8067.

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

Railway.

Read again the following paper :—

G.O., dated 27th June 1890, No. 930 R., Public Works.

Read again the following paper :—

G.O., dated 2nd April 1890, No. 464 R., Public Works.

Read again the following paper :—

G.O., dated 13th March 1890, No. 359 R., Public Works.

Read again the following papers :—

G.O., dated 11th January 1890, No. 31 R., Public Works.

From the Consulting Engineer for Railways, dated Madras, 8th January 1890, No. 9.

From the Agent, South Indian Railway, to the Consulting Engineer for Railways, dated Trichinopoly, 2nd January 1890, No. 3.

Referring to your letter, No. 851, of the 19th September 1889, I beg to forward, herewith, proposals regarding the Pennér bridge on the Villupuram-Guntakal Railway, together with three drawings, and I shall be obliged by your communicating to me early orders of Government thereon.

Enclosure.

VILLUPURAM-GUNTAKAL STATE RAILWAY.

Proposals for Bridging the Pennér river near Pamidi.

The river Pennér takes its rise in the Mysore territory within about twenty-five miles of Bangalore and from its source to the proposed crossing * of the Villupuram-Guntakal Railway, it traverses about 130 miles measuring along its general direction without following all its windings. The drainage basin has an average width of about twenty-five miles and an area of 2,835 square miles, as shown on the accompanying map.† From this it will be seen that the basin is long and narrow, the river being fed from hilly sides, which, it may be assumed, discharge into the main channel with considerable rapidity.

* About 24 miles south of Guntakal.

† No. 59.

2. Examinations of and investigations in connection with the river crossing were conducted under Mr. Lambert‡ who prepared the project for the Hindupur extension, of which the Dharmavaram-Guntakal section forms the northern part, and a bridge of fifteen 100 feet girder spans was proposed and included in his estimates, but further study and investigations point to a larger provision of waterway being necessary.

‡ Chief Engineer of Bellary-Kistna State Railway.

3. It seemed to me possible, when inspecting the locality, that a better crossing could be obtained about half a mile higher up the river, when it is hemmed in by a high rocky hill on the southern bank, but further consideration leads me to recommend adherence to Mr. Lambert's original proposal, which was, I understand, approved by Sir Guilford Midlesworth as on the

whole best suited to the circumstances of the case, one of which now is that any alteration would involve the abandonment of a considerable length of railway embankment already formed to the north of the crossing, and in these views Major Gracey, Superintending Engineer of that part of the line, concurs.

4. The rocky hill before referred to on the south bank of the river, acting as a groyne, deflects the river to the north, causing a heavy spill over the northern bank. The southern bank below the rocky hill is well defined and is to a great extent elevated above flood level, but the northern bank is low and shelving both at and above and below the crossing.

5. The width of the river bed, proper, at the proposed crossing is 2,400 feet, while the spill on the north bank in high floods extends for 2,850 feet farther, making a total flood width of 5,250 feet with an average depth of $4\frac{3}{4}$ feet of water when the river is in high flood.

6. Opposite the rocky hill on the south bank about half a mile above the railway crossing, the river bed is about 1,800 feet and the spill 2,200 feet wide, the waterway in flood then aggregating 4,000 lenial feet.

About $1\frac{1}{2}$ miles down stream from the proposed crossing opposite the village of Pamidi, which there juts out from the northern bank, the river is confined to a width of about 1,700 feet.

7. The proposed crossing is, therefore, at an unusually wide part of the river when the flood-spread is great and velocity reduced where it is well protected on the southern side and on the northern, exposed to a wide shallow spill, in dealing with which no special difficulty is anticipated.

8. In the original project (Mr. Lambert's) a long training bund is provided and was executed as a famine-relief work above the approach to the bridge on the northern bank of the Pennér so as to deflect the spill back into the river. In addition to this work, it is proposed to heavily pitch the upstream side of the railway embankment where it comes within flood limits. A long nulla diversion, shown on the plan on the north side of the river, was also carried out by famine labour and so far it has got into train and worked very satisfactorily.

9. The Pennér is crossed by the Madras Railway about twenty-five miles lower down than the Villupuram-Guntakal Railway crossing, and the following data connected with the Madras Railway bridge has been kindly furnished by Mr. H. R. P. Carter, the Chief Engineer of that line :—

Drainage area of river Pennér above Madras Railway	4,500 sq. miles.
Fall of river bed	6·36 ft. per mile.
Mean velocity	8·2 ft. per second.
Area of section to H. F. Level	16,911 sq. ft.
Discharge	138,670 C. ft. per second.
Madras Railway bridge (131 × 13)	1,703 lineal ft.

To this discharge $D = 500 \sqrt[3]{M^2}$ of Ryves' formula very nearly applies, the coefficient obtained being 508 in place of the 500 of the formula, and the discharge is equal to about 31 cubic feet per second for each square mile drained. A result very similar to that obtained by Colonel Colleyer for the actual discharge of the Pálár with an almost equal area.

10. Applying Ryves' formula,* with coefficient 508, to the drainage area (2,835 square miles) above the proposed Villupuram-Guntakal Railway bridge, the discharge arrived at is 101,787 cubic feet per second, or about 35 cubic feet per mile drained; again working out the discharge from the following data the result is 108,279 cubic feet per second, thus—

* $D = 508\ M^{\frac{2}{3}}$.

Fall of river bed per mile at Villupuram-Guntakal Railway crossing	$\frac{5,280}{550} = 9·6$ ft.
Maximum depth of flood	7·5 ft.
Mean area of section to H. F. L.—	
River bed	16,622 sq. ft. H. M. D. 6·93 ft.
Spill on north bank	13,851 „ „ 4·86 „
Velocity by Kulter's formula—	
Bed portion ($\sqrt{}$)...	3·95 ft. per second.
Spill „ ($\sqrt{}$)...	3·07 „
Bed discharge	65,657 C. ft.
Spill „	42,522 „
Total, discharge ...	108,179 „

This discharge is equal to about 38 cubic feet per mile drained.

* $\frac{108,179}{7 \times 7·5} = 2,064$

11. The waterway required is therefore 2,064 * lenial feet with a velocity of $7\frac{1}{2}$ feet per second and an average depth of 7 feet.

12. I observe that on Mr. Lambert's original section he provided a bridge of fifteen 150 feet girders spans = 2,250 lenial feet, although he estimates for only fifteen 100 feet spans = 1,500 lenial feet, but this would not span the main part of the river by about 900 feet and would cause a head and scour which ought to be avoided in a river of such a volume flowing along a sandy bed in which it is of importance to prevent heavy scour round the piers of the bridge.

I therefore venture to recommend a bridge of about 2,000 lineal feet of waterway, which would not, it is thought, cause any dangerous heading up the river.

13. *Bridge.*—There can be no doubt that the bridge should be founded on wells and I propose that each pier should be carried on one 20 feet drain masonry well corbelled out at top to take the pier; the masonry of which would be 19 feet 6 inches long with cutwaters each projecting 4 feet 9 inches. The pier would stand about 25 feet above the top of the well. The borings taken under Mr. Lambert's orders are shown on the accompanying section, and are all reported to have reached rock at depth varying from a minimum of 32 to a maximum of $58\frac{1}{2}$ feet.

Taking 2,000 lineal feet as the minimum aggregate length of bridge, the choice of spans lies between —

(1) 10 spans of 200 feet = 2,000 lineal feet.
(2) 14 „ 150 „ = 2,100 „
(3) 17 „ 120 „ = 2,050 „

14. The comparative estimates * of three bridges of the foregoing spans, excluding abutments which are common to all, show that in round numbers —

* See Appendix.

10 spans, 200 lineal feet would cost Rs. 6,30,000 or Rs. 315 per lineal foot.
14 „ 150 „ „ „ 5,75,000 or „ 274 „ „
17 „ 120 „ „ „ 5,67,000 or „ 276 „ „

From this it appears that, taking the estimated costs of the different spans, without considering or allowing for the extra risk and uncertainty in those in which there are the greater number of wells to sink in the river bed, the cost of the 120 and 150 feet spans is practically the same and considerably cheaper than the 200 feet spans. Taking into consideration the greater elements of uncertainty in larger number of well foundations, I believe that the 150 feet spans will prove the most economical and I recommend that a bridge of thirteen 150 feet spans aggregating 1,950 lineal feet of waterway be adopted.

15. I shall be obliged by the issue of early orders, as it is important to get an immediate start with the work.

16. I propose to build the 20 feet wells of stonework laid on wrought iron curbs, which, in order to save time, ought to be made in this country, and I ask sanction to making arrangements at once for their manufacture in India.

