, that the weight of no single portion of either the screw-piles or superstructure should be in excess of what the ordinary carriage of the country can readily convey :—

A bullock cart drawn by two bullocks will carry about	800 lbs.
Do. drawn by four do. do	1,200 ,,
A camel will carry about	400 ,,
A pack-bullock do.	160 ,,

Estimates. 12. I.—An estimate (in the lump) of the probable cost of a complete pier and two spans of each description of bridge is required.

II.—In the above estimate should be shown, as a separate item, the probable cost of the spare screw piles and fittings which may be required, in proportion to the above-mentioned extent of bridging.

Drawings. III.—Drawings to scale should accompany each estimate for each description of span on which should be shown—

A side elevation of the two spans with the screw-pile pier.

A plan of the roadway, with the cross-girders, bracing, &c.

A transverse section of the screw-pile pier.

A brief explanatory description may be entered on the face of each drawing.

Estimate to include cost of bridging complete, landed at Bombay. NOTE.—The estimate should include the total cost at which one screw-pile pier and two spans of each description of bridge, with the spare screw-piles and fittings, *the whole complete as to iron-work*, could be landed at Bombay.

Parts of Bridges to be distinctly marked. 13. All parts of the bridges should be distinctly marked to facilitate their being put together by the common work-people of the country.

14. Bolts to be used; no rivets.

From R. BROTHERWOOD, Esq., Chippenham, to Colonel P. L. HART, dated 11th December 1863.

As requested, I now beg to forward you (by book post) drawings of the lattice bridges which I manufacture, and I enclose herewith tender for the construction and delivery of the same free on boardship in London.

I have estimated for the three pile piers in each case as per elevations and plan D. These piers could of course be guarded, supported, or strengthened by timber starlings, piles, wallings, braces, struts, &c., as may be required; but should it be preferred to have four, five, or even seven cast pile piers, as shown in plans E and F, they can be supplied at prices in proportion to those I have already quoted; and should I receive an order, you may depend on its having my best attention.

From R. BROTHERWOOD, Esq., Chippenham, to Colonel P. L. HART, dated 5th January 1864.

I now enclose you a letter received from the Shipping Agent in London who shipped all the bridges I made for Ceylon. I have given you the total weights of the two spans in each case, including screw-piles and columns, which I hope will answer your purpose and prove satisfactory. I believe Mr. Winckley is the Shipping Agent for other Government Colonies as well as Ceylon.

From J. H. WINCKLEY, Esq., London, to R. BROTHERWOOD, Esq., Chippenham, dated 4th January 1864.

I was unable to get the required information in time to reply to yours of the 1st instant on Saturday last; but I now beg to state that the average rate of freight for iron-work (lattice bridges, &c.,) from London to Bombay is from 30*s.* to 35*s.* per ton, and 5*s.* per cent. primage thereon: in a vessel just commencing to load, you could obtain freight at 30*s.*, but would have to pay 35*s.*

in a ship presuming she was more than half loaded. The rate of insurance would be 40s. per cent. on the value of the work, and all the other London expenses (after the work had been delivered alongside the export ship) would not exceed 1s. per ton.

WEIGHTS OF BRIDGES AND SCREW-PILES.

		Tons.	cwt.	qrs.	lbs.
2 100-feet spans, including all columns and piles	...	82	18	1	1
2 60-feet ditto	...	46	8	2	7
2 30 feet ditto	...	19	3	0	0

Mem.—Taking the weight of these bridge spans and one pier at 83, 46½, and 19½ tons, and the freight at 35s per ton, insurance 2 per cent. on the value, and export and other charges at 1s. per ton, landed at Bombay, the cost of freight, &c., &c., of each would be as follows:—

For the 2 100-feet	...	...	...	£180
For the 2 60-feet	...	...	...	100
For the 2 30-feet	...	...	...	46

TENDER FOR THE MANUFACTURE AND SUPPLY OF LATTICE BRIDGES TO THE BOMBAY GOVERNMENT.

I, ROWLAND BROTHERWOOD, of Chippenham, Wilts, Contractor, hereby offer to manufacture and supply wrought-iron lattice bridges, with screw-pile piers, according to the accompanying drawings, at and for the following prices, viz.:—

BRIDGE A with 2 spans of 30 feet each in the clear span, and 22 feet clear roadway, constructed with the best wrought-iron and workmanship; also 1 pier consisting of 3 cast columns, 10 inches outside diameter, ½ inch thick, on screw-piles, with caps complete as per elevation A and plan D, each measuring 20 feet from top of column to bottom of pile, including sundry extra bolts, painting, marking, packing, and carriage, delivered free on boardship in London for the sum of Three Hundred and Eighty-five pounds ... ... £ 335 0 0

BRIDGE B with two spans of 60 feet each in the clear span, and 22 feet clear roadway, constructed with the best wrought-iron and workmanship; also 1 pier consisting of 3 cast columns, 12 inches outside diameter, ⅝ inch thick, on screw-piles, with caps complete as per elevation B and plan D, each measuring 30 feet from top of column to bottom of pile, including sundry extra bolts, painting, marking, packing, and carriage, delivered free on boardship in London for the sum of Eight Hundred and Fifty-eight pounds ... ... £ 858 0 0

BRIDGE C with 2 spans of 100 feet each in the clear span, and 22 feet clear roadway, constructed with the best wrought-iron and workmanship; also 1 pier consisting of 3 cast columns, 15 inches outside diameter, 1 inch thick, on screw-piles, with caps complete as per elevation C and plan D, each measuring 40 feet from top of column to bottom of pile, including sundry extra bolts, painting, marking, packing, and carriage, delivered free on boardship in London for the sum of Sixteen Hundred and Forty-five pounds ... ... £ 1,645 0 0

Should extra cast columns and piles be required, I would undertake to supply them as follows, viz.:—

Column and cap with screw-pile attached, 20 feet in length, 10 inches outside diameter, ½ inch thick, including fittings, for the sum of Thirteen pounds each .. .. £ 13 0 0

Column and cap with screw-pile attached, 30 feet in length, 12 inches outside diameter, ⅝ inch thick, including fittings, for the sum of Twenty-seven pounds each ... ... £ 27 0 0

Column and cap with screw-pile attached, 40 feet in length, 15 inches outside diameter, 1 inch thick, including fittings, for the sum of Forty-eight pounds, Ten shillings each ... ... £ 48 10 0

RAILWAY WORKS, CHIPPENHAM,
11th December 1863.

(Signed) R. BROTHERWOOD.

From HARRY GRISSELL, Esq., London, to Colonel P. L. HART, dated 22nd December 1866.

In answer to your communication dated 20th November 1863, I herewith beg to forward you tracing of the bridges I should recommend, and I would desire to state that I shall be prepared to deliver in ship at Bombay the following works:—

Two spans of wrought-iron lattice girders with the cross wrought-iron girders complete, so far as the iron-work is concerned, fitted with drilled holes and turned bolts, marked, painted one coat, and packed, for the sum of £ 2,210. The above sum includes one cast-iron pier with screw-pile shoes, 3 feet diameter. The piles will be faced in the lathe, and accurately fitted and painted complete, as shown upon the tracing.

Two spans of wrought-iron girders for 60 feet span with cross girders, and one cast-iron screw-pile pier, with screws 2 feet diameter; the general detail in all other respects as for the 100 feet spans, for the sum of £ 1,160.

Two spans of wrought-iron girders for 30 feet span, with cross girders, and one cast-iron screw-pile pier, with screws 2 feet diameter; the general detail in all other respects as above, for the sum of £ 490. For the spare material my price would be, also delivered at Bombay:—

		£	s.	d.
1	3-feet diameter screw...	7	0	0
1	14-inch column for do., 10 feet long, flanges faced	12	10	0
1	2-feet diameter screw...	3	10	0
1	10-inch column for do., 10 feet long, flanges faced	9	0	0
1	Pier complete for 100 feet spans	500	0	0
1	Do. do. 60 do.	350	0	0
1	Do. do. 30 do.	105	0	0

One span consists of two main girders with the necessary cross girders and bolts, &c.

