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Ebening Meeting.

Monday, May 1st, 1865.

REAR-ADMIRAL R. COLLINSON, C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between the 24th April and the 1st May, 1865.

ANNUAL.

Gordon, L. G., Lieut.-Col., Royal Engineers. 1l.

Lane, J. V., Assist.-Surg., 4th King's Own.

Browne, James, Lieut., 91th Regt.

Blackett, L. F., Lieut., Rifle Brigade.

1l.

Travers, Jas., Brig.-Gen., Bengal Army.

THE NAVIGATION OF THE RIVER HOOGHLY, AND THE PROPER MEANS TO BE ADOPTED FOR ITS AMELIORATION, ESPECIALLY IN REFERENCE TO THE DANGEROUS JAMES AND MARY SHOALS.

By W. A. Brooks, Esq., C.E.

THE state of the river Hooghly, which has been for so many ages the almost sole outlet for the commerce of the richest districts of India, embracing an area of above half a million of square miles of land, is surely an object well worthy of the deepest attention.

Far different at the present day is the demand for accommodation for commercial interests, from that which existed when India was subject only to her native princes, and the little trade which was carried on was principally by small coasting vessels, which passed with ease over the shoalest parts of the navigation of the Hooghly. Those shoals now throttle the trade of the port of Calcutta; and the well-known and dangerous shoals, called the James and Mary, entail annually a greater charge upon the trade of the port than would suffice to remove them. Ships of large draught of water can only pass over them at or about the period of high water, rendering it therefore

necessary for them to bring up in their vicinity on their voyage down the river, in order to pass with safety at the proper time of tide.

It is thus that while a single day often suffices for a ship to sail up to Calcutta with a flowing tide, she is usually compelled to take two or three days before she is able fairly to get to sea out of the Hooghly. Still, the Hooghly is a noble river. From the fairway buoy to "The City of Palaces" the various channels seldom possess less than a depth of five fathoms at low water in the straight reaches, and from seven to ten where the stream ranges along concave shores; and in a well regulated state of the river there would be nowhere found less than five fathoms at low water; the existing shoal places being met with only where the stream is allowed to abruptly change its course from one bank of the river to the other, or where the navigation, from being divided into several channels, in lieu of being confined in one, loses necessarily in depth.

Shoals are also encountered where the course taken by ships changes from one of those channels into that of another, owing to the conservators of the port having lighted up and buoyed out a mere lateral or flood-tide channel, which is destitute of any deep-water passage into it from above. Thus ships, after having safely reached the Saugor roadstead, find their further passage up the river barred by the vast bank of sand which separates the Saugor roadstead from the western or main channel of the Hooghly, and can only get into that channel by passing over the bank at the slack places or channels, which are buoyed off through it. The southernmost of these swatchways, called Lloyd's Channel, has barely a depth in it of two fathoms at low water; and the Bedford, or northernmost, has generally only the same limited depth. These channels would therefore be impracticable for ships of large draught of water but for the lift of tide of from 12 to 14 feet during spring tides, and from 6 to 9 feet during neap tides.

The resolution to light up and buoy out the noble roadstead abreast of Saugor Island, in lieu of the main or western channel of the Hooghly, has thus entailed upon the navigation of the Hooghly the difficulties of passing either by Lloyd's or the Bedford channels, through that vast bank of sand and mud which will at some future period form part of Saugor Island; because, like the latter, its shoal condition is due to the deflection of the ebbing waters of the Hooghly by the trend of the left bank of the river above Saugor Island, thus forming a vast eddy abreast of the latter, which forms a place of deposit for the alluvions of the Hooghly, which are only partially removed by the action of the current of the flood tides. Having regard to the increased navigable depth which is required for the trade of Calcutta, as well as the reasonable probability of a still further diminution of the present navigable passes called "Lloyd's and the Bedford Channels," owing to the silent operations of nature, it will probably not be long before the Trinity House of Calcutta will take as much pains to effectually light up, and buoy the main or western channel, as they have that of the eastern channel. Saugor roads; a more direct and deeper navigable channel will be the result, and ships will seldom experience the necessity of bringing up to anchor to wait for the tide, as they are now

so often obliged to do in Saugor roads. It is desirable also to close up the channel between the left bank of the Hooghly and the north point of Saugor Island, so as to concentrate the whole power of the currents of ebb and flood tides through the western or main channel, a measure which will also have the effect of ameliorating the condition of the navigation of the channel above Saugor Island; and this is probably all that is at present practicable towards increasing the safety and depth of the navigation through the estuary of the Hooghly.