17. If Government approve of the proposal to adopt one 20 feet well for each pier, the same size and design of well curb will be required, whether the spans decided on are 200, 150 or 120 feet. If it is considered necessary that further investigation is required before the aggregate span of the bridge is decided on, there need be no delay to the work while this is going on, if the individual span to be adopted is settled, for the work could at once be commenced at the southern and defined bank of the river.

(Signed) DAVID LOGAN,
Chief Engineer.

Submitted to Government, with reference to its Order, No. 993 R., dated 13th September 1889.

2. I concur in the recommendation of the Chief Engineer and recommend that it be submitted to the Government of India with a request that sanction, at least for the construction of well curbs in this country, be communicated by wire.

Order—dated 11th January 1890, No. 31 R., Public Works.

Ordered to be forwarded to the Government of India with the request that sanction to, at least, the construction of well curbs in this country, may, if the design for the piers is approved, be communicated by wire.

(Here enter No. 32 R., dated 11th January 1890.)

(True Extract.)

(Signed) C. J. SMITH, Colonel, R.E.,
Joint Secy. to Govt., P.W.D.,
Railway Branch.

Endorsement—dated 11th January 1890, No. 32 R., Public Works.

Forwarded.

(By Order.)

(Signed) C. J. SMITH, Colonel, R.E.,
Joint Secy. to Govt., P.W.D.,
Railway Branch.

Telegram from the Joint Secretary to the Government of Madras, Public Works Department, Railway Branch, to the Secretary to the Government of India, Public Works Department, dated Madras, 22nd January 1890.

Our 32 R., 11th January, Pennér bridge, Villupuram-Guntakal Extension. If you approve site and design of pier, please wire permission to order well curbs. This season's work depends on prompt sanction for this. Aggregate waterway and length of each span can be discussed subsequently if necessary.

G.O., dated 7th February 1890, No. 201 R., Public Works.

From the Consulting Engineer for Railways, dated Madras, 3rd February 1890, No. 83.

From the Agent, South Indian Railway, to the Consulting Engineer for Railways, dated Trichinopoly, 15th January 1890, No. 64.

At the request of the Chief Engineer I forward to you the accompanying copies of three letters written by Major Gracey, Superintending Engineer on the Northern portion of the Villupuram-Guntakal State Railway.

In submitting these letters the Chief Engineer wrote to me as follows:—

"When framing the proposals forwarded with above quoted letter, I had received his letters, Nos. 50 and 73, and duly considered them when making my recommendations, a copy of which was sent to Major Gracey, and his No. 191 is in response thereto; as he has asked to have his letters forwarded, I do so, but I see no reason to modify my recommendations.

"If the discharge and velocity of the river Pennér at the Villupuram-Guntakal Railway crossing are what Major Gracey estimates, there is, in my opinion, necessity for more, rather than less, waterway than I have proposed.

"As regards the estimates, they were put forward for purposes of comparison and are approximate only.

"I do not consider it required of me to forward representations and copies of letters from the officers under my orders, on every occasion on which their views may differ from mine, but I have done so in the present case on an exceptionally important point."

Enclosures.

From the Superintending Engineer, Villupuram-Guntakal Railway, to the Chief Engineer, Trichinopoly, dated Bellary, 7th December 1889, No. 50 V.G.

It appears that founds will be got at the Pennér bridge at about 40 feet below the surface except for a gap of 300 feet, where the depth will be about 60 feet. I estimate the total discharge at 306,000 cubic feet per second by Dicken's formula and the velocity at 16 feet per second. This velocity would appear to be under the actual greatest velocity in high flood as I have measured velocities of 14 feet per second in the rivers in Upper India, where the fall of the bed is very much less than at the Pennér, where it averages about 10 feet per mile.

2. With such a velocity it is evident that large spans must be used so that the waterway may not be too much obstructed with piers.

3. A circle 20 feet in diameter would contain a rectangle 18 feet 4 inches long by 8 feet wide without oversetting the sides. If to this pier rectangular cutwaters be added, the total length of the pier from nose to nose would be 26 feet 4 inches, and it would be necessary to corbel out the wells 3 feet 2 inches each end. This amount of corbelling should offer no difficulties. In the bridge over the Jumna at Muttra, some of the wells had to be corbelled out 6 feet at each end and at the Jumna at Kalpi 5 feet at each end, and in both cases in brickwork. The latter bridge has 250 feet spans with wells 90 feet deep and piers 75 feet high from bed of river to bottom of girders.

4. A rectangle, 18 feet 4 inches × 8 feet, should give sufficient space for either 120 or 150 feet spans with the roadway between girders, and these spans appear to be suitable for the river.

5. Piers for girders of 120 feet and 150 feet spans might also be founded in two wells 12 feet 6 inches in diameter, which are, I think, the smallest that should be used.

6. In deciding whether one 20 feet well or two 12 feet 6 inches are best, there are several points to be considered:—

(1) Ease and quickness with which the work can be carried out.
(2) Cost.
(3) Stability of the structure.

(1) *Ease and quickness with which the work can be carried out.*—The thickness of the well steining in a 12′ 6″ well cannot exceed 3 feet in the 20 feet well; it will be 5 feet. In the 12′ 6″ well the header stones will have to be tapered and the strechers rounded in the face. In the 20 feet well ordinary stones with straight faces can be used. The masonry can conseqently be carried out much more quickly and cheaply in 20 feet wells than in 12 feet 6 inches.

The delays in well sinking are caused by well standing for masonry to set, fixing up sinking apparatus and loading the well, and finally by unloading the well after each length is sunk. All these operations take half the time for a well that is taken for two.

The quickness with which a well will go down in sand is almost entirely dependent upon the ratio between the weight applied and the stein friction. The stein friction varies as the circumference of the well and the weight applied varies without loading as the area of the well steining. In the 20 feet well the circumference is 63 feet nearly and the area of the steining 236 feet or as 1 : 3·7. In the 12′ 6″ well the circumference is 39 feet and the area of the steining 89 feet or as 1 : 2·3. It is therefore evident that, without loading, the 20 feet well will go down better than the 12 feet 6 inches and that, if loading is required, a smaller load for the former will suffice. In sinking 28 feet wells with 7 feet steining I found that in pure sand, the deeper the wells were sunk the more easily they went down, showing that the weight of the steining was greater than the stein friction. It would therefore appear that one 20 feet well can be more easily built and more easily and quickly sunk than two wells of 12 feet 6 inches diameter.

(2) *Cost.*—The cost of the wells excluding establishment and plant will vary at the very most as the squares of their diameter or the cost of one 20 feet well will be to the cost of two 12′ 6″ wells as $20^2 : 2 \times (12 - 6)^2$ or the 20 feet well will cost about 25 per cent. more, which will be in a great measure saved in establishment and plant.

(3) *Stability.*—There can, I think, be no question that one 20 feet well would be more stable than two 12′ 6″ wells, the area of the base is greater and there is no damage from unequal settlement.

7. It would therefore appear that in everything except cost the 20 feet well is superior to the two 12′ 6″ wells and if tools and plant and establishment be taken into account, it is doubtful if the 20 feet well would not be the cheaper also. If boulders are met with over the rock which would appear to be very probable, there is no question that they can be more easily dealt with in a 20 feet well than a 12′ 6″ well.

8. It appears to me that a well 20 feet in diameter is required to carry the 120 or 150 feet spans and I also think a column of sound masonry 20 feet in diameter and 40, or in case of two piers 60, feet high, will carry any reasonable weight that can be placed upon it.

6. The provision in the estimate for Portland cement and special plant will, in my opinion, be found altogether inadequate. The first 4 or 5 feet of concrete in the bottom of the well should, I think, be of Portland cement, in order to give the well a firm foundation upon what must, of necessity, be more or less shelving rock. The well curb should, I think, be filled in with Portland cement concrete. Though not absolutely necessary, it would also be desirable to build the masonry of the steining up to the top of the corbelling in Portland cement mortar. All this will require from 125 to 150 barrels of Portland cement per well. The portable engine mortar, mills, steam hoists and dredgers will alone cost more than the sum entered for special plant.

7. The latest rough estimate, that I have formed, of the cost of the Pennér bridge with 18 spans at 100 feet with road way on top flange is—

	Rs.
19 piers and abutments at Rs. 15,000 each	2,85,000
18 girders of 100 feet each at 48 tons each Rs. 338 per ton ...	2,85,120
Pitching and protection works (say)	25,000
Total (say) ...	5,95,000

and this is what I would now recommend. There would be one well 20 feet in diameter to each pier.