From Messrs. COCHRANE & Co., Dudley, to Colonel P. L. HART, dated 23rd December 1863.

Referring to your letter of the 20th ultimo, we now beg to inform you that our prices for the bridge-work for India therein referred to will be as follows:—

	£	s.	d.
1st.—The one screw-pile pier for the bridge, 100 feet span, the sum of...	268	10	0
2nd.—The whole of the requisite iron-work for two spans of superstructure, each span being 100 feet from centre of pier to face of abutment, the sum of	2,250	0	0
3rd.—The one screw-pile pier for the bridge, 60 feet span, the sum of ...	142	10	0
4th.—The whole of the requisite iron-work for two spans of superstructure, each span being 60 feet from centre of pier to face of abutment, the sum of	1,015	0	0
5th.—The one screw-pile pier for the bridge, 30 feet span, the sum of ...	70	0	0
6th.—The whole of the requisite iron-work for two spans of the superstructure, each span being 30 feet from centre of pier to face of abutment, the sum of	330	0	0

7th.—Additional screws, piles, &c, for the piers at the following prices:—

BRIDGE, 100 FEET SPAN.

Wrought-iron piles, per foot lineal	0	15	6	
Coupling boxes of cast-iron with wrought-iron keys	each	1	15	0
Cast-iron screws	each	2	5	0

BRIDGE, 60 FEET SPAN.

Wrought-iron piles, per foot lineal	0	11	0	
Cast-iron coupling boxes with wrought-iron keys	each	1	10	0
Cast-iron screws	each	1	15	0

and three suitable wrought-iron railing bars will extend the whole length of the bridge on each side. The cross-girders will be firmly attached to the compression beam of the main trusses, and will thereby give them lateral support, which will be necessary on account of the compression beams having to be jointed in so many places for convenience of carriage. The holes for the piers in the main trusses will be accurately bored, the joints in the compression beams planed, and the bolt holes drilled. The cross-girders will be arranged with a joint at the centre. Suitable bed plates and rollers will be provided for the abutment ends.

DESIGN No. 2 shows the bridge 60 feet span, which will be precisely similar in character to the one described. The piles will be 5 inches diameter, and their total length is estimated at 23 feet.

DESIGN No. 3 shows the bridge 30 feet span, which will also be somewhat similar in character; the piles will be 3½ inches diameter, and their length is estimated at 18 feet.

The bridges will be complete as far as the iron-work is concerned, and hoop iron tonguing will be provided for the planking, and the necessary bolts for securing them to the girders.

The whole of the work will be of a thorough substantial character, fitted in the most accurate manner, and carefully marked to facilitate the final erection. It will be arranged so that it can all be put together in India without the use of rivets.

The work will receive two coats of oil paint, be packed as required for shipment, and delivered f. o. b. in London or Liverpool.

WROUGHT-IRON GIRDER BRIDGES ON SCREW-PILES, &c., REQUIRED FOR INDIA.

From Messrs. FAIRBAIRN & Co., Manchester, to Colonel P. L. HART, dated 24th December 1863.

In conformity with your letter and instructions under date 20th ultimo, we have now the pleasure of handing you drawings showing designs for common road-bridges of 100 feet, 60 feet, and 30 feet spans, constructed on principles that, whilst possessing all the strength and good properties of ordinary well-made lattice girders, yet enables us to dispense with the usual top and bottom plates, and thus simplify the putting these girders together *in situ*.

We can confidently recommend the kind of girder in question, which, although apparently similar to others heretofore constructed, yet differs in possessing all the lightness of what is termed the "Warren Girder," like those used on many of the Indian Railways, but without its disadvantages, the security of the latter depending upon the whole as an entirety, that is to say, the fracture of a single pin would endanger the whole structure, whilst in ours there would be a temporary local weakness or disturbance, but no real danger to the bridge as a whole, and this is an important point.

Should our estimates be favorably received, and the execution of these bridges be entrusted to us, we shall make special arrangements with our makers for the supply of the particular kind of iron that we shall use, and shall prepare rollers for producing the exact sections of iron required.

In framing our estimates, we have borne in mind the following, and which we desire to place conspicuously before you, namely :—

That the bridges being constructed with the fewest possible number of details or parts, the cost of re-erection will be reduced to a minimum, whilst the freight from this country and subsequent transfer to India will be kept as low as possible, from the fact of their being divided into parcels under average weight and dimensions.

That we shall erect all of them in this country, and ascertain by actual loading that each bridge presents no weak points, and that perfect uniformity of manufacture be maintained, so that for any given span any part of one bridge will, if required, fit a corresponding part of another bridge.

That the state of the iron manufacture of this country at the present time, and the rise in its price, consequent on the immense and increasing demand for it, and the present state of the labor market, compels us to qualify these estimates with the condition, that any

Wrought-iron [illegible] ... each [illegible]
Cast-iron [illegible] ... each [illegible]
Cast-iron screws ... each [illegible]

All the work to be made as [illegible] to fit the ground and [illegible] better, but with such [illegible] as are suggested by the necessary [illegible] ration

The prices are, for the work [illegible] coats and delivered free on board a ship Liverpool. Terms of payment, [illegible]

We cannot undertake to deliver [illegible] cost on freight and insurance would be [illegible] as follows :—

On three Nos. 1 and 2 the sum of £ [illegible] These amounts will be [illegible]
On three Nos. 1 and 2 ... £ [illegible] one month after the [illegible]
On three Nos. 1 and 2 ... £ [illegible] when the work is shipped

The prices are based on the present value of materials, and are subject to [illegible]

The Tracings we send are marked Nos. 1, 2, and 3, and they are sent to illustrate our [illegible] as to the best kind of bridges and [illegible] for the purpose. We are decidedly of opinion that wrought-iron piles will be best, and that the roadway should, if possible, be carried on the [illegible] the girders. The necessity for bracing up the compression beam into very small pieces, joining it in India with bolts, renders it necessary to give it lateral support, and this will be very effectually by placing the cross-girders over the [illegible] as shown.

If the cross-girders are placed on the lower member of the truss, there will be a [illegible] of the compression beam "buckling" at the joints, unless it can be rivetted up in [illegible] pieces.

According to our arrangements, no piece will exceed 1,200 lbs. in weight, and 10 or [illegible] feet in length, and the whole of the work can be put together in India *without the use of rivets.*

Trusting the information given will be satisfactory, and will lead to business.

GENERAL DESCRIPTION OF WROUGHT-IRON GIRDER BRIDGES ON SCREW-PILES DESIGNED FOR INDIA.

The bridges referred to in this Specification and the accompanying Tender, are three in number, viz. :—

One 100 feet span, Design No. 1.
One 60 " " " 2.
One 30 " " " 3.

DESIGN No. 1 shows the bridge 100 feet span, the centre pier of which will be formed by eight solid wrought-iron piles, six inches diameter, arranged in two groups of four, connected at the top by cast-iron circular caps, and having cast-iron screws 33 inches diameter, fitted on their lower end. Each group will be braced at the centre by wrought-iron clip rings, and the two groups will be firmly tied together by transverse and diagonal bracing. The wrought-iron piles will be sent out in lengths not exceeding 11 feet, and cast-iron coupling boxes, with wrought-iron keys, will be supplied for jointing the lengths together in a simple and efficient manner. The cast-iron screws will be stotted and provided with wrought-iron hoops. The wrought-iron piles will be accurately fitted at the ends, and the cast-iron caps will be planed and faced, and the whole will be fitted up in the most perfect and substantial manner. The length from the top of the cast-iron cap to the point of the screw is estimated at 30 feet.