Higher up the river we have the encouragement of the good results produced by that natural embankment which has been produced by the deposit of alluvial matter on each side of the channel of the Hooghly, leaving nothing for man to improve upon in the course of many miles of its noble navigation. Thus from Currie's Docks, on the right bank of the river abreast of Calcutta, to 21 nautical miles below "the City of Palaces," a fine channel exists, capable of being navigated at the lowest state of the river by ships of the largest draught of water; and this channel extends for a further length of 13 nautical miles, or to the upper end of the James and Mary shoals, only broken for a short course at three places by the five-fathom channel being reduced to $3\frac{1}{4}$ fathoms at low water by the crossing of the stream from the right bank of the river to the left bank at Allumpoor; by another similar crossing at the Brool Semaphore, from the left to the right bank, but with still as much as $4\frac{1}{4}$ fathoms at low water; and lastly, by a shoal abreast of the Dhaja Semaphore, where the current of the ebb crosses from the right to the left bank, but with happily the same depth of $4\frac{1}{4}$ fathoms at low water.

The navigation over those three shoals is also unattended with any great difficulty, and therefore while dangerous shoals remain, such as those of the James and Mary, it is evidently proper to concentrate every available resource on the removal or clearance of the latter.

The James and Mary shoals consist of what may be properly designated a maze of shoals, varying in form and depth with every change of the condition of the river as affected by the preponderating influence at the time of either the freshes or the strong flood tides of the south-west monsoon. This much may, however, be depended upon, as regards the influence of the pure tidal currents, that in no case will the latter be found capable of maintaining permanently deep or continuous channels; such will always be found to be dependent upon the current of the ebb, or upon the channel being directly open to and occupied by the natural backwater or drainage of the country.

The object which should be steadily kept in mind by an engineer charged with the improvement of a navigation is to seek to lead the flood currents into the same channel which is taken by the ebbing current; and this can always be effected, although wherever there is a great difference between the period of discharge of the ebb over that taken by the flood current, the latter will, at the early part of the flood, force its way along the shores, and particularly on the convex side of the channel, where it meets with less resistance from the current of the ebb.

On the examination of the chart (Pl. xxix) where the River Damoodah

falls into the Hooghly, we find that the combined currents produce a noble and central deep-water channel for two miles below, and that this channel only begins to shoal as the direction of the ebbing current through it feels the influence of the trend of the right bank towards the point of Koorchee-bariah, by which it is thrown towards the eastern or left bank of the Hooghly, abreast of Neely Koll, or Crossing Creek. The current, in thus crossing so abruptly from the right to the left bank, gains in breadth, and consequently loses in depth; and in consequence of this crossing, the available depth of channel is barely $2\frac{1}{2}$ fathoms at low water, in lieu of from 5 to 9 fathoms, which is found in the channel above the shoal of the James and Mary. The current after thus crossing to the left bank ranges along that shore, and, finally, at the lower end of the reach, again crosses over towards the right bank, nearly opposite the mouth of the Roopnarain river, but in this case the depth is usually greater, or amounts to about $3\frac{1}{2}$ fathoms at low water, because it is here subjected to the useful scour or discharge from the Roopnarain river, which, as in the example above of the Damoodah river, has the effect of deepening the navigation below its junction with the Hooghly; at the same time it must be admitted that the Roopnarain discharges its waters into the Hooghly so abruptly, that the dangers of the navigation of the Hooghly through the James and Mary shoals are greatly increased: no doubt can also arise as to the prejudicial effect produced by the flood tide being allowed to flow freely up the channel of the Roopnarain river, and to only find its course up that of the Hooghly by an abrupt and tortuous direction.