8. I would ask the favor that copies of this and of my former letters might be sent to the Government for perusal.

Note by the Consulting Engineer for Railways, dated 30th January 1890.

The Villupuram-Guntakal State Railway, Pennér bridge case, might, I think, with advantage receive further consideration, or at all events elucidation, if there are other circumstances connected with it besides those which appear in the records.

It is of course impossible to speak very confidently in the absence of drawings. The following appear to be the principal points in the cases.

The correspondence shows that the Madras Railway crosses the Pennér river at a point about 25 miles lower down the river than the point at which the Villupuram-Guntakal State Railway will cross it, also that the fall in the bed of the river at the Madras Railway crossing is about 6·36 feet to the mile; while at the Villupuram-Guntakal State Railway crossing the fall is 9·6 feet to the mile. The average depth of the flood water at the Madras Railway crossing is shown by the correspondence to be 16911/1703 or about 9·9 feet. The average depth at the Villupuram-Guntakal State Railway crossing is assumed by the Chief Engineer to be about 7 feet and by Major Gracey to be 8 feet.

Mr. Lambert, however, after careful inquiry ascertained as stated in para. 3 of his report No. 4430 of the 24th October 1885, that the Pennér rises "about 14 feet during the highest floods." The bed of the river is sandy at both crossings with shale at a depth of 43 to 53 feet at the Madras Railway crossing and rock at a depth of 40 to 60 feet at the Villupuram-Guntakal State Railway crossing.

The mean velocity at the Madras Railway crossing is assumed by the Chief Engineer of the Madras Railway to be 9 feet per second.

The mean velocity at the Villupuram-Guntakal State Railway crossing is calculated by the Chief Engineer, South Indian Railway, in para. 10 of his "Proposals for bridging the Pennér river near Pamidi" to be 3·95; but in para. 11 he assumes that the mean velocity will be increased to 7½ feet when the bridge is constructed.

Major Gracey in para. 10 of his No. V.G 50 of the 7th ultimo, assumes that the velocity at the Villupuram-Guntakal State Railway crossing will be 16 feet per second, but he is probably referring to surface and not mean velocity, because, he says, that 16 feet per second "would appear to be under the actual greatest velocity in high flood."

In para. 3 of his No. V.G. 173 of the 14th December 1889, Major Gracey takes the mean velocity at 14 feet per second. There is therefore a very great discrepancy between the mean velocity of 3·95 feet per second shown by the Chief Engineer's calculations and the velocity of 14 to 16 feet per second adapted by Major Gracey.

It seems impossible at first sight to reconcile estimates which differ so widely as these. Fortunately, however, there is something more reliable to go upon than mere

opinions; for the Madras Railway have had long experience of the floods in the Pennér, in cyclones as well as in ordinary seasons, and they have taken the mean velocity in the highest floods at their Pennér crossing at 8 feet per second. Mr. Lambert in para. 6 of his report No. 4430 of the 24th October 1885, says, that the highest flood of which there is any recollection amongst the villages near the site of the proposed Villupuram-Guntakal State Railway bridge, occurred in 1851. It would not, therefore, be safe to assume that higher floods may not occur than any of which the Madras Railway have as yet had experience. But it may be assumed that it would not be safe to work with a lower velocity than that adapted by the Madras Railway after long experience.

Taking then 8 feet per second as the mean velocity at the Madras Railway crossing with a depth of about 10 feet and a fall of 6·36 feet per mile, it would manifestly not be safe to take a lower mean velocity than 14 feet at the Villupuram-Guntakal Railway crossing with a fall of about 9·6 feet to the mile and a depth of 14 feet if Mr. Lambert is right.

I gather then from the correspondence that Major Gracey's estimate of the mean velocity is the lowest which can safely be taken.

In addition to this, though in the absence of all knowledge of the site and in the entire absence of drawings giving sections of the river bed, I must speak with the greatest diffidence; I gather from the correspondence also that the Chief Engineer's estimate of the mean velocity at the proposed bridge site is not so incorrect as appears at first sight. It is necessary to notice that while Major Gracey's estimate deals with a waterway 1,800 feet in width only; the Chief Engineer's calculations deal with a main channel 2,400 feet wide and a spill extending over a width of 2,850 feet.

It is necessary to notice also that a reef of rock occurs at the village of Pamidi about 1½ mile below the bridge site by which the channel of the river is contracted to 1,700 feet according to the Chief Engineer (para. 12 of his report), or to 1,670 feet according to Major Gracey (para. 7 of his No. V.G. 50 of the 7th December 1889).

It appears possible, therefore, that the railway crosses the river in the middle of a great pool filled with water headed up by the Pamidi reef and that there is a strong current along the southern edge of this pool while the rest of the pool is backwater or dead water.

Major Gracey confines his inquiry to the portion of the pool affected by the current and thus gets a high velocity confined to a small area.

The Chief Engineer deals with the whole pool, including backwater, and therefore gets a very low velocity spread over a wide area.

In this way the discrepancy between the two sets of calculations can be reconciled.

If this is the right view it seems probable that the current will use a portion only of the wide bridge proposed by the Chief Engineer and the rest of the bridge will carry backwater.

Mr. Lambert in para. 8 of his report says, that the sand in the Pennér is "of a coarser description" than the sand in the rivers in Upper India and that the scour is not so great as in those rivers; in any case, however, a large amount of scour will apparently have to be faced with current velocities such as those indicated by the correspondence.

Apart from the considerations referred to above, it is difficult to see why a bigger bridge should be provided on the Villupuram-Guntakal State Railway than is provided on the Madras Railway for the same river at a point 25 miles lower down in its course where the fall in the bed of the river is not nearly so great as at the Villupuram-Guntakal State Railway crossing, unless indeed there are large spill channels between the two sites by which the channel at the Madras Railway crossing is relieved of a portion of the discharge.

At the same time it is necessary to notice that if Mr. Lambert is right as to the occurrence of 14 feet floods in the Pennér, Major Gracey's proposals in para. 4 of his No. V.G. 173 of the 14th ultimo, to reduce the formation level will apparently require reconsideration.

(Signed) C. J. SMITH, Col., R.E.,
Consulting Engineer for Railways.

P.S.—I think it would be well to study the discharge at the Pamidi village 1½ mile below the site of the proposed bridge where the channel is contracted to a width of about 1,700 before finally deciding the question of the amount of waterway to be allowed. This need not delay in any way the construction of the bridge to a minimum of 1,800 feet. By using a pier abutment on the north side an additional span of 150 feet could be put in at any time.

From the Consulting Engineer for Railways, dated 24th January 1890.

The nett result of Major Gracey's investigation does not differ largely from that arrived at by Mr. Logan.

The former recommends 18 spans each of 100 feet—1,800 lineal feet in all.

Mr. Logan recommends 13 spans each of 150 aggregating 1,950 lineal feet.

I incline strongly to the larger provision first, because, as may be gathered from Mr. Lambert's report, No. 4430, dated 24th October 1885, where it is stated that the river rises to a depth of 14 feet as against 7 feet estimated by Mr. Logan and 8 feet as estimated by Major Gracey, we know very little for certain about the floods in the Pennér river at Pamidi.

2*ndly*, because I do not know of a single river in Southern India, of which we have fairly accurate statistics extending back, to say 30 years, that is not shown to be likely to beat its record.

3*rdly*, because as shown at the site of the Pennér bridge lower down, the river is liable to breaching tanks, which, although in this case some of the large ones are situated below the site of the proposed bridge, might very materially affect the level of the flood at this bridge.

4*thly*, because there is a very extensive spill on the north margin, which, as Major Gracey fully recognizes, must be specially provided against; and the further the bridge extends on this side of the river the better.

As is well known by those conversant with the Pennér river and its affluents in high floods, the rivers seldom, if ever, run parallel to their banks and the obstruction offered by the piers is in no way represented by their transverse section. At the Pennér in October last the afflux on a pier exceeded 8 feet.

Calculations based on Dickens' formula, or on Ryves' formula, or on any other formula, though useful for comparison, cannot be relied on and a safer guide in estimating the aggregating lineal waterway of such a bridge is to compare the section at site with others, if possible, where there is no spill and allow an ample margin for the pier obstruction.

I have no doubt in my own mind, judging by the floods of 1874 and 1889, that the bridge over the Pennér on the Madras Railway would be far less severely tried if it were larger by several spans and it ought not to be accepted as any guide in designing the bridge over the same river at Pamidi.