The superstructure will consist of two wrought-iron girders, on the triangular or Warren's patent principle, fixed 12 feet apart on the piles, and connected at intervals by diagonal bracing as shown. On the top of the girders there will be placed, at intervals of about 4 feet 6 inches, transverse roadway girders, 22 feet 6 inches long, on which the planking will be placed. Wrought-iron railing standards will be provided to the end of each cross-girder,

subsequent rise in the price of the raw materials must be added thereto, whilst, on the other hand, any fall in price will be cheerfully deducted by us, as our only object is to protect ourselves against a loss we cannot otherwise anticipate. We think the justice of this arrangement will be readily conceded.

The designs referred to have been calculated to sustain four times the rolling load, taking the latter at one ton per foot.

We should have given you more elaborate drawings had time permitted, but the details can be modified hereafter.

We annex estimates, and assure you of our readiness to use every possible endeavor to give you good and substantial bridges.

ESTIMATE FOR INDIA BRIDGES.

Messrs. Fairbairn & Co., Engineers, Manchester, are prepared to undertake the construction of the iron-work of the several bridges as per annexed statement, delivered at Liverpool, alongside a quay, packed, painted, and marked in every way ready for shipment at the following amounts :—

	£
100 Feet Span.	
Cost of a complete pier and two spans of 100 feet each	3,420
Cost of pier only	250
Cost of spare parts of pier	65
Cost at which a complete pier and two spans of 100 feet each, with spare parts of pier and spare bolts for girders, could be delivered at Bombay, taking freight at 32*s.* 6*d.* to 35*s.* per ton, and including insurance at 40*s.* per cent	3,905
60 Feet Span.	
Cost of a complete pier and 2 spans of 60 feet each	1,396
Cost of pier only	135
Cost of spare parts of pier	36
Cost at which a complete pier and 2 spans of 60 feet each, with spare parts of pier and spare bolts for girders, could be delivered at Bombay, taking freight at 32*s.* 6*d.* to 35*s.* per ton, and including insurance at 40*s.* per cent.	1,617
30 Feet Span.	
Cost of a complete pier and 2 spans of 30 feet each	520
Cost of pier only	60
Cost of spare parts of pier	20
Cost at which a complete pier and 2 spans of 30 feet each, with spare parts of pier and spare bolts for girders, could be delivered at Bombay, taking freight at 32*s.* 6*d.* to 35*s.* per ton, and insurance at 40*s.* per cent	585

The above amounts are based on the assumption that many bridges of these several spans will be required. If only one of each is ordered, we do not bind ourselves to these estimates.

From Messrs. BRAY, WADDINGTON & Co., Leeds, to Colonel P. L. HART, dated 2nd January 1864.

Below we beg to hand you prices of the wrought-iron bridges, the designs and descriptions of which the writer delivered to you last Saturday. We have, in accordance with your request, given you the approximate cost delivered at Liverpool, as well as at Bombay, and trust they will meet with your approval.

	Delivered in Liverpool.			Delivered in Bombay.
30 *Feet Spans.*				
	£	*s.*	*d.*	£
Two continuous spans of wrought-iron plate girder bridges, with screw-pile pier, bracings, &c.,	327	0	0	372
complete to Design No. 1	18	0	0	22
Spare screw-piles, bracings, &c.				
60 *Feet Spans.*				
Two continuous spans of wrought-iron lattice girder bridges, with screw-pile pier, bracings, &c.	1,038	0	0	1,180
complete to Design No. 2	47	0	0	56
Spare screw-piles, bracings, &c., ...				
100 *Feet Spans.*				
Two continuous spans of wrought-iron lattice girder bridges, with screw-pile pier, bracings, &c.,	3,053	10	0	3,464
complete to Design No. 3	108	0	0	128
Spare screw-piles, bracings, &c.				

The workmanship and materials to be of the best description and to your satisfaction, or of whom the Bombay Government may appoint.

If you should require any further information, we shall be glad to furnish it, and trust we may be favored with your orders.

From Messrs. KENNARD BROTHERS, Westminster, to Colonel P. L. HART, dated 7th January 1864.

We have the honor to enclose you tracings of bridges of 30 feet and 60 feet spans, prepared in accordance with the specification handed to us, which, with the tracings already sent, complete the number required.

We have designed these bridges with great care to meet all the requirements specified. We propose to use Blaenavon cold-blast bars, which is the strongest iron we have in this country, and will bear a tensile strain of 24 tons to the inch. We also propose to drill all bolt holes, and to turn the bolts, so that they may accurately fill the holes. We also propose to make all the several parts throughout the spans of equal dimensions, so that each bar can be placed in any position. The price of these bridges delivered f. o. b. in this country would be as under, viz. :—

	£	*s.*	*d.*
For a bridge consisting of two spans of 100 feet each, with screw-pile piers, as shown on drawings	3,490	0	0
Additional for 5 per cent. of spare materials in superstructure, and one spare column of screw-pile	190	10	0
For a bridge consisting of two spans of 60 feet each, with one pier of screw-piles as shown on tracing	1,630	0	0
Additional for 5 per cent. of spare material in superstructure, and one spare column of screw-pile	91	0	0
For a bridge consisting of two spans of 30 feet each, with one pier of screw-piles, as shown on tracing ...	554	0	0
Additional for 5 per cent. of spare materials in superstructure, and one spare column of screw-pile... ...	33	0	0

The strains on these bridges are calculated to be tested to one ton to the foot run of live load, and supposing one ton to the foot run in ballast and platform. With this load the iron would in no case be strained more than four tons in compression, and five tons in tension. These bridges are necessarily very heavy in consequence of the unusual test load, the ordinary test being one ton to the foot run, whilst these are two tons. There is also some additional weight in consequence of having the bars throughout of the same section, which you considered desirable to facilitate the simplicity of fixing, and we quite think necessary under the circumstances.

The specification requires the delivery to be in Bombay. We have made enquiries at the India Store Department, and find the ordinary freight to that port is about 35*s.* per ton, but it is sometimes as much as £4 per ton, and as we have no means for ascertaining at what seasons the shipments will be made, we think it better to quote prices delivered in this country. We shall be very happy to wait upon you at your own residence, or to see you here, to give you any explanation you may require, or if you prefer it, at our works at Crumlin, which would probably be the best place ;

but if there, we should like to have one or two days' notice, so that our Mr. Howard Kennard may be able to meet you; and as the Blaenavon iron-works, in which we are largely interested, are near our works, we should be very pleased if you could spare a day to see them, and at the same time the quality of the iron we should employ. In the present unsettled state of the iron market, we should be obliged by your settling the question as soon as possible: the price is now £ 4 a ton higher than it was three months since, and there is every probability of a further considerable increase.

From Messrs. KENNARD BROTHERS, Westminster, to Colonel P. L. HART, dated 9th January 1864.

We have the honor to acknowledge your esteemed favor of the 8th instant.

The estimated weight of the 100 feet bridge is

Spare material	...	160 tons.
Sixty feet bridge	...	10 ,,
Spare material	...	80 ,,
Thirty feet bridge	...	5 ,,
Spare material	...	33 ,,
	...	2 ,,

Our price was based upon delivery at our shipping ports, Newport and Grangemouth. The carriage from thence to London or Liverpool would be one pound per ton.

MEMORANDUM.

Freight. Tons.	£	Insurance. £			Other charges 1*s.* per Ton. £
170 at 35*s.*	297	3,680	40*s.*	per cent. £ 73	8
85 ,,	148	1,751		,, 35	4
35 ,,	61	587		,, 11	2

Freight, &c.						Estimated delivery at Bombay.
100 feet bridge	297	+ 73	+ 8	= 378	+ 3,680	= 4,058
60 ,,	148	+ 35	+ 4	= 187	+ 1,751	= 1,938
30 ,,	61	+ 11	+ 2	= 74	+ 587	= 661

From ROB. BROAD, Esq., *p. pro.* the HORSELY COMPANY, Tipton, Staffordshire, to Colonel P. L. HART, dated 7th January 1864.