It has been shown that the trend of the shore of the right bank of the River Hooghly, below the mouth of the Damoodah, has the effect of throwing the current of the ebb towards the left bank, and thus also forming an eddy or still-water abreast of the right bank below Koorchee-bariah point, as far as the mouth of the Roopnarain river, and thus the whole of that part of the bed of the river would have consisted of dry banks, or very shoal water, but that a large portion of the deposit of sand on every ebb tide is swept away by the strong run of the flood tide over it from out of the Diamond reach of the Hooghly, and thus is scoured out the channel along the right bank of the river between Fort Mornington point, at the mouth of the Roopnarain, and Koorchee-bariah point. This flood-tide channel has 14 fathoms at low water at its lower end, and $2\frac{1}{2}$ fathoms at its upper end, where it falls into a pool which is made by the waters of the Hooghly, when the river is in a state of inundation. A second bank of $2\frac{1}{2}$ fathoms has afterwards to be crossed to reach the main channel of the ebb. It is a well-ascertained fact, that this western channel or gut is always opened out by the strong flood tides of the south-west moonsoon.

The main features of the navigation of what may be termed the region of shoals of the Hooghly consist therefore in the ebb and flood occupying different channels, each alternately crossing at nearly the centre of the reach between Koorchee-bariah on the right bank and Neely Koll, or Crossing Creek, on the left bank.

The remedy for this evil would appear to be found by the simple, although expensive process, of straightening the navigation by boldly filling up the bight or concave portion of the channel abreast of the left bank of the river between Nynan and half a mile below Noorpoor, thus forming a new foreshore as per blue line drawn on the chart. Such a work would have the effect of scouring away the point of land at Koorchee-bariah, and a nearly straight and safe navigation would supersede the very dangerous one which now exists. The flood and ebb currents would almost entirely pass over the same bed.

The sole remaining question to be now considered is whether the execution of such a work, the groining up of this left bank, which has heretofore been proposed (at least the principle of the work, by the proposition "to construct a groin or spur at Crossing Creek") is such as would produce the greatest possible benefit to the navigation if carried into effect? The result of such an inquiry must be against such a plan, because it would be an imperfect one. It would still leave a very tortuous navigation round Hooghly Semaphore point, between the James and Mary and the Diamond reaches; but, above all, it would, as at present, leave the strength of the flood-current to set up the Roopnarain river, in lieu of the Hooghly channel above Diamond reach.

The relative directions of the Hooghly and Roopnarain channels above the Diamond reach are as injurious to the former as beneficial to the latter; and on this account the lower part of the channel of the Roopnarain river presents an extent of channel beyond that which would be due to it by reason of the amount of drainage or natural backwater which passes down it.

To groin, or fill up the bight on the left bank of the Hooghly above Diamond reach, would, therefore, be to leave difficulties in the navigation which might be removed by the adoption of a simpler and, it is believed, much less expensive plan, or by the formation of a new cut or channel across the neck of land which lies on the left bank between the James and Mary and the Diamond reaches, as particularly described on the chart. The right bank of this new cut will be concentric with the trend of the present right bank of the Hooghly, between the mouth of the Damoodah river and Koorchee-bariah point, and also the trend of the right bank of the Diamond reach below the point of Rajnagore.

To execute this great change, which will allow the streams of the Hooghly and Roopnarain to form easy connections with the Diamond reach, and altogether get clear of the dangerous navigation through the James and Mary shoals, it will only be necessary to make a cut of 2,240 yards in length, about one mile and a quarter, which, if broken into, just before the period when the great land floods commence, will, from the shortness of the new course, become rapidly the Hooghly navigation. The narrow cut first made on what would be the concave shore, would, in a few days, become a broad and deep channel. It would be advisable to guard against too deep a scour by facing the new concave bank, and possibly it might be advisable to construct a groin, at Koorchee-bariah point, concentric with the same shore of

the new cut, to more rapidly convert into land what now forms the principal portion of the sites of the James and Mary shoals.