I would also remark that the sections of the Pennér river vary to my personal knowledge from 600 yards to 2 miles, and that any attempt to deduce the surface fall of a flood, when at its highest points, from the fall of the river bed as ascertained by level, would be futile.

This river relieves itself by scouring away the bed to a depth in one place that I know of 20 to 30 feet and, as is well known, opens out its section during a high flood by clearing away islets and accumulations to such an extent, and so surely, that no deductions from sections of the bed taken after a decade of light or no floods, can in any way be relied on.

Almost any possible flood can be forced through a bridge, if formation be high enough and inundation of surrounding property can be tolerated, but there is a limit of risk to which the foundation ought to be exposed, and, in my opinion, this limit should be lower with masonry cylinders which can only with difficulty be firmly and evenly bedded on shelving rock, than with iron cylinders that can be truly seated.

My own view is that thirteen 150 feet spans give the minimum aggregate lineal waterway that ought to be provided for the Pennér at Pamidi—that with this

waterway the rock under the masonry cylinder should be carefully levelled by divers —and that if this cannot be thoroughly done, the piers should be specially protected by loose stone thrown in round them.

That masonry cylinders resting on shelving rock are insecure, the fall of the Vikravándi bridge on the South Indian Railway, proved beyond doubt; and that 40 feet of local scour in the coarse sandy beds of the Pennér river and its affluents is by no means impossible is now generally allowed.

(Signed) C. J. SMITH, Col., R.E.,
Consulting Engineer for Railways.

Submitted to Government in continuation of this office endorsement No. 9, dated 8th January 1890.

Order—dated 7th February 1890, No. 201 R., Public Works.

Ordered to be forwarded to the Government of India in continuation of Proceedings of this Government, Nos. 31-32 R., dated 11th January 1890.

(Here enter No. 202 R., dated 7th February 1890).

(True Extract).

(Signed) C. J. SMITH, Colonel, R.E.,
Joint Secy. to Govt., P.W.D.,
Railway Branch.

Endorsement—dated 7th February 1890, No. 202 R., Public Works.

Forwarded.

(By Order.)

(Signed) C. J. SMITH, Colonel, R.E.,
Joint Secy. to Govt., P.W.D.,
Railway Branch.

Read also the following paper:—

Telegram from the Secretary to the Government of India, Public Works Department, to the Joint Secretary to the Government of Madras, Public Works Department, Railway Branch, dated Calcutta, 7th March 1890, No. C. 15.

Your telegram of 22nd January and letter No. 202 R., of 7th February, Pennér bridge. No work should be commenced until complete plans and estimates have been sanctioned. Letter follows.

Order—dated 13th March 1890, No. 359 R., Public Works.

Communicated to the Consulting Engineer for Railways, with reference to his endorsements, Nos. 9 and 83, dated 8th January and 3rd February 1890.

(True Extract.)

(Signed) C. J. SMITH, Colonel, R.E,
Joint Secy. to Govt., P.W.D.,
Railway Branch.

Read also the following paper :—

From the Secretary to the Government of India, Public Works Department (Railway Construction), to the Joint Secretary to the Government of Madras, Public Works Department, Railway Branch, dated Calcutta, 14th March 1890, No. 238 R.C.

I am directed to acknowledge the receipt of your letters marginally noted, submitting for orders proposals for bridging the Pennér river near Pamidi, on the Villupuram-Guntakal State Railway.

No. 32 R., dated 11th January 1890.
„ 202 R., „ 7th February „

2. It is observed that the Chief Engineer of the South India Railway recommends the adoption of 13 spans of 150 feet girders for this bridge, and proposes to sink wells 20 feet in diameter, one for each pier; the wrought iron well-curbs being procured in India.

3. The Government of Madras concurs generally in the Chief Engineer's proposals, and immediate sanction is asked to the construction of the well-curbs in this country with a view to save time.

4. You were informed in Public Works Department telegram No. C. 15, dated 7th March, that no work should be commenced until complete plans and estimates had been sanctioned, and that further orders would follow by post.

5. I am now to say that it does not appear to the Government of India that the site selected for the bridge is beyond doubt the best that could be chosen, and, as the river is broader here than it is higher up, I am accordingly to suggest that a site, about 600 yards up-stream which seems to present certain advantages, may with the concurrence of the Governor in Council be examined as an alternative crossing. If the foundations here are not worse than those at the down-stream site the upper site would appear the better, as the channel is narrower, and one side at least would be perfectly protected by the rocky hill there, while the other could be protected by a training bund with pitching.

6. As regards the size of spans, the Government of India considers a short bridge with comparatively long girder spans preferable to a long bridge with short spans, as the former would obstruct the waterway less. The Government of India therefore desires that 11 spans of 150 feet each may be adopted.

7. Further it seems probable that the velocity of the Pennér river in flood is more likely to be 14 feet per second as calculated by Lieutenant-Colonel Gracey than 4 feet as calculated by the Chief Engineer. With the former velocity the river would in flood scour down to the rock, and for this reason the Government of India prefers two wells each of 12 feet diameter to one of 20 feet as proposed, as the double wells would obstruct the waterway less, and with 11 spans of 150 feet girders would give 88 feet more waterway than could be provided with 20 feet wells.

8. The difficulties of sinking two small wells as compared with one large one may, in this case, be neglected, as the wells would have to go down only about 40 feet, and judging by the experience gained at the Chenab bridge at Sher Shah, where the double wells were easily sunk to a depth of 80 feet, the foundations at the Pennér bridge should give but little trouble. Two wells would also be safer perhaps than a single well with the pier overhanging the up and down-stream sides, and, as rock is met with at a moderate depth, with fairly large spans no possible velocity in the river could be dangerous to good foundations. The wells resting on rock should be carefully underpinned with Portland cement concrete and protected by stone pitching, as the stability of any well resting on shelving rock will depend on the care with which it is underpinned.

Order—dated 2nd April 1890, No. 464 R., Public Works.

Communicated to the Consulting Engineer for Railways, in continuation of Proceedings, No. 359 R., dated 13th March 1890.

2. The alternative site proposed in para. 5 of letter from the Government of India read above, should be investigated and a report of the result of such investigation should be submitted for the information of Government.

Read also the following paper :—

From the Consulting Engineer for Railways, dated Madras, 24th June 1890, No. 442.

From the Agent, South India Railway, dated Trichinopoly, 28th May 1890, No. 757.

From the Agent, South Indian Railway, to the Consulting Engineer for Railways, dated Trichinopoly, 20th June 1890, No. 884.

Your letter No. 399 of the 5th of April last, I forward herewith copy of a report from the Chief Engineer giving the result of a further investigation as to the most suitable site for the proposed bridge across the Pennér.

2. Will you please obtain the orders of Government hereon as soon as possible.

Enclosure.

From the Chief Engineer, to the Agent, South Indian Railway, dated Trichinopoly, 18th June 1890, No. V. G. 184-931.

Pennér Bridge.

[Your letter No. 5476-361, of 7th April 1890].

In compliance with the request of Government that a further investigation should be made as to the most suitable site for the proposed bridge across the Pennér, I now send you survey * and sections on the line suggested † for trial by the Government of India.

2. The result of the borings taken shows that although the foundations of the first three piers from the southern bank would not be so deep as on the old alignment, they would be pitched on more shelving rock which goes quickly deeper towards the north. Borings have not yet been taken throughout the breadth of the river, but one boring sunk on the northern bank gives a depth of 52 feet to rock and it is probable that the depths of rock are much the same on both lines.

3. There appears, therefore, no advantage in foundations to be gained on the alternative alignment suggested, on the contrary, the more shelving rock and the great likelihood of meeting with isolated boulders near the up-stream rocky hills point to the old alignment as preferable. There is nothing to be gained in the way of protection from the rocky hill on the south bank by moving nearer to it as suggested by the Government of India in para. 5 of letter, No. 238 R.C., for this bank (right) is already completely under the protection of the hill referred to for a considerable distance below the original alignment, and no change in the bank which is of a sandy nature is known to have taken place for many years during which heavy floods have been experienced, and one abnormally high flood is stated to have occurred only last year.

4. Under the circumstances there does not appear to be any advantages on the side of the alternative (up-stream) alignment to justify the abandonment of nearly 2½ miles of railway embankment already thrown up from the north bank of the river northwards towards Guntakal, and I recommend that the original alignment selected by Mr. Lambert and approved by Sir Guildford Molesworth after examination of the ground be adopted.