By railway to-day we send you three drawings, being designs for bridges for ordinary roads in India, as requested in your favor of the 20th of November last, which we trust will meet your approval. These designs have been arranged to meet the special requirements specified in your instructions, and are capable of carrying more than four times the specified load of one ton per foot lineal.

Our price for these bridges, fitted here and marked for re-erection, packing where necessary, painting, and delivery to Bombay, will be as under :—

One complete pier and two spans of 30 feet bridge	£	£
Spare materials	... 220	
	... 10	
One complete pier and two spans of 60 feet bridge		230
Spare materials	... 630	
	... 30	
One complete pier and two spans of 100 feet bridge		660
Spare materials	... 2,300	
	... 100	
		2,400

Any further explanation you may require we shall be most happy to render.

From ROB. BROAD, Esq., *p. pro.* the HORSELY COMPANY, Tipton, Staffordshire, to Colonel P. L. HART, dated 9th January, 1864.

In reply to your favour of yesterday's date, we beg to say that our prices quoted for bridge work included all freight and insurance charges to Bombay. Below we hand you the estimated amounts divided for delivery at London or Liverpool, or Bombay :—

	London or Liverpool.	Bombay.
One complete pier and two spans of 30 feet bridges.	£197	£220
Spare materials	10	10
	207	230
One complete pier and two spans of 60 feet bridges.	550	630
Spare materials	25	30
	575	660
One complete pier and two spans of 100 feet bridges	2,070	2,300
Spare materials	85	100
	2,155	2,400

No. 300. ORDER THEREON, 15th December 1866, No. 3,961.

CIVIL WORKS, No. 61.

1. Circulated to the Superintending Engineers in continuation of G. O. No. 2,392, dated the 20th August 1864.

2. The five copies of the sets of drawings which have been received will be distributed as follows :—

Superintending Engineers 1st, 2nd, and 7th Divisions one each...	3
Principal of the Civil Engineering College	1
In Store	1
	5

(True Extract.)

Colonel, R. E.,
Secretary to Government.

To the Superintending Engineers.
,, Principal of the Civil Engineering College, Plans already sent.

Exd. S. T. Augustin.

Description of girder for wrought-iron bridges best suited for India.

Dated 12th January, 1864.

From—Colonel P. L. Hart, *Engineers (Retired List), Bombay,*

To—Under Secretary of State for India.

In acknowledging the receipt of the correspondence as per margin, relative to the supply of wrought-iron bridges required by the Bombay Government, I have the honour to report, for the information of Her Majesty's Principal Secretary of State for India, that I addressed a letter, with a printed general description of these bridges (a copy of which is annexed), to the following principal Manufacturers:—

Letter from the Under Secretary of State for India, dated 13th November 1863.

Letter No. 1775 of 1863, dated 14th September, from the Secretary, Bombay Government, Public Works Department.

Letter No. 42 of 1863, dated 14th September, (copy of) from the Bombay Government, to Her Majesty's Principal Secretary of State for India.

R. Brotherwood, Railway Works, Chippenham, Wilts,
Harry Grissell, Regents Canal Iron Works, City Road,
Cochrane and Co., Woodside Iron Works, near Dudley,
Fairbairn and Co., Manchester,
Bray, Waddington and Co., New Dock Works, Leeds,
Kennard Brothers, Crumlin Works, Monmouthshire,
The Horseley Company, Tipton, Staffordshire,

and that I subsequently had interviews with either the Principals or their Agents at their several works and offices.

2. The result is, that I now beg to submit tenders numbered from 1 to 7, and drawings and tracings (in a tin case) numbered from 1 to 20, for wrought-iron bridges on screw-piles of 100, 60, and 30 feet spans, each tender being for two spans and one pier complete. An abstract for easy reference is annexed, showing the cost of the various bridges, and other information in connection with them.

3. It will be seen from the tenders that, generally speaking, with the increase of span, how greatly the cost is increased; and, as I am sure, there are few rivers in Western India which cannot safely be bridged with spans of 60 feet, I would earnestly recommend the Bombay Government not to exceed that span, except in special cases.

4. The drawings and tenders now submitted will, I trust, enable the Bombay Government to select any design which they may consider the best adapted; they are all very simple, and have been prepared in strict conformity with the Government instructions, which I embodied on the printed description forwarded to the different Manufacturers. After a very careful consideration of these designs, with due regard to their cost, I am of opinion that the following will be found best suited to the purpose required:—

	£
1st.—*For the* 100 *feet spans*, Mr. Brotherwood's design (plan No. 1, tender No. 1) being a wrought-iron lattice girder; the amount of estimate for two complete spans and one pier, landed at Bombay, being	1,826
2nd.—*For the* 60 *feet spans*, Mr. Brotherwood's design (plan No. 1, tender No. 1) being a wrought-iron lattice girder, precisely similar to the above; the amount of estimate for two complete spans, and one pier, landed at Bombay, being	958
3rd.—*For the* 60 *feet spans*, I would request particular attention to the Horseley Company's design (plan No. 19, tender No. 7) of a wrought-iron girder of segmental form; and would recommend that, with any order given, a few of this span should be sent. It is easily put together, and the cost very moderate, being, for two continuous spans, with screw-pile, pier, tracing, &c., complete, landed at Bombay	660
4th.—*For the* 30 *feet spans*, Bray, Waddington and Co.'s design (plan No. 11, tender No. 5) being wrought-iron plate girders; the amount of estimate being, for two complete spans and one pier, with spare materials, landed at Bombay	394

5. I would observe that the amounts now tendered for these bridges are subject to such variations as may exist in the prices of iron, freight, &c., and the general state of the trade at the time the order is given; and that some slight modifications will require to be made when the working drawings are prepared.

6. I would further observe that it was explicitly explained to the Manufacturers that their estimates were to include no commission or percentage of any description, they are therefore the *bonâ fide* prices for the work tendered.

Abstract showing the amount of Tenders, Manufacturers' names, &c., &c.

Number of Drawings or Tracing.	Number of Tender.	Name and Address of Manufacturer.	Amount of Tender for Two Spans and one Pier complete.			Bridges where delivered.	Remarks.
			100 feet.	60 feet.	30 feet.		
1	1	R. Brotherwood, Railway Works, Chippenham, Wilts.	£ 1,615 *1,526	£ 858 953	£ 385 431	Free on boardship at London. At Bombay.	These amounts include sundry extra bolts. The cost of extra cast-iron columns and piles is shown in Mr. Brotherwood's tender. * This has been calculated with freight at 35s. per ton, insurance 40s. per cent. on the value of the work, and all other expenses (after the work has been delivered alongside the export ship) at 1s. per ton.
2	2	Harry Grissell, Regents Canal Iron Works, Eagle Wharf Road, N.	2,210	1,160	490	At Bombay.	These amounts do not include the spare materials, the cost of which is shown in Mr. Grissell's tender.
3	3	Cochrane and Co., Woodside Iron Works, near Dudley.	2,518	1,157	400	Free on boardship at London or Liverpool. At Bombay.	These amounts do not include the cost of spare fittings; they are, however, shown in Cochrane and Co.'s tender. Cochrane and Co. do not undertake to deliver at Bombay.
4	4	Messrs. Fairbairn and Co., Manchester.	2,818	1,297	450	At Bombay.	Messrs. Fairbairn and Co. undertake to deliver alongside a quay at Liverpool, though the cost is given, parts of piers, &c., and are based on the assumption that many bridges of these several spans will be required.
5	5	Bray, Waddington and Co., new Dock Works, Leeds.	3,905	1,617	585	At Liverpool. At Bombay.	In these amounts the spare screw-piles, bracings, &c. are included.
6	6	Kennard Brothers, Crumlin Works, Monmouthshire.	3,161 3,592	1,085 1,236	345 394	At Newport or Grangemouth. At Bombay.	In these amounts the spare fittings are included.
7	7	The Horseley Company, Tipton, Staffordshire.	3,680 †4,058	1,751 1,938	587 661	At London or Liverpool. At Bombay.	† Freight, insurance, and other charges have been calculated at the same rates as above to Mr. Brotherwood's bridges.
8			2,155 2,400	575 660	700 223		In these amounts the spare materials are included.
9							
10							
11							
12, 13							
14, 15							
16, 17							
18							
19							
20							

GENERAL DESCRIPTION OF WROUGHT-IRON GIRDER BRIDGES ON SCREW-PILES REQUIRED FOR INDIA.