The whole of the works necessary to effect this improvement of the navigation, irrespective of the purchase of land, would not cost £200,000.

Having, I trust, read nature's book correctly, in this my description of the features of the navigation of the Hooghly, I purpose now to submit to your investigation those views or theories which have already been propounded to the public on the same subject, for it could not be otherwise than that the dangerous navigation of the Hooghly has often been discussed.

Thus one author on the subject, and who is entitled to respect on account of the nautical information which he undoubtedly possesses, has told us that it is the influence of the Damoodah current which has led to the formation and maintenance of the James and Mary shoals; and the remedy proposed by that gentleman, and by several who have taken the same view, is "to divert the channel of the Damoodah from its present embouchure above the James and Mary shoals, and turn its waters into the Roopnarain river by a cut of four miles in length, from near Bagnan." To the above a reply has been given, where, in this paper, I have already shown that so far from the Damoodah having done any harm, it is proved to be of great service to the navigation below its junction with the Hooghly; and there is the further objection to its diversion into the Roopnarain, inasmuch as that measure could not be carried out without injury to the channel between its present embouchure and that of the Roopnarain, because of the abstraction of a large portion of the backwater which now keeps that channel open. It is said that in ancient times the waters of the Damoodah formed a junction with the Hooghly above Calcutta, and surely a restoration in that direction would be a more consistent course to adopt.

Another author, who has given his views professionally on the same question, as to the cause of the formation of the James and Mary shoals, attributes the same to "the strong ebb tide from the Roopnarain checking the Hooghly current".

To this theory an objection has been already offered in this paper, where I have shown that the only effect of the ebbing current of the Roopnarain can be in scooping away part (the lowermost margin) of the James and Mary sands, the current of the Roopnarain must be quite innocent of being the cause of any deposit or formation of sand on the sites of the James and Mary shoals; and this must be manifest when it is borne in mind, that while the water of the Roopnarain debouches into the Diamond reach below, the waters or current of the Hooghly are also taking the same course, and, in fact, the direction of the channel in the upper portion of the Diamond reach is the resultant of the two forces or discharges from the channels of the Hooghly and Roopnarain.

The Roopnarain current could only cause a deposit in the channel of the Hooghly above the embouchure of the Roopnarain, provided still water existed in the Hooghly above, a circumstance which can never

occur. By still water I mean comparatively still water. Thus supposing the rate of discharge of the Roopnarain very greatly exceeded that of the ebbing current of the Hooghly, the course of the latter might be diverted more towards its left bank, and partial slack water formed at the point of land immediately above the Roopnarain, but such is not the case, and the same is proved by deep water (14 fathoms) being found there, even at low water.

A notice of the Hooghly can hardly be considered satisfactory which omits a consideration of the necessity which exists of providing dock or still-water accommodation for the valuable class of ships which are now so exposed to disasters while moored in an open stream, which, in its inundated state, runs with the fearful velocity of six nautical miles an hour.

It must be evident that no moorings can be relied upon when they are subject to the shock of even a single heavy ship coming down upon them with so great a velocity.

It has been proposed to construct docks out of the land, on the left, or Calcutta bank, above the city; and, doubtless, such a work is practicable, but to give ample accommodation to the shipping, as well as to the country boats bringing goods, the acreage of the dock must be of great extent; but, above all, will be found the difficulty of providing easy, and safe access to such a dock during the period of inundations.

Having regard to these objects, as well as the convenience of the existing trade and shipping establishments, surely it would be more judicious to give the preference to the system of providing the required accommodation out of the present channel, without disturbing the vast vested interests on the shore of the city of Calcutta; as was done in the case of the construction by me of Northumberland Dock, in the Tyne, a few years since, where 70 acres of the stream were enclosed by a river embankment, and a dock was formed abreast of numerous staithes, at which above a million and a quarter of tons of coals were then annually shipped, and this, too, was done without stopping that valuable trade for a single day, and the new channel was simultaneously scoured by the current out of the maze of shoals which it displaced.