5. With reference to the size of the wells for the foundations of the bridge, our experience on the South Indian Railway has been confined to wells of 12 feet in diameter and under, of which we have sunk a great many in the deep sandy beds of our East Coast rivers, and other things being the same I prefer that diameter (12 feet) of well to a larger one, but under the conditions met at the Pennér, a rock substratum and the probability of meeting with boulders in sinking foundations to this rock. I think that Colonel Gracey's recommendation to use one well of 20 feet in diameter in preference to two of 12 feet diameter for each pier, carries much weight.

6. In forwarding to me the survey ‡ and section now sent to you Colonel Gracey writes.

* Tracings No. $\frac{2050}{4159} / \frac{6}{90}$ and $\frac{2051}{4160} / \frac{6}{90}$

† Letter No. 238 R.C., dated 14th March 1890, from Secretary to Government of India, to Joint Secretary to Government of Madras, Public Works Department, Railway Branch.

‡ Taken by Executive Engineer Major White, R.E.

"I cannot see that the proposed new crossing offers any advantage commensurate with the cost of shifting the approaches on the north bank of the river. I am, therefore, of opinion that the crossing originally proposed should be adhered to.

"It must be borne in mind that the water which is shown as overflowing the bank on the north side of the river, does not run with any velocity. This was proved last year by the fact that the bank which has been thrown up was hardly cut into at all by the flood water although the material of which it is composed is very sandy.

"I am still of opinion that the piers should each be founded on one well of 20 feet diameter as the beds of the rivers in this part of the country have all large boulders overlying the rock. It will, in my opinion, be possible to deal with these boulders in a well 20 feet in diameter but with wells 12 feet in diameter the whole of the internal space at the bottom of the well may be plugged up with one moderate sized boulder which it will be almost impossible to remove. Moreover the stone that can be procured is not suitable for building wells with thin steining."

7. I shall be glad to receive early final orders as to (1) the site and (2) the diameter of well to be adopted so that the estimate required by Government for the Pennér bridge may be completed.

8. The boring operations at the alternative (up-stream) alignment are going on, and the result will be reported as soon as possible, but I trust that sufficient data have now been submitted to enable Government to decide on the points under reference. The borings have hitherto been delayed owing to scarcity of labor and sickness in the locality.

Submitted to Government for transmission to the Government of India, with reference to its letter No. 238 R.C., embodied in Proceedings of Government, No. 464 R., dated 2nd April 1890.

2. The Agent, South Indian Railway, submits copy of a report from the Chief Engineer giving the result of a further investigation as to the most suitable site for the proposed bridge across the Pennér river on the Villupuram-Guntakal State Railway.

3. The Chief Engineer does not consider that there would be any advantage in the alternative alignment suggested by the Government of India to justify the abandonment of nearly $2\frac{1}{2}$ miles of embankment already thrown up, and recommends that the original alignment be adopted.

4. Colonel Gracey, R.E., recommends that 20-feet wells as originally proposed instead of 12-feet wells should be adhered to, on account of the probability of meeting with large boulders when sinking the foundations. The Chief Engineer concurs in this opinion, and recommends their adoption.

5. Early orders are solicited regarding the site, and the diameter of well to be adopted, in order that the estimate for the Pennér bridge may be completed.

Order—dated 27th June 1890, No. 930 R., Public Works.

Ordered to be forwarded for the early orders of the Government of India, with reference to its letter, No. 238 R.C., dated 14th March 1890.

(Here enter No. 931 R., dated 27th June 1890.)

(True Extract.)

(Signed) R. R. E. DRAKE-BROCKMAN, Lt.-Col., R.E.,
Ag. Joint Secy. to Govt., P.W.D.

Endorsement—dated 27th June 1890, No. 931 R., Public Works.

Forwarded.

(By Order.)

(Signed) R. R. E. DRAKE-BROCKMAN, Lt.-Col., R.E.,
Ag. Joint Secy. to Govt., P.W.D.

Read also the following paper:—

From the Secretary to the Government of India, Public Works Department (Railway Construction), to the Joint Secretary to the Government of Madras, Public Works Department, Railway Branch, dated Simla, the 30th July 1890, No. 668 R.C.

I am directed to acknowledge the receipt of your No. 931 R., dated 27th June 1890, forwarding correspondence from the Agent of the South Indian Railway Company, enclosing a report by the Chief Engineer on the result of the further investigations made with a view to find the most suitable site for the proposed bridge over the Pennér river near the Kalluru Station, Villupuram-Guntakal State Railway.

2. It is observed that the Chief Engineer does not consider that there would be any advantage in adopting the alternative alignment suggested by the Government of India in Public Works Department letter, No. 238 R.C., dated 14th March 1890, to justify the abandonment of nearly $2\frac{1}{2}$ miles of embankment already thrown up; and that he apparently concurs in Lieutenant-Colonel T. Gracey's recommendation that 20 feet instead of 12-feet wells be adhered to.

3. I am to enclose for information a copy of a note by the Consulting Engineer to the Government of India for State Railways on the subject, and to request that the several points raised therein may be carefully considered, especially that relating to the probability of finding a layer of boulders overlying the rock in the bed of the river, and that the project and estimate for the bridge may be drawn up in accordance with the decision which, after consideration of the views expressed in this note may be arrived at by the Company's Engineers, and approved by the Government of Madras.

Enclosure.

Note by the Consulting Engineer to the Government of India for State Railways, dated 10th July 1890.

There is nothing in the information now furnished which induces me to alter the opinions previously given that double wells are more suitable for the foundations for the piers of the Pennér bridge than single wells, and that the upper site is the preferable one.

The cost of sinking a single well is certainly less than that of a pair of wells, but if the work is done by experienced men, the difference is hardly a matter of moment.

Sir Guildford Molesworth's opinion is quoted more than once, but I know that he strongly objected to single wells in other cases. A perusal of the notes on Mr. Lambert's estimate for the Guntakal-Hindupur line shows his remarks on the Pennér bridge as follows:—"At the Pennér bridge I should prefer spurs with protected ends running out at right angles from the main bund rather than a continuous bund pitched with stone. The ends of the spurs should run out with a flat slope of say 1 in 10, with a broad deposit of loose stone at the foot of the slope."

Mr. Lambert had proposed double wells $12\frac{1}{2}$ feet diameter, and the presumption is that Sir Guildford Molesworth agreed, as he does not mention the subject.

If well foundations are decided on, and bricks are not procurable for well steining, I would much prefer Portland cement concrete to rubble masonry as being far stronger, and, if the stones have to be dressed and sammered, as being cheaper.

Rubble masonry is by its nature little fitted for any stresses except direct compression, while wells have to endure many different strains while being sunk into position.

If concrete is used, it should either be moulded into blocks, to be afterwards set in place, or moulded *in situ* so that the wells may be monoliths. I have used concrete in both ways and found it most successful.

It is an easy matter to keep the sinking and the building up of wells progressing simultaneously. Much of the difficulty experienced in sinking wells is due to the loading and unloading system in which the sinking is stopped for days while the wells are being loaded. This stoppage allows the sand or silt to settle round the well and grip it, making the restarting troublesome.

By keeping the well "alive" and using the late Mr. Brunlees' system of forcing jets of water through the curb just above the cutting edge very little, if any, extraneous weighting is

necessary in sinking through ordinary sand, the weight of the well itself being sufficient if it is kept always on the move, both night and day.

But in the matter of these foundations another question arises. In the last report of the Chief Engineer, South Indian Railway, the probability of meeting boulders overlying the rock is brought forward more prominently. Mr. Logan says "isolated boulders"—Colonel Gracey says "large boulders overlying the rock."

In building the bridge over the same river for the Madras Railway, 25 miles lower down, a thick boulder bed was met with, necessitating the use of iron cylinders and pneumatic apparatus to sink them. This is a matter which should, I think, be carefully considered, for large boulders are very difficult to deal with in any well, large or small. Again, the proper bedding of wells on shelving rock is no easy operation, whether the wells be twelve or twenty feet diameter, and can only be done by underpinning with bags of cement concrete laid by divers.

The Engineer can know nothing as to the actual way in which this is done, having to take on trust what the diver tells him. A subsequent inspection reveals nothing, for the concrete will have been filled close up to the top of the well-curb, and the real underpinning may have been scamped.