Spans. The following are the different spans required :—

Span.	From Bed of River to Roadway.	Depth of piles below the bed of the river to be taken at ten feet deep.
One hundred feet.	About thirty feet.	
Sixty feet.	„ twenty feet.	
Thirty feet.	„ ten feet.	

Bridges where required. 2. These bridges are required over such rivers and streams where ordinary building materials are very scarce, and where, owing to the alluvial character of the soil, founding heavy structures in the usual manner is a very expensive operation.

Screw-piles for Piers. 3. Screw-piles for piers could most easily be managed, and it is proposed to use cast-iron hollow piles, because they can be sent out in lengths, and be made applicable to any height of bridge, which would not be the case with wrought-iron piles.

Diameter of Pile. 4. It is not proposed to use piles of large diameter, and probably, for such bridges as are required, the outer diameter of the piles need not exceed ten or at most twelve inches for the smaller spans, and fifteen inches for the larger, but on this point the advice of the manufacturer will be required: all that is absolutely necessary is, that, without being unwieldy, the piles should be sufficiently strong, not only to carry the bridge, but to stand a reasonable amount of wear and tear.

Size of Screw. 5. The screws should be from twenty-four to thirty inches in diameter.

Spare fittings, &c. 6. A complete pier should accompany every two spans of bridging, and there should be a few spare screw-piles and fittings. Abutments will be provided in the usual manner.

Width of Roadway. 7. The width of roadway should not be less than twenty-two feet clear.

Strength of Girders. 8. The strength of the girders should be equal to one ton per foot run of line road on the complete bridge, the breaking weight being calculated at, at least, four times that amount.

Girders for small spans. 9. For the thirty feet span, plate girders would, perhaps, be best, and for the larger spans some kind of lattice.

Girders for larger spans. 10. For the larger spans, where the depth of the lattices must be considerable, and the roadway must rest on the lower booms, two girders only in each span may be required, but for the small thirty feet spans there may be three, or even four, if it is considered an advantage; the great object being of course to obtain the requisite amount of strength with the safe minimum of metal. Of course all cross-girders, bed-plates, bracing, &c., must be arranged for, *and each span and pier sent out quite complete as to iron-work.*

Difficulty of transit, a most important point to remember. 11. Owing to the great difficulty of transport in the part of India where these bridges are required, *it is a most important point* that the component parts of the bridge spans and their supports should be as light and manageable as possible; an idea can be easily formed on this point when it is mentioned that the only means of transport are bullock carts of a very rough construction, without springs, drawn by either two or four bullocks, camels, and pack-bullocks, over roads, (the natural surface of the country) composed of either deep ruts in black alluvial soil or deep sand, which are always excessively heavy for draught. It would be advisable, therefore, if possible, that the weight of no single portion of either the screw-piles or superstructure should be in excess of what the ordinary carriage of the country can readily convey :—

A bullock cart drawn by two bullocks will carry about	800 lbs.
Do. drawn by four do. do.	1,200 „
A camel will carry about	400 „
A pack-bullock do.	160 „

Estimates. 12. I.—An estimate (in the lump) of the probable cost of a complete pier and two spans of each description of bridge is required.

II.—In the above estimate should be shown, as a separate item, the probable cost of the spare screw-piles and fittings which may be required, in proportion to the above-mentioned extent of bridging.

Drawings. III.—Drawings to scale should accompany each estimate for each description of span on which should be shown—

A side elevation of the two spans with the screw-pile pier.
A plan of the roadway, with the cross-girders, bracing, &c.
A transverse section of the screw-pile pier.
A brief explanatory description may be entered on the face of each drawing.

Estimate to include cost of bridging complete, landed at Bombay.

Note.—The estimate should include the total cost at which one screw-pile pier and two spans of each description of bridge, with the spare screw-piles and fittings, *the whole complete as to iron-work*, could be landed at Bombay.

13. All parts of the bridges should be distinctly marked to facilitate their being put together by the common work-people of the country.

Parts of Bridges to be distinctly marked.

14. Bolts to be used; no rivets.

Dated 11th December, 1863.

From—R. Brotherwood, Esq., *Chippenham*,
To—Colonel P. L. Hart.

As requested, I now beg to forward you (by book post) drawings of the lattice bridges which I manufacture, and I enclose herewith tender for the construction and delivery of the same free on boardship in London.

I have estimated for the three pile piers in each case as per elevations and plan D. These piers could of course be guarded, supported, or strengthened by timber starlings, piles, wallings, braces, struts, &c., as may be required; but should it be preferred to have four, five, or even seven cast pile piers, as shown in plans E and F, they can be supplied at prices in proportion to those I have already quoted; and should I receive an order, you may depend on its having my best attention.

Dated 5th January, 1864.

From—R. Brotherwood, Esq., *Chippenham*,
To—Colonel P. L. Hart.

I now enclose you a letter received from the Shipping Agent in London who shipped all the bridges I made for Ceylon. I have given you the total weights of the two spans in each case, including screw-piles and columns, which I hope will answer your purpose and prove satisfactory. I believe Mr. Winckley is the Shipping Agent for other Government Colonies as well as Ceylon.

Dated 4th January, 1864.

From—J. H. Winckley, Esq., *London*,
To—R. Brotherwood, Esq., *Chippenham*.

I was unable to get the required information in time to reply to yours of the 1st instant on Saturday last; but I now beg to state that the average rate of freight for iron-work (lattice bridges, &c.) from London to Bombay is from 30*s.* to 35*s.* per ton, and 5*s.* per cent. primage thereon: in a vessel just commencing to load, you could obtain freight at 30*s.*, but would have to pay 35*s.* in a ship presuming she was more than half loaded. The rate of insurance would be 40*s.* per cent. on the value of the work, and all the other London expenses (after the work had been delivered alongside the export ship) would not exceed 1*s.* per ton.

WEIGHTS OF BRIDGES AND SCREW-PILES.

		Tons.	cwt.	qrs.	lbs.
2 100-feet spans, including all columns and piles	...	82	18	1	1
2 60-feet ditto	...	46	8	2	7
2 30-feet ditto	...	19	3	0	0

Memo.—Taking the weight of these bridge spans and one pier at 83, 46½, and 19⅞ tons, and the freight at 35*s.* per ton, insurance 2 per cent. on the value, and export and other charges at 1*s.* per ton, landed at Bombay, the cost of freight, &c., &c., of each would be as follows:—

For the 2 100-feet	...	...	...	...	...	£180
For the 2 60-feet	...	...	...	...	...	100
For the 2 30-feet	...	...	...	...	...	46

TENDER FOR THE MANUFACTURE AND SUPPLY OF LATTICE BRIDGES TO THE BOMBAY GOVERNMENT.