It may here be observed, that at all the great northern docks for shipping coal, the use of lockage is, in practice, dispensed with as much as possible.

The tide is allowed to freely enter when it has reached the level at which ships are water-borne in the docks, the gates being only closed to retain sufficient water to float the ships; but, inasmuch as in this great tidal basin or dock, projected by me abreast of Calcutta, the depth, even at low water, is ample for that purpose—ranging, in fact, from four to eight fathoms, it will not be necessary to provide entrance-gates or locks.

A space would be left open at the lower end of the dock of 450 feet in width, between the dock embankment and the shore, through which entrance, ships would freely sail on the flood or ebb tide, and also during the inundated state of the river, when they are able to make way against the current. On approaching the dock entrance, they would fall

into an easy tide, and at once pass freely up the dock to the wharves to which they are destined.

It is also proposed to leave another entrance, if required, through the body of the embankment for the admission of country boats. At the upper end of the dock sluice-gates will be constructed, to give the power of scouring away any accumulation of silt within the dock, which would be brought in by the flood tides.

This northern barrier would not be closed until after the long river embankment has been completed.

During the period of inundation, it would not be necessary to make use of the sluices, because at that time there would be comparatively little deposit, as the water in the dock would be still, or nearly unchanged; in fact, its level would only vary with that of the floods. The current outside, raging along at the rate of six miles an hour, would bear with it those vast alluvions with which it is at such times charged.

An accumulation would take place near the entrance, but the area of the deposit would be so limited that it could readily be kept clear by dredging, the annual outlay for which would be small in comparison to the returns necessary to meet the great charge which would be entailed by the construction of locks and gates on the indifferent foundation which the bed of the Hooghly and adjacent land everywhere affords; to say nothing of the greater facilities to trade which would be afforded by free ingress and egress without that delay which takes place in passing numerous vessels through gates and locks.

Without going minutely into the calculation of either docks excavated out of the land, or, as proposed by me, formed out of the bed of the river, it may be safely assumed that, without the purchase of land, a dock of only 25 acres, made out of the ground above the city of Calcutta, would cost more than one of 220 acres, if the latter were made by enclosing a portion of the bed of the Hooghly.

One great recommendation of the present scheme is, that it would not disturb the existing trade, or interfere with local mercantile establishments, and the expensive moorings which have been laid down.

The plan shows an alternative dock, of 205 acres, abreast of the northern division of Calcutta, between which dock and the Great Indian Railway a ready connection might be made by the bridge over the Hooghly, which is about to be constructed by the Railway Company.

Although the works proposed by me would, probably, answer all the requirements of the trade of Calcutta, in the simple form of a great tidal basin, nevertheless, it is quite practicable to convert the same into a floating-dock by the construction of gates at the south end, and founding them upon a thick bed of concrete.

Before you is a plan of Northumberland Dock, in the River Tyne, which has been referred to in this paper, and it will be seen that it appears as if traced out as an example for a work to be executed in the Hooghly, abreast of Calcutta, so precisely similar are the relative features of both sites, the advantage being, however, in favour of the Hooghly; because the site of the long embankment or river-wall in

the Tyne had to be constructed on a bed of sand, which was not penetrated through by borings carried to a depth of 60 feet below low water of spring-tides.

The CHAIRMAN: The subject which Mr. Brooks has brought before us to-night appears to me to divide itself into two sections. There is, first of all, the improvement of the lower part of the Hooghly in that particular crossing where the Damoodah river interferes with the navigation; the other portion relates to the construction of docks for the accommodation of shipping opposite to Calcutta. We shall be glad to hear any observations on the subject, and I hope the discussion will follow the course taken by Mr. Brooks, who began at the lower part of the river, and then passed from the lower part of the river to the upper.