For these reasons I much dislike shallow wells bedded on any thing except clay, and would, in the case of the Pennair bridge, prefer iron cylinders sunk to the rock and then properly bedded by having the rock cut level to receive the cylinder. This can be done if the pneumatic system is used, and the work can be inspected by the Engineer in full light before concrete or other filling is placed in the cylinder. Absolute certainty as to the stability of the foundations is thus insured.

The Madras Railway have close by all apparatus for sinking such cylinders which can no doubt be made available for use by the Pennér bridge Engineer.

Regarding the site for this bridge, I can find no reference to it in Sir Guildford Molesworth's note other than the general remark referring to the whole line that "I satisfied myself that the line had been laid out with great skill and care."

A good deal has been made of the quantity of earthwork to be abandoned if a change of site is determined on. I have calculated this out from the sections sent with the report now being noted on, and find it amounts to just 30 lakhs of cubic feet, which, at Rs. 4 per thousand, will cost twelve thousand rupees, hardly sufficient to cause the site for a work which may cost six lakhs to be considered a fixture.

Still, as I have been only once on the ground, I will not press my own ideas regarding the actual site, for Colonel Gracey, while Superintending Engineer on the district, has no doubt studied the question at length on the spot and taken more matters into consideration than he has given in his report; but a study of both plans and sections does not alter my preference for the upper site, which would bring the bridge square with the stream, and would afford absolute protection to one abutment.

Whichever site is eventually adopted, I strongly recommend that the river may be guided to the bridge by training bunds on Mr. J. R. Bell's system.

To recapitulate—

I prefer the upper site, but the difference between the two sites is not sufficiently great to induce me to press my opinion on the local Engineers, and I recommend—

(*a*) 12½ feet diameter wells instead of 20 feet built (if bricks are not available) with Portland cement concrete;

(*b*) the use of iron cylinders instead of wells if many boulders are likely to be met with, or if the rock is very shelving;

(*c*) that training bunds on Mr. J. R. Bell's system be constructed to guide the river through the bridge.

(Signed) F. L. O'CALLAGHAN.

Order—dated 21st August 1890, No. 1236 R., Public Works.

Communicated to the Consulting Engineer for Railways, with reference to his endorsement, No. 442, dated 24th June 1890.

2. This Government having considered the further suggestions of the Government of India forwarded with its letter read above, would prefer to adhere to the proposals originally submitted regarding the alignment of the Pennér bridge and its construction on wells of 20 feet diameter, as both the Consulting Engineer for Railways and the Chief Engineer, South Indian Railway, are in favor of these arrangements.

3. A copy of these Proceedings will be forwarded for the information of the Government of India.

(Here enter No. 1237 R., dated 21st August 1890.)

(True Extract.)

(Signed) T. GRACEY, Lieut.-Colonel, R.E.,
Offg. Joint Secy. to Govt., P.W.D.,
Railway Branch.

To the Consulting Engineer for Railways.
" " Examiner, Guaranteed Railway Accounts.

Endorsement—dated 21st August 1890, No. 1237 R., Public Works.

Forwarded.

(By Order.)

Lieut.-Colonel, R.E.,
Offg. Joint Secy. to Govt., P.W.D.,
Railway Branch.

Exd. G. A. Lewis.
Spare Copies

RAILWAY.

Govt. of {1890} Madras.

PUBLIC WORKS.

Dated August, 21st.

Recd.

Encl.

G.O., 21st Aug. 1890, Nos. 1236, 1237 R.

AUGUST.

Penner Bridge

Forwarding copy of Proceedings adhering to the proposals originally submitted regarding the alignment and construction of the — on wells of 20 feet diameter.

No. 3

South Indian Railway,

AGENT'S OFFICE,

TRICHINOPOLY, 2nd January 1890.

From

The Agent,
SOUTH INDIAN RAILWAY.

To

The CONSULTING ENGINEER FOR RAILWAYS,
MADRAS.

Sir,

Referring to your letter No. 851 of the 19th September 1889 I beg to forward herewith proposals regarding the Penner Bridge on the Villupuram Guntakal Railway together with three drawings and I shall be obliged by your Communicating to me early orders of Government thereon.

I am
Sir,
Your most obedient Servant,

Enclos: 8.

William Betts
Agent.

+ Sent by Hand

16

REGISTER
No.
FILE
No.

Cust
PW 213
1890

From

THE AGENT,
South Indian Railway,
Trichinopoly.

To

THE CONSULTING ENGINEER FOR
RAILWAYS,
Madras.

Dated 2nd Jan 1890
Received 3rd Jan 1890 No. 7

ENCLOSURE. 1

Proposals for Bridging Pennar River

2 SB

Villupuram Gumtakal State Railway

Proposals for Bridging the Pennar River near Pamidi

about 24 Miles South of Gumtakal.

1. The River Pennar takes its rise in the Mysore territory within about twenty-four miles of Bangalore and from its source to the proposed crossing" of the Villupuram Gumtakal Railway, it traverses about 130 miles measuring along its general direction without following all its windings: The drainage basin has an average width of about twenty-five miles and an area of 2835 square miles, as shewn on the accompanying map. From this it will be seen that the basin is long and narrow, the river being fed from hilly sides which it may be assumed discharge into the main channel with considerable rapidity.

2 No. 59.

Chief Engr of B.B.&C.I. Ry.

2. Examinations of and investigations in connection with the River Crossing were conducted under Mr. Lambert who prepared the project for the Hindupur Extension of which the Dharmavaram Gumtakal section forms the northern part, and a bridge of fifteen 100 feet girder spans was proposed and included in his estimates, but further study and investigations point to a larger provision of waterway being necessary.

3. It seemed to me possible when inspecting the Locality that a better crossing could be obtained about half a mile higher up the river, where it is hemmed in by a high rocky hill on the South bank, but further consideration leads to that recommend adherence to Mr Lambtischar's

REGISTERED
No.
FILE
No.

Cust
PW 213
1890

From
The Agent,
South Indian Railway,
Trichinopoly.

To
The Consulting Engineer for
Railways,
Madras.

Dated 2.9.90
Received 4.9.90 No. 59

Enclosure. 1/

w/ Sketch Drg
to Govt &
Chief Engr
Bridges
Dir Ry Bd
3 Oct 90
Secy

Print

2 SP

Villupuram Gudalur State Railway

Proposals for Bridging the Pennar River near Panruti

1. The River Pennar takes its rise in the Mysore territory within about twenty-ten miles of Bangalore and from its source to the proposed crossing of the Villupuram Gudalur Railway, it traverses about 130 miles measuring along its general direction without following all its windings: The drainage basin has an average width of abut twenty-five miles and an area of 2835 square miles, as shewn on the accompanying map. From this it will be seen that the basin is long and narrow, the river being fed from hilly sides which it may be assumed discharge into the main channel with considerable rapidity.

about 24 Miles South of Gudalur.

2 No 59.

2. Examinations of and investigations in connection with the River Crossing were conducted under Mr, Lambert who prepared the project for the Hindhupur Extension of which the Dharmavaram Gudalur section forms the northern part, and a bridge of fifteen 100 feet girder spans was proposed and included in his estimates, but further study and investigations point to a larger provision of waterway being necessary.

Chief Engr of B.K.S. Ry.

3. It seemed to me possible when inspecting the Locality that a better crossing could be obtained about half a mile higher up the river, where it is hemmed in by a high rocky hill on the South bank, but further consideration leads to that recommend adherence to the Panruti discharge

4 28

8

it is well protected on the Southern side and on the northern exposed to a wide shallow spill in dealing with which no special difficulty is anticipated.

8. In the original project (Mr Lamberts) a long training bund is provided and was executed as a famine relief work, above the approach to the bridge on the northern bank of the Penner — so as to deflect the spill back into the river. In addition to this work it is proposed to heavily pitch the up stream side of the Railway embankment where it comes within flood limits. A long nulla diversion, shewn on the plan on the north side of the river was also carried out by famine labour and so far it has got into train and worked very satisfactorily.

9. The Penner is crossed by the Madras Railway about twenty five miles lower down than the Villupuram Gunlakal Railway crossing and the following data, connected with the Madras Railway Bridge has been kindly furnished by Mr. A.R.P. Carbis the Chief Engineer of that line.

Drainage area of River Penner above Madras Ry. — 4500 Sq miles
Fall of River bed feet per mile. — 6.36 feet.
Mean Velocity — 8.2. " per second.
Area of Section to H.F. Level — 16911 Sq feet.
Discharge — 138670 C ft. per second.
M.R. Bridge. 131 x 13 = 1703 lineal feet.