I, Rowland Brotherwood, of Chippenham, Wilts, Contractor, hereby offer to manufacture and supply wrought-iron lattice bridges, with screw-pile piers, according to the accompanying drawings, at and for the following prices, *viz.*:—

BRIDGE A with 2 spans of 30 feet each in the clear span, and 22 feet clear roadway, constructed with the best wrought-iron and workmanship; also 1 pier consisting of 3 cast columns, 10 inches outside diameter, ¾ inch thick, on screw-piles, with caps complete as per elevation A and plan D, each measuring 20 feet from top of column to bottom of pile, including sundry extra bolts, painting, marking, packing, and carriage, delivered free on boardship in London for the sum of Three Hundred and Eighty-five pounds ... ... £ 385 0 0

BRIDGE B with 2 spans of 60 feet each in the clear span, and 22 feet clear roadway, constructed with the best wrought-iron and workmanship; also 1 pier consisting of 3 cast columns, 12 inches outside diameter, ⅞ inch thick, on screw-piles, with caps complete as per elevation B and plan D, each measuring 30 feet from top of column to bottom of pile, including sundry extra bolts, painting, marking, packing, and carriage, delivered free on boardship in London for the sum of Eight Hundred and Fifty-eight pounds ... ... £ 858 0 0

BRIDGE C with 2 spans of 100 feet each in the clear span, and 22 feet clear roadway, constructed with the best wrought-iron and workmanship; also 1 pier consisting of 3 cast columns, 15 inches outside diameter, 1 inch thick, on screw-piles, with caps complete as per elevation C and plan D, each measuring 40 feet from top of column to bottom of pile, including sundry extra bolts, painting, marking, packing, and carriage, delivered free on boardship in London for the sum of Sixteen Hundred and Forty-five pounds ... ... £ 1,645 0 0

Should extra cast columns and piles be required, I would undertake to supply them as follows, *viz.*:—

Column and cap with screw-pile attached, 20 feet in length, 10 inches outside diameter, ¾ inch thick, including fittings, for the sum of Thirteen pounds ... ... each £ 13 0 0

Column and cap with screw-pile attached, 30 feet in length, 12 inches outside diameter, ⅞ inch thick, including fittings, for the sum of Twenty-seven pounds ... ... each £ 27 0 0

Column and cap with screw-pile attached, 40 feet in length, 15 inches outside diameter, 1 inch thick, including fittings, for the sum of Forty-eight pounds, Ten shillings ... ... each £ 48 10 0

R. BROTHERWOOD.

Railway Works, Chippenham;
11*th December*, 1863.

Dated 22nd December, 1863.

From—Harry Grissell, Esq., *London*,
To—Colonel P. L. Hart.

In answer to your communication dated 20th November 1863, I herewith beg to forward you tracing of the bridges I should recommend, and I would desire to state that I shall be prepared to deliver in ship at Bombay the following works:—

Two spans of wrought-iron lattice girders with the cross wrought-iron girders complete, so far as the iron-work is concerned, fitted with drilled holes and turned bolts, marked, painted one coat, and packed, for the sum of £ 2,210. The above sum includes one cast-iron pier with screw-pile shoes, 3 feet diameter. The piles will be faced in the lathe, and accurately fitted and painted complete, as shown upon the tracing.

Two spans of wrought-iron girders for 60 feet span with cross girders, and one cast-iron screw-pile pier, with screws 2 feet diameter; the general detail in all other respects as for the 100 feet spans, for the sum of £ 1,160.

Two spans of wrought-iron girders for 30 feet span, with cross girders, and one cast-iron screw-pile pier, with screws 2 feet diameter; the general detail in all other respects as above, for the sum of £ 490. For the spare material my price would be, also delivered at Bombay :—

	£	s.	d.
1 3-feet diameter screw	7	0	0
1 14-inch column for do., 10 feet long, flanges faced	12	10	0
1 2-feet diameter screw	3	10	0
1 10-inch column for do., 10 feet long, flanges faced	9	0	0
1 Pier complete for 100 feet spans	500	0	0
1 Do. ditto 60 ditto	350	0	0
1 Do. ditto 30 ditto	105	0	0

One span consists of two main girders with the necessary cross girders and bolts, &c.

Dated 23rd December, 1863.

From—Messrs. Cochrane & Co., *Dudley*.

To—Colonel P. L. Hart.

Referring to your letter of the 20th ultimo, we now beg to inform you that our prices for the bridge-work for India therein referred to will be as follows :—

	£	s.	d.
1st.—The one screw-pile pier for the bridge, 100 feet span, the sum of	268	10	0
2nd.—The whole of the requisite iron-work for two spans of superstructure, each span being 100 feet from centre of pier to face of abutment, the sum of	2,250	0	0
3rd.—The one screw-pile pier for the bridge, 60 feet span, the sum of	142	10	0
4th.—The whole of the requisite iron-work for two spans of superstructure, each span being 60 feet from centre of pier to face of abutment, the sum of	1,015	0	0
5th.—The one screw-pile pier for the bridge, 30 feet span, the sum of	70	0	0
6th.—The whole of the requisite iron-work for two spans of the superstructure, each span being 30 feet from centre of pier to face of abutment, the sum of	330	0	0

7th.—Additional screws, piles, &c., for the piers at the following prices :—

Bridge, 100 Feet Span.		
Wrought-iron piles, per foot lineal	0	15 6
Coupling boxes of cast-iron with wrought-iron keys ... ... each	1	15 0
Cast-iron screws ... ... each	2	5 0
Bridge, 60 Feet Span.		
Wrought-iron piles, per foot lineal	0	11 0
Cast-iron coupling boxes with wrought-iron keys ... ... each	1	10 0
Cast-iron screws ... ... each	1	15 0
Bridge, 30 Feet Span.		
Wrought-iron piles, per foot lineal	0	5 6
Cast-iron coupling boxes with wrought-iron keys ... ... each	0	15 6
Cast-iron screws ... ... each	1	2 6

All the work to be made in general conformity with the printed conditions attached to your letter, but with such modifications as are suggested by the accompanying Tracings and Specification.

The prices are, for the work painted two coats and delivered free on boardship in London or Liverpool. Terms of payment, cash in full against Bill of Lading.

We cannot undertake to deliver in Bombay, but for your guidance, we may mention that the cost on freight and insurance would be *approximately* as follows :—

On items Nos. 1 and 2 the sum of ...	£300	0	0	These amounts will be subject to variation according to the time of year when the work is shipped.
On items Nos. 3 and 4 „ ...	140	0	0	
On items Nos. 5 and 6 „ ...	50	0	0	

The prices are based on the present value of materials, and are subject to market variations.

The Tracings we send are marked Nos. 1, 2, and 3, and they are sent to illustrate our ideas as to the best kind of bridges and piers for the purpose. We are decidedly of opinion that wrought-iron piles will be best, and that the roadway should, if possible, be carried on the top of the girders. The necessity for breaking up the compression beam into very small pieces, and joining it in India with bolts, renders it necessary to give it lateral support, and this will be done very effectually by placing the cross-girders over the top as shown.

If the cross-girders are placed on the lower member of the truss, there will be a danger of the compression beam "buckling" at the joints, unless it can be rivetted up in longer pieces.

According to our arrangements, no piece will exceed 1,200 lb. in weight, and 10 or 12 feet in length, and the whole of the work can be put together in India *without the use of rivets*.

Trusting the information given will be satisfactory, and will lead to business.

GENERAL DESCRIPTION OF WROUGHT-IRON GIRDER BRIDGES ON SCREW-PILES, DESIGNED FOR INDIA.

The bridges referred to in this Specification and the accompanying Tender, are three in number, *viz.*:—

One 100 feet span, Design No. 1.
One 60 „ „ „ 2.
One 30 „ „ „ 3.

Design No. 1 shows the bridge 100 feet span, the centre pier of which will be formed by eight solid wrought-iron piles, six inches diameter, arranged in two groups of four, connected at the top by cast-iron circular caps, and having cast-iron screws 33 inches diameter, fitted on their lower end. Each group will be braced at the centre by wrought-iron clip rings, and the two groups will be firmly tied together by transverse and diagonal bracing. The wrought-iron piles will be sent out in lengths not exceeding 11 feet, and cast-iron coupling boxes, with wrought-iron keys, will be supplied for jointing the lengths together in a simple and efficient manner. The cast-iron screws will be stotted and provided with wrought-iron hoops. The wrought-iron piles will be accurately fitted at the ends, and the cast-iron caps will be planed and faced, and the whole will be fitted up in the most perfect and substantial manner. The length from the top of the cast-iron cap to the point of the screw is estimated at 30 feet.