Captain FISHBORNE, R.N., O.B.: I think the subject of rivers, and the way in which they can be improved, has been too much overlooked. I fall very much into Mr. Brooks' views, though in some respects I differ from him; inasmuch as he said the effect of this current could not produce the James and Mary shoal. Now the effect of the flood coming up, meeting with the current coming from the Roopnarain is, that the flood is checked, and the moment it is checked in its flow upwards, there is a deposit which forms the James and Mary. Of course, that will not be very much. I quite agree with Mr. Brooks, that cutting a passage from the Damoodah river into the Roopnarain would be fatal, and make the shoal worse than it is at present. A necessary consequence of the former river coming in where it does, is to join the current coming down, the result of which is to produce the straight and strong current which now keeps the channel open, as shown in the diagram. Cut that off, the current from the Damoodah, and the main stream would shoot over against the right bank, and then over to the left, from which there would be a succession of transverse currents, which would create an increased number of shoals; it would also decrease the rapidity of the current, and the volume of it by the amount of that river, and besides the alteration of the direction of the current, it would tend to increase the difficulties of the James and Mary shoals. Now, let us suppose the effect of this increased current. We see that an evil would have arisen. If the cut were made, the current down would be increased. The effect would be this: the flood coming up would meet an increased down current; it would be resisted more than it is now, and it would bend round more than it does at present, and make the passage more intricate. I concur in Mr. Brooks' view as to the advantage of a new cut where he proposes it should be made, and do not think the cost would be great. I remember seeing a railway viaduct over a river upon which a great deal of money had been spent, because it was being continually undermined by the river, and they had to put in buttresses and all kinds of things to support the bridge. The engineer came to look at it. He saw where the stream struck, and he ordered some cart-loads of stones to be thrown in at that point. The result was that the stream was shot fair through the bridge, and the necessity for any further buttresses and props was rendered unnecessary. A groin at Koorchee-bariah would tend to turn the river over into the new direction, after the cut was opened, and of throwing the whole current straight through it; so groins in different parts would straighten the course, and would of course help to deepen it in the same way. It is a very unpleasant passage over the shoals at the present moment. Generally speaking, I agree with Mr. Brooks, and I feel, perhaps even more strongly than he does, that it would be fatal to the main river to change the embouchure of the Damoodah; besides which it would be a great expense, inasmuch as the distance is four miles instead of one.

MR. BROOKS: That would exactly be the effect which Captain Fishbourne describes; the stream would strike on the right bank, and then rebound again.

A MEMBER: What is the width of the cut you propose?

MR. BROOKS: A mile and a quarter. I propose merely to cut one-third through in breadth; it will soon tear all the rest away, and perhaps cut three or four branches all across the other part of the channel, but care must be taken to have the concave shore well protected, otherwise on that side it would get too deep, and would go back round to the westward.