To this discharge $D = 500 \sqrt[3]{M^2}$ of Rynes formula very nearly applies, the coefficient obtained being 508 in place of the 500 of the formula and the discharge is equal to about 31 Cubic feet per second for each Square mile drained. A result very similar to that obtained by Col Colleys for the actual discharge

vide X

6

I therefore venture to recommend a bridge of about 2000 lineal feet of waterway which would not, it is thought, cause any dangerous heading up the river.

Bridge. 13 There can be no doubt that the bridge should be founded on wells and I propose that each pier should be carried on one 20 feet drain masonry well corbelled out at top to take the pier; The masonry of which would be 19' 6" long with cutwaters each projecting 2'-9". The pier would stand about 25 feet above the top of the well. The borings taken under Mr Lambert's orders are shewn on the accompanying section, and are all reported to have reached rock at depth ranging from a minimum of 32 to a maximum of 58½ feet.

Taking 2000 lineal feet as the minimum aggregate length of Bridge the choice of spans lies between:-

(1.) 10 spans of 200 feet = 2000 lineal feet.
(2) 14 " " 150 " = 2100 " "
(3) 17 " " 120 " = 2050 " "

14. The comparative estimates* of three bridges of the foregoing spans excluding abutments which are common to all show that in round numbers

* See appendix.

10 spans 200 lineal feet would cost Rs 630000 or 315 Rs per lineal feet
14 " 150 " " 575000 or 274 "
17 " 120 " 567000 or 276 "

From this it appears that taking the estimated costs of the different spans, without considering or allowing for the extra risk and uncertainty in those in which there are the greater number of wells to sink in the river bed the cost of the 120 and 150 feet spans is practically the same and considerably cheaper than the 200 feet spans. Taking into consideration the greater elements of uncertainty in larger numbers of-

6

Of well foundations, I believe that the 150 feet spans will prove the most economical and I recommend that a bridge of 13-150 spans aggregating 1950 lineal feet of waterway be adopted.

15. I shall be obliged by the issue of early orders as it is important to get an immediate start with the work.

16. I propose to build the 20' wells of stonework laid on wrought iron curbs, which in order to save time ought to be made in this country and I ask sanction to making arrangements at once for their manufacture in India.

17. If Government approve of the proposal to adopt one 20 feet well for each pier, the same size and design of well curb will be required whether the spans decided on are 200, 150 or 120 feet. If it is considered necessary that further investigation is required before the aggregate span of the bridge is decided on, there need be no delay to the work while this is going on, or if the individual span to be adopted is settled, for the work could at once be commenced at the Southern and defined bank of the river.

David Logan

Chief Engineer

William Betts
Agent

B. No. 31 R 8 11th Jany 1890.

Form No. 3.

C.S. 10.1.90

Rec'd 10 Jan

Ordered to be forwarded to the Government of India with the request that sanction to, at least, the construction of well curbs in this country, may, if the design for the piers is approved, be communicated by wire.

B.R. No. 32 R 11th Jany 1890

Forwarded.

C.S. 9.1.90 R.

Ref despatch to India with 2 drawings 11/1/90.

From

THE CONSULTING ENGINEER

FOR RAILWAYS,

MADRAS,

No. 9

Dated 8th
Received 9 } January 1890

No. of Enclosures. one (with 4 plans)

Subject.

Submitting correspondence regarding the proposals for bridging the Pennar river near Pamidipundi on Villupuram Gudtakal State Railway.

B. No. 31/32 R 8 11th Jany 1890.

H.m. 9-1-90 R. 10-1-90

No. 64

South Indian Railway,

AGENT'S OFFICE,

TRICHINOPOLY, 15th January 1890.

From

TELEGRAM ~~URGENT~~ ~~ORDINARY~~ DEFERRED

FROM E. R.

To Works Chief Engineer Madras.

Our 32 R 11th Jan. Pennar Bridge - V.G. & Cuddapah - If you approve site and design of piers please wire permission to work well curbs, this season but depends on prompt sanction for this ~~appeal~~ waterway and length if not as can be passed subsequently if necessary.

C.S. 22.1.90

Telegram desp. 22-1-90

"Pennar at the V. G. Railway Crossing are what Major "Gracey estimates, there is in my opinion necessity "for more rather than less waterway than I have "proposed".

Engineer I of three letters nding Engineer d Guntakal

the Chief

forwarded with his letters on when making was sent response thereto forwarded dify my

of the River

as

4

No. 64

South Indian Railway,

AGENT'S OFFICE,

TRICHINOPOLY, 15th January 1890.

From

The Agent,
SOUTH INDIAN RAILWAY.

To

The CONSULTING ENGINEER FOR RAILWAYS,
MADRAS.

Sir,

At the request of the Chief Engineer I forward herewith the accompanying Copies of three letters written by Major Gracey Superintending Engineer on the northern portion of the Villupuram Gunlakal State Railway.

In submitting these letters the Chief Engineer wrote to me as follows:-

"When framing the proposals forwarded with
" above quoted letter I had received his letters
" dtd. 50 and 73 and duly considered them when making
" my recommendations a copy of which was sent
" to Major Gracey and his dtd. 191 is in response thereto
" as he has asked to have his letters forwarded
" I do so but I see no reason to modify my
" recommendations."

"If the discharge and velocity of the River
" Penner at the V. G. Railway Crossing are what Major
" Gracey estimates, there is in my opinion necessity
" for more rather than less waterway than I have
" proposed."

As

4

"As regards the estimates they were put
" forward for purposes of Comparison and are approximate
" only.

"I do not Consider it required of me to
" forward representations and Copies of letters from
" the Officers under my orders, on every occasion
" on which their views may differ from mine, but
" I have done so in the present case on an
" exceptionally important point."

I am,
Sir,
Your most Obedient Servant.

William Bell

Agent.

From
The Agent,
South Indian Railway,
Trichinopoly.

To
The Consulting Engineer for
Railways,
Madras.

Dated 1st Jan 1890
Received 6th " "
No. 65

Enclosure 3

Correspondence
Col Rio of 1889

REGISTER
No. 65
FILE
No.

H.m. 9-1-90 R 10-1-90

Print

No. V 650

V. G. Railway,
South Indian Railway
Superintending Engineer's Office
Bellary 7th December 1889.

David Logan, Esq
Chief Engineer.
Trichinopoly

Dear Sir,

It appears that formda will be got at the ~~Perrear~~ Penner bridge at about 40 feet below the surface except for a gap of 300 feet where the depth will be about 60 feet. I estimate the total discharge at 30,000 cft per second by Dicksons formula and the velocity at 16 feet per second. This velocity would appear to be under the actual greatest velocity in high flood as I have measured velocities of 14 feet per second in the Rivers in Upper India where the fall of the bed is very much less than at the ~~Perrear~~ Penner where it averages about 10 feet per mile.

2. With such a velocity it is evident that large spans must be used so that the water-way may not be too much obstructed with piers.

3. A circle 20 feet in diameter would contain a rectangle 18'-4" long by 8' wide without oversetting the sides. If to this pier rectangular cutwaters be added the total length of the pier from nose to nose would be 26'-4" and it would be necessary to corbel out the walls 3'-2" each end. This amount of corbelling should offer no difficulties. In the bridge over the Jumna at Cluttra some of the walls had to be corbelled out 6 feet at each end and at the Jumna at Kalpi 5 feet at each end and in both cases in brickwork. The latter bridge has 250 feet spans with walls 90 feet deep and piers 75 feet high from bed of river to bottom of girders.

4

4. A rectangle 18'-4" × 8' should give sufficient space for either 120 or 150 feet spans with the Roadway between girders and these spans appear to be suitable for the river -

5. Piers for girders of 120 feet and 150 feet spans might also be founded in two wells 12'-6" in diametre which are I think the smallest that should be used.

6. In deciding whether one 20 foot well or two 12'-6" are best there are several points to be considered.

1st Ease and quickness with which the work can be carried out.

2d Cost.

3d Stability of the structure.

1st Ease and quickness with which the work can be carried out — The thickness of the well steining in a 12'-6" well cannot exceed 3 feet in the 20 foot well it will be 8 feet. In the 12'-6" well the headers & stretchers will have to be tapered and the stretchers rounded in the face. In the 20 foot well ordinary stones with straight faces can be used. The masonry can consequently be carried out much more quickly and cheaply in 20 ft wells than in 12'-6".