The superstructure will consist of two wrought-iron girders, on the triangular or Warren's patent principle, fixed 12 feet apart on the piles, and connected at intervals by diagonal bracing as shown. On the top of the girders there will be placed, at intervals of about 4 feet 6 inches, transverse roadway girders, 22 feet 6 inches long, on which the planking will be placed. Wrought-iron railing standards will be provided to the end of each cross-girder, and three suitable wrought-iron railing bars will extend the whole length of the bridge on each side. The cross-girders will be firmly attached to the compression beam of the main trusses, and will thereby give them lateral support, which will be necessary on account of the compression beams having to be jointed in so many places for convenience of carriage. The holes for the piers in the main trusses will be accurately bored, the joints in the compression beams planed, and the bolt holes drilled. The cross girders will be arranged with a joint at the centre. Suitable bed plates and rollers will be provided for the abutment ends.

Design No. 2 shows the bridge 60 feet span, which will be precisely similar in character to the one described. The piles will be 5 inches diameter, and their total length is estimated at 23 feet.

Design No. 3 shows the bridge 30 feet span, which will also be somewhat similar in character; the piles will be 3½ inches diameter, and their length is estimated at 18 feet.

The bridges will be complete as far as the iron-work is concerned, and hoop iron tonguing will be provided for the planking, and the necessary bolts for securing them to the girders.

The whole of the work will be of a thorough substantial character, fitted in the most accurate manner, and carefully marked to facilitate the final erection. It will be arranged so that it can all be put together in India without the use of rivets.

The work will receive two coats of oil paint, be packed as required for shipment, and delivered f. o. b. in London or Liverpool.

WROUGHT-IRON GIRDER BRIDGES ON SCREW-PILES, &c., REQUIRED FOR INDIA.

Dated 24th December, 1863.

From—Messrs. Fairbairn & Co., *Manchester*,

To—Colonel P. L. Hart.

In conformity with your letter and instructions under date 20th ultimo, we have now the pleasure of handing you drawings showing designs for common road-bridges of 100 feet, 60 feet, and 30 feet spans, constructed on principles that, whilst possessing all the strength and good properties of ordinary well-made lattice girders, yet enables us to dispense with the usual top and bottom plates, and thus simplify the putting these girders together *in situ*.

We can confidently recommend the kind of girder in question, which, although apparently similar to others heretofore constructed, yet differs in possessing all the lightness of what is termed the "Warren Girder," like those used on many of the Indian Railways, but without

its disadvantages, the security of the latter depending upon the whole as an entirety, that is to say, the fracture of a single pin would endanger the whole structure, whilst in ours there would be a temporary local weakness or disturbance, but no real danger to the bridge as a whole, and this is an important point.

Should our estimates be favourably received, and the execution of these bridges be entrusted to us, we shall make special arrangements with our makers for the supply of the particular kind of iron that we shall use, and shall prepare rollers for producing the exact sections of iron required.

In framing our estimates, we have borne in mind the following, andwhich we desire to place conspicuously before you, namely,—

That the bridges being constructed with the fewest possible number of details or parts, the cost of re-erection will be reduced to a minimum, whilst the freight from this country and subsequent transfer to India will be kept as low as possible, from the fact of their being divided into parcels under average weight and dimension.

That we shall erect all of them in this country, and ascertain by actual loading that each bridge presents no weak points, and that perfect uniformity of manufacture be maintained, so that for any given span any part of one bridge will, if required, fit a corresponding part of another bridge.

That the state of the iron manufacture of this country at the present time, and the rise in its price, consequent on the immense and increasing demand for it, and the present state of the labour market, compels us to qualify these estimates with the condition, that any subsequent rise in the price of the raw materials must be added thereto, whilst, on the other hand, any fall in price will be cheerfully deducted by us, as our only object is to protect ourselves against a loss we cannot otherwise anticipate. We think the justice of this arrangement will be readily conceded.

The designs referred to have been calculated to sustain four times the rolling load, taking the latter at one ton per foot.

We should have given you more elaborate drawings had time permitted, but the details can be modified hereafter.

We annex estimates, and assure you of our readiness to use every possible endeavour to give you good and substantial bridges.

ESTIMATE FOR INDIA BRIDGES.

Messrs. Fairbairn & Co., Engineers, Manchester, are prepared to undertake the construction of the iron-work of the several bridges as per annexed statement, delivered at Liverpool, alongside a quay, packed, painted, and marked in every way ready for shipment at the following amounts:—

100 Feet Span.

	£
Cost of a complete pier and two spans of 100 feet each	3,420
Cost of pier only	250
Cost of spare parts of pier	65
Cost at which a complete pier and two spans of 100 feet each, with spare parts of pier and spare bolts for girders, could be delivered at Bombay, taking freight at 32*s.* 6*d.* to 35*s.* per ton, and including insurance at 40*s.* per cent.	3,905

60 Feet Span.

	£
Cost of a complete pier and 2 spans of 60 feet each	1,396
Cost of pier only	135
Cost of spare parts of pier	36
Cost at which a complete pier and 2 spans of 60 feet each, with spare parts of pier and spare bolts for girders, could be delivered at Bombay, taking freight at 32*s.* 6*d.* to 35*s.* per ton, and including insurance at 40*s.* per cent.	1,617

30 Feet Span.

	£
Cost of a complete pier and 2 spans of 30 feet each	520
Cost of pier only	60
Cost of spare parts of pier	20
Cost at which a complete pier and 2 spans of 30 feet each, with spare parts of pier and spare bolts for girders, could be delivered at Bombay, taking freight at 32*s.* 6*d.* to 35*s.* per ton, and insurance at 40*s.* per cent.	585

The above amounts are based on the assumption that many bridges of these several spans will be required. If only one of each is ordered, we do not bind ourselves to these estimates.

Dated 2nd January, 1864.

From—Messrs. Bray, Waddington and Co., *Leeds*,

To—Colonel P. L. Hart.

Below we beg to hand you prices of the wrought-iron bridges, the designs and descriptions of which the writer delivered to you last Saturday. We have, in accordance with your request, given you the approximate cost delivered at Liverpool, as well as at Bombay, and trust they will meet with your approval.

30 Feet Spans.	Delivered in Liverpool. £	s.	d.	Delivered in Bombay. £
Two continuous spans of wrought-iron plate girder bridges, with screw-pile pier, bracings, &c., ...	327	0	0	372
complete to Design No. 1	18	0	0	22
Spare screw-piles, bracings, &c.				
60 Feet Spans.				
Two continuous spans of wrought-iron lattice girder bridges, with screw-pile pier, bracings, &c.	1,038	0	0	1,180
complete to Design No. 2	47	0	0	56
Spare screw-piles, bracings, &c.				
100 Feet Spans.				
Two continuous spans of wrought-iron lattice girder bridges, with screw-pile pier, bracings, &c., ...	3,053	10	0	3,464
complete to Design No. 3	108	0	0	128
Spare screw-piles, bracings, &c.				

The workmanship and materials to be of the best description and to your satisfaction, or of whom the Bombay Government may appoint.

If you should require any further information, we shall be glad to furnish it, and trust we may be favoured with your orders.

Dated 7th January, 1864.

From—Messrs. Kennard Brothers, *Westminster*,

To—Colonel P. L. Hart.

We have the honour to enclose you tracings of bridges of 30 feet and 60 feet spans, prepared in accordance with the specification handed to us, which, with the tracings already sent, complete the number required.