General BOILEAU, R.E., F.R.S.: The James and Mary shoal has been the great

bugbear of the Hooghly river for half a century. I have known it for 45 years, and it is still the same dangerous shoal; but really I believe that the danger of the James and Mary is much more imaginary than real. We do not hear of ships being lost there. At all events, if there are any lost there they are so few in number that they almost negative the fear that people have of going up the Hooghly, or turning that point. I have been five times up and down myself. It never gave me the slightest anxiety or thought beyond the fact that we knew we were near the James and Mary. I passed it in March, 1857, in the "Marlborough," a ship of 1,500 tons, drawing 25 feet of water. We went over it just as easily as we went down any other part of the river. There have doubtless been ships lost there, and there is certainly this fact—that if a ship does touch on the James and Mary she may not get over. The great safety now of the navigation of the Hooghly lies in the number of powerful steam tugs which are always available. When ships had formerly to sail up, the danger was great, but now these powerful steam tugs meet ships low down in the river and bring them safely to Calcutta. The disadvantage is the delay, which has been very correctly explained by Mr. Brooks, of being obliged to anchor until the tide serves. With regard to the formation of the James and Mary, the question is one which I do not think can be decided or properly understood by an examination of the map. The locality must be inspected. The rivers which fall into the Hooghly at Hooghly point, viz., the Damoodah and the Roopnarain would then be better understood than they can be from the sketch that has been prepared, or from the description that has been given. They are both very large rivers, draining an extensive surface of country. For the whole period of our occupation of the Bengal provinces they have been the cause of the greatest anxiety, trouble, and expense to the Government. Different and ever-varying projects have been submitted for preventing the disastrous consequences of the enormous floods which come down these rivers, and which for a time it was endeavoured to control by embankment, so that the body of water which was poured into the Hooghly was very much greater than it is now. It has lately been decided by the Government to do away with the embankments through a length of about 20 miles of the Damoodah. They were found so difficult to maintain, so expensive to construct, and required so much watching, and the failures were so numerous, that at last, in 1857 and 1858, the Government decided that the embankment should be removed within the above limits, and the river is now allowed to flow over its natural banks. It would be interesting to ascertain what the effect of that arrangement has been on the James and Mary. When the Damoodah and the Roopnarain rivers were both fully embanked, and the water poured down them in the rainy seasons, what was the effect then on the James and Mary, and what has it been since the Damoodah embankments have been removed? Then, we may go back to a period far beyond that, because it is well known that the Damoodah river fell into the Hooghly, or as it was probably then called, the Bhageeruttee river, about 70 miles further up, that is, at a place called Nya Serai, eight miles to the north of the town of Hooghly. What are we to suppose was the state of the river in those days? Did the James and Mary exist? or did it not exist? These are the points which are interesting in respect of the agency through which these sands are deposited, and which, I think, would guide to a considerable extent those who undertake the theory of deciding in what way the James and Mary is formed. My opinion of it is pretty much the same that Mr. Brooks and Captain Fishbourne have expressed. The waters of the Damoodah, Roopnarain, and Hooghly rivers are held up by the flood tides of the Hooghly, and during that time the Damoodah and the Roopnarain, which would otherwise pass away and carry their silt with them, are held back, and a deposit takes place. When the flood recedes, and the waters of the tributaries pass down, they keep their deep channel course, and the sand which has been deposited remains there. I believe this action is continually going on, and that the James and Mary is maintained simply by such agency. There is a part at George's point which it is exceedingly difficult to get by, and Lloyd's channel is almost entirely filled up. But it is expected, and I have no doubt it will be found to be so, that as one channel fills up another channel is opened. The Marine Department of Calcutta are engaged constantly in taking soundings, and in buoying out channels as changes render the

work necessary. I believe the Hooghly pilots are so thoroughly aware of the channels of the river that if you hand them over a ship at the floating light they would take her up to Calcutta almost with their eyes shut. They work by soundings. Therefore, fully agreeing with the lecturer as to the James and Mary being a danger in the river, I think the danger is not so great as is generally supposed, from the facilities which steam navigation has given to ships going up. It is a singular fact that in the last year the trade of the port of Calcutta has more than doubled, without, I believe, a single accident having occurred at the James and Mary sand.

Captain FISHBOURNE: I can bear testimony to the wonderful accuracy of the soundings. I have made the Hooghly at night, and I went on all night simply by the soundings, without pilots, lights, or anything else. I went on without anything more than the lead.

The CHAIRMAN: The question of docks at Calcutta is one of great importance, and if any gentleman has any remarks upon that subject we shall be glad to hear him.

General BOILEAU: The subject of docks in Calcutta is one which has engaged the attention of several parties, and which is now under the consideration of others. I have no doubt that most of the gentlemen present will be aware that there is a grand battle going on between the Hooghly and the river called the Mutlah, which is situated about 19 or 20 miles to the east of Calcutta. A railway has been formed between Calcutta and Canning Town, which, I believe, is at present not a very productive one. Canning Town is only in embryo, and the other engineering works which it is in contemplation to construct there, are scarcely yet commenced. But the Bombay people, who seem to have taken up the question lately, have got a scheme for carrying out the Canning Town project, and for erecting landing stages, and other things necessary for a large port; and if they should do this, there is every probability of that project being ere long completed. How far that will affect the question of having docks in Calcutta I am not prepared to say; but there is no doubt that those most deeply interested in the subject are taking it up *con amore*, and that in a short time we shall have docks at Calcutta, as well as a new port at Canning Town on the Mutlah river. All the other conveniences for commerce and passenger traffic, I think, railway communication affords.