We have designed these bridges with great care to meet all the requirements specified. We propose to use Blaenavon cold-blast bars, which is the strongest iron we have in this country, and will bear a tensile strain of 24 tons to the inch. We also propose to drill all bolt holes, and to turn the bolts, so that they may accurately fill the holes. We also propose to make all the several parts throughout the spans of equal dimensions, so that each bar can be placed in any position. The price of these bridges delivered f. o. b. in this country would be as under, *viz.*:—

	£	s.	d.
For a bridge consisting of two spans of 100 feet each, with screw-pile piers, as shown on drawings ...	3,490	0	0
Additional for 5 per cent. of spare materials in superstructure, and one spare column of screw-pile ...	190	10	0
For a bridge consisting of two spans of 60 feet each, with one pier of screw-piles as shown on tracing ...	1,660	0	0
Additional for 5 per cent. of spare material in superstructure, and one spare column of screw-pile ...	91	0	0
For a bridge consisting of two spans of 30 feet each, with one pier of screw-piles, as shown on tracing ...	554	0	0
Additional for 5 per cent. of spare materials in superstructure, and one spare column of screw-pile ...	33	0	0

The strains on these bridges are calculated to be tested to one ton to the foot run of live load, and supposing one ton to the foot run in ballast and platform. With this load the iron would in no case be strained more than four tons in compression, and five tons in tension. These bridges are necessarily very heavy in consequence of the unusual test load, the ordinary test being one ton to the foot run, whilst these are two tons. There is also some additional weight in consequence of having the bars throughout of the same section, which you considered desirable to facilitate the simplicity of fixing, and we quite think necessary under the circumstances.

The specification requires the delivery to be in Bombay. We have made enquiries at the India Store Department, and find the ordinary freight to that port is about 35*s.* per ton, but it is sometimes as much as £4 per ton, and as we have no means for ascertaining at what seasons the shipments will be made, we think it better to quote prices delivered in this country. We shall be very happy to wait upon you at your own residence, or to see you here, to give you any explanation you may require, or if you prefer it, at our works at Crumlin, which would probably be the best place; but if there, we should like to have one or two days' notice, so that our Mr. Howard Kennard may be able to meet you; and as the Blaenavon iron-works, in which we are largely interested, are near our works, we should be very pleased if you could spare a day to see them, and at the same time the quality of the iron we should employ. In the present unsettled state of the iron market, we should be obliged by your settling the question as soon as possible: the price is now £4 a ton higher than it was three months since, and there is every probability of a further considerable increase.

Dated 9th January, 1864.

From—MESSRS. KENNARD BROTHERS, *Westminster*,

To—COLONEL P. L. HART.

We have the honour to acknowledge your esteemed favour of the 8th instant.

The estimated weight of the 100 feet bridge is	160	tons.
Sixty feet bridge	10	,,
Spare material	80	,,
Thirty feet bridge	5	,,
Spare material	33	,,
... ...	2	,,

Our price was based upon delivery at our shipping ports, Newport and Grangemouth. The carriage from thence to London or Liverpool would be one pound per ton.

MEMO.

Freight. Tons.	£	Insurance. £		£	Other charges 1*s.* per Ton. £
170 at 35*s.*	297	3,680	40*s.* per cent.	73	8
85 ,,	148	1,751	,,	35	4
35 ,,	61	587	,,	11	2

Freight, &c.	£	£	Estimated delivery at Bombay. £
100 feet bridge	297 + 73 + 8 = 378	+ 3,680	= 4,058
60 ,,	148 + 35 + 4 = 187	+ 1,751	= 1,938
30 ,,	61 + 11 + 2 = 74	+ 587	= 661

Dated 7th January, 1864.

From—ROB. BROAD, Esq., *p. pro.* THE HORSELEY COMPANY, *Tipton, Staffordshire*,

To—COLONEL P. L. HART.

By railway to-day we send you three drawings, being designs for bridges for ordinary roads in India, as requested in your favour of the 20th of November last, which we trust will meet your approval. These designs have been arranged to meet the special requirements specified in your instructions, and are capable of carrying more than four times the specified load of one ton per foot lineal.

Our price for these bridges, fitted here and marked for re-erection, packing where necessary, painting, and delivery to Bombay, will be as under:—

	£	£
One complete pier and two spans of 30 feet bridge ...	220	
Spare materials	10	
		230
One complete pier and two spans of 60 feet bridge ...	630	
Spare materials	30	
		660
One complete pier and two spans of 100 feet bridge ...	2,300	
Spare materials...	100	
		2,400

Any further explanation you may require we shall be most happy to render.

Dated 9th January, 1864.

From—ROB. BROAD, Esq., *p. pro.* THE HORSELEY COMPANY, *Tipton, Staffordshire*,

To—COLONEL P. L. HART.

In reply to your favour of yesterday's date, we beg to say that our prices quoted for bridge work included all freight and insurance charges to Bombay. Below we hand you the estimated amounts divided for delivery at London or Liverpool, or Bombay:—

	London or Liverpool.		Bombay.	
One complete pier and two spans of 30 feet bridges ...	£197		£220	
Spare materials	10		10	
		207		230
One complete pier and two spans of 60 feet bridges ...	550		630	
Spare materials	25		30	
		575		660
One complete pier and two spans of 100 feet bridges ...	2,070		2,300	
Spare materials	85		100	
		2,155		2,400

Bridges

2-7

CIRCULAR No. 91 PUBLIC WORKS.

GOVERNMENT OF INDIA.

PUBLIC WORKS DEPARTMENT.

Civil Works.

Communications.

SIMLA, OCTOBER 17, 1866.

Description of Girder for Wrought-iron Bridges best suited for India.

Read:—

The annexed papers containing Tenders for, and general description of, the above Bridges.

ORDER.—Ordered, that the above papers, with sets of the drawings referred to, be forwarded to the Local Governments and Administrations marginally noted, for information, in continuation of Public Works Circular No. 41 of 1864.

Governments of Madras, Bengal, North Western Provinces, and Punjab.
Chief Commissioners of Oudh, British Burmah, and Central Provinces.
Commissioners of Mysore and Coorg.
Resident at Hyderabad.
Governor General's Agents, Central India and Rajpootana.
Governor, Straits Settlements.

(Signed) C. H. DICKENS, *Lieut.-Col., R. A.,*
Secy. to the Govt. of India.

William McSherry *C. E.*
Offg. Asst. Secy. to the Govt. of India.

To The Secy. to Govt. of Madras
Public Works Department

Public Works Department. 8

29

e/e 3761

PROCEEDINGS of the MADRAS GOVERNMENT
Under date the 15 Dec 1866
Read the following

From The Officiating Secy to the Govt of India

(Here enter No. 91 dated 17 Octr 1866)

Circulated to the Supt Engineers in continuation of P. D. No 2392 dated the 20th August 1864 — The Supt copies of the drawings which have been received with the above Circular are forwarded to the Chief Engineer 1st Circle — 1 Copy to Executive Engineer 1st & 2nd Circle — 1 Principal Superintending Engineer 1st Circle — 1 Do Do 2nd Circle — 1 Do Do 3rd Circle — 1 Do Do 4th Circle — 1 Do Do 5th Circle — 1

To the Superintending Engineer — Plans already sent

To the Executive Engineer 7 & 8 Circle — Plans already sent

Recd 17th December

Plans duly sent to the Supdg Engr 1st Circle on 22nd Dec 1866

20 Aug 1864 — No 2392

P. W. 1865 Copies

No 4829

GOVERNMENT OF INDIA.

PUBLIC WORKS DEPARTMENT.

CIVIL WORKS.

To The Secy. to Govt Madras

CIRCULAR No. 91 PUBLIC WORKS.

Dated SIMLA, *October* 17, 1866.

Received 20 October 66.

Enc. 2.

No. 299.

Description of Girder for Wrought-iron Bridges best suited for India.

e/e 3961 — 15th Dec 1866.

e. 5th Dec 1866 Ch. Sec

P. W. 186 . Department.

Pbo. of Govt for Deer

No. 3961

PROCEEDINGS OF GOVERNMENT, Judicial

Dated 16th Decr 86

Orders of the Govt of India forwarding papers containing tenders for wrought iron bridges with general description of girder required, Estimates &c. to be submitted &c.

Re 299-300