Mr. BROOKS: It would be very easy to form docks at Calcutta. It has been done on a large scale in the Tyne, and done rapidly.

The CHAIRMAN: How do you propose to form the walls?

Mr. BROOKS: There the only difficult work is to get the material. The way they provide ballast for the great railways in Bengal is by burning clay. Now, the clay itself would not be efficient; you would have to burn it in the form of bricks, but I calculate upon forming the embankment with large slopes. There is another way in which it might be done very readily indeed. There would be no pressure. The water standing outside and inside at the same level, if you could possibly place a sheet of paper between it, would make still water. That could be readily done by using screw iron piles up and down. You could do it in twelve months. Put wrought iron piles of four or five inches—put ten down every four feet apart, with three feet screws to them. Put those down twenty feet below the lowest part of the bed; then drop your plates in grooves between them, and you would readily close all up. You would have to stay it well. The only difficulty you would have would be to bear against the wind, the violent effects of the hurricanes; but you could protect it by masses of brick and stone, if you can get stone as ballast. I went into the calculation, and the entire work could be done for £300,000.

The CHAIRMAN: With the screw piles?

Mr. BROOKS: With the screw piles, putting in three-foot screws at the bottom of each pile. The piles would be above 72 feet in length. That would be a very ready way of doing it.

General BOILEAU: Would you put in single rows of piles?

Mr. BROOKS: Single rows of piles, putting in cast-iron plates—four-foot plates dropped down into the grooves with occasional stay piles.

The CHAIRMAN: What is the rise and fall there?

Mr. BROOKS: About 15 or 16 feet.

The CHAIRMAN : So that ships would have to be made fast allowing for the rise and fall of the tide.

Mr. BROOKS : Yes; all the present moorings would be undisturbed.

The CHAIRMAN : That is to say, at a certain period of the tide they could not unload.

Mr. BROOKS : They could always unload, because we have got five fathoms at low water.

The CHAIRMAN : But they would have to hoist.

Mr. BROOKS : They would have to hoist, the same as in a dock. For three months in the year, when the river is in a flooded state, it stands nearly at the same level. There is no rise and fall, in fact. The flood merely checks the downward current at high water; it does not run up. The way I have described would be a cheap way of doing the work. A dock like that in the Tyne, as per plan on the wall, constructed in the ordinary way, would have been a two million job, whereas it did not cost £200,000.

Rear-Admiral HALSTED : What is the rate of the spring tide?

Mr. BROOKS : About three miles an hour.

Admiral HALSTED : The Hooghly is a wild and capricious beast.

Mr. BROOKS : It is a wild beast; much more so than the Tyne. I have seen the tide in the Tyne running down four knots an hour; but in a dock of this kind you would not have to stem the tide—the tide would run right in. A ship could not turn at right angles into the excavated dock, as formerly proposed. It would be a very difficult operation indeed.

The CHAIRMAN : I am sure you will join me in returning our thanks to Mr. Brooks for the lucid manner in which he has put forward what he thinks is the best that should be done with the Hooghly. This question of dealing with rivers on alluvial soils is probably one of the most difficult problems the engineer has to solve, because, in the first place, he has got no foundation that he can depend upon. He cannot put down anything but what will be undermined. And we learn another lesson from what Mr. Brooks has set before us—the wonderful effect which tributaries entering into the main streams at right angles have upon the main body of the river. There we always find the most serious obstructions. I quite agree with what has fallen from Mr. Brooks that to connect the Damoodah with the Roupnarain would tend to make the place really worse than it is. The question of that proposed new cut depends entirely upon whether we can get a foundation for it. Undoubtedly that would improve the channel of the river, and entirely do away with the difficult shoal. But the question comes, if you once interfere with that point, would you not wash it all away? I should like to see the river improved, yet I do not think it can be done without sinking cylinders to an extent that would render the expense something very great.