The delays in well sinking are caused by well standing for masonry to set, fixing up sinking apparatus and loading the well, and finally by unloading the well after each length is sunk. All these operations take half the time for a well that is taken for two -

The quickness with which a well will go down in sand is almost entirely dependent upon the ratio between the weight applied and the stein friction. The stein friction varies as

1358

as the circumference of the well and the weight applied varies without loading as the area of the well steining. In the 20 foot well the circumference is 63 feet nearly and the area of the steining 236 feet or as 1 : 3.7. In the 12'-6" well the circumference is 39 feet and the area of the steining 89 feet or as 1 : 2.3. It is therefore evident that without loading the 20 foot well will go down better than the 12'-6" and that if loading is required a smaller load for the former will suffice. In sinking 28 foot wells with 7 foot steining I found that in pure sand the deeper the wells were sunk the more easily they went down showing that the weight of the steining was greater than the stein friction. It would therefore appear that one twenty foot well can be more easily built and more easily and quickly sunk than 2 wells of 12'-6" diameter -

2d Cost — The cost of the wells excluding establishment and plant will vary very most as the squares of their diametres or the cost of one 20 foot well will be to the cost of two 12'-6" wells as $20^2 : 2 \times (12\text{-}6)^2$ or the 20 foot well will cost about 25 per cent more which will be in a great measure saved in establishment and plant.

3rd Stability — There can I think be no question that one 20 foot well would be more stable than two 12'-6" wells the area of the base is greater and there is no danger from unequal settlement.

7. It would therefore appear that in everything except cost the 20 foot well is superior to the two 12'-6" wells and if Tools and Plant and Establishment be taken into account it is doubtful if the 20 foot well would not be the cheaper also. If Boulders are met with over the rock which would appear to be very probable there is no question that they can be more easily dealt with in a 20 foot well than a 12'-6" well -

8. It appears to me that a well 20 foot in diameter is required to carry the 120 or 150 foot spans and I also think a column of sound masonry 20 foot in diametre and 40 or in case of 2 piers to feet high will carry any reasonable weight that can be placed upon it.

9. What I should be inclined to recommend is Iron well curbs State Railway pattern 20 foot in diameter (I understand that these curbs were designed by Mr Rondel and Mr Molesworth so that iron of ordinary market sizes would cut to waste as little as possible and that a small change in the diameter might cause a considerable alteration in the cost of the curb). The curbs to be filled in with Portland Cement Concrete and the well steining to be of good coursed rubble masonry 6 foot thick. The wells when sunk to rock to be carefully cleared by divers and about 5 or 6 foot of good rich Portland Cement concrete to be put in the bottom. The Portland Cement in this Concrete will according to my experience be preped out and any sand left in the bottom or sides of the well will be set hard for a distance of about 2 feet. The remainder of the well could be filled in with concrete of course river sand, lime and coorkie. The tops of the wells to be corbelled in or out in courses about 9" thick projection of about 6" each course until the seat of the pier which might be a rectangle 18'-6" x 8' with rectangle cut waters is obtained. The corbel stones should not be less than 2'-6" long).

Two of the piers would be in the deep gap where the borings show about 60 feet of sand and for this portion 150 foot spans might be used. The remainder of the bridge might

be of 120 foot spans.

The piers founded at 40 foot would I estimate cost roughly as under.

Well curb tie rods at site	Rs 3,000
40 foot of well masonry including Sinking at Rs 160/- per foot rim	6,400
Portland Cement	600
Pier	2,500
Tools and Plant	1500
Total	Rs 14,000

and the pier in 60 foot well would cost about Rs 3000 more or say Rs 17,000. The abutment should I think be exactly the same as the piers the slope of the bank being heavily pitched and a large quantity of loose stone thrown in at the upper end of the slope. In the event of a flood greatly in excess of that estimated occurring the pitching and earthen bank would be carried away without further injury to the bridge.

10. I have indicated above my general idea of what the bridge should be i.e. it should provide for a flood of 3,06,000 cft per second and the velocity will be about 16 feet per second. The piers might be founded on one well 20 feet in diameter and the spans might be 3 of 150 feet and 10 spans of 120 feet. I regret that I am unable to send in plans and sketches illustrating what I mean but I have no instruments and neither plans nor drawing paper and I cannot wait longer as I am going into Camp tomorrow.

Yours faithfully.
(Sd) J. Gracey Major R.E.
Superintending Engineer
V. G. Railway

Secretary

Compared

Pennair with a fall of 10 feet per mile must run in flood.

I am therefore of opinion that as no great improvment in the present crossing can be obtained the existing alignment should be retained.

2 In my last letter containing proposals for this bridge I find that the flood level I worked from was not correct.

This year the river in flood rose a very little over 6 feet above its bed and the high flood level may be safely taken at 8 feet. This would I estimate give a velocity of 14 feet per second which as I have already said I believe to be much under the mark as I have myself measured a velocity of 14 feet per second in the Jumna which although double the depth has not a slope of more than 9 inches to the mile.

3 With a velocity of 14 feet per second the sand of the bed of the river must be moving; but it is impossible to determine the velocity with which it moves. In the places upon which the river beats the sand must be in motion down to the rock in other places only the surface sand would be in motion I think it may be safely assumed that the sand in the bed of the river would be in motion to an average depth of 8 feet so that the discharge per second from a lineal foot of Waterway would be $8 \times 14 + 8 \times \frac{14}{2} = 168$ c ft. per second and the number of lineal feet required for the discharge of 3,06,000 c ft per second would be 1800 lineal feet which would give either 3 spans of 150 feet and 11 spans of 120 feet or 12 spans of 150 ft so that the bridge including piers would be about 1900 ft long.

4 The formation level at the river is 12 feet above high flood level and if spans with the road way between Girder are adopted I think the height of formation above high flood level might be safely reduced to 8 feet this would give a width of bank at high flood level of 48 feet which appears to be ample and 8 feet above water appears to be sufficient to clear the girders from danger from all floating debris. on the other hand if it is desired to run the road way on the top of Girders, there would be no difficulty in raising the approaches to the bridge an additional 8 feet.

The gradients off the bridge being 1 in 100 at each end.

5 The right bank of the river on the present alignment is good firm earth which apparently has never been disturbed overlaid with sand, and a very small amount of pitching would be required to protect the toe of the slope of the bank. On the left bank it will be necessary to protect the toe of the bank with a large quantity of pitching & in addition I would recommend that a layer of large stone about 50 feet wide & 5 ft thick should be laid in from left bank abutment to the first pier which should also be surrounded with pitching. This flooring would prevent all chance of scour in the first span and would consequently lower the velocity of the water through it and would help to protect the bank behind the abutment.

6. In Conclusion I would ask that something should be settled without further delay in order that the well curbs may be ordered from Messrs Richardson and Cruddas & that at least a commencement may be made upon the bridge before the ensuing rains. If 150 foot spans are adopted, 12 curbs for 150 foot spans might be ordered leaving the exact number of spans for future consideration. If the abutments are exactly similar to the piers as I think they undoubtedly should be an additional well and span could be easily added if it were subsequently thought necessary. I don't think there should be any difficulties in obtaining sufficient stone &c. to make a commencement on the work at once.

7 Since writing the above I have had the width of the river measured opposite the Village of Damidi about 1½ miles below the existing alignment where the river is narrow & runs between high banks. The width there is 1670 ft so that 1800 feet of Waterway for the Bridge should be ample.

I have the honor to be
Sir
Your most Obedient Servant.
(Signed) J. Gracey Major R.E.
Superintending Engineer
V.G. Section

Compared.

at Nuttra where the depth of the water is about 12 ft and the slope of the bed about 9 inches to the mile or less than 1/13 of what the fall is in the ~~Lennar~~ Sennér

4. It is known that in high flood the sand of the river is in motion to a considerable depth and that a good deal of the water in high flood is discharged below what is the bed of the river in the dry season.

5. Taking all these matters into consideration I have as I have explained in detail in a former letter come to the conclusion that 800 ft of waterway is sufficient and that the spans should not exceed 150 ft and might be of 100 ft with Roadway on the top of girders.

6. The provision in the Estimate for Portland Cement & Special plant will in my opinion be found altogether inadequate. The first 4 or 5 ft of Concrete in the bottom of the well should I think be of Portland cement in order to give the well a firm foundation upon what must of necessity be more or less shelving rock. The well curb should I think be filled in with Portland Cement Concrete. Though not absolutely necessary it would also be desirable to build the masonry of the Striaing up to the top of the Cobbling in Portland Cement mortar. All this will require from 125 to 150 barrels of Portland cement per well. The portable Engine, mortar mills, Steam hoists & dredges will alone cost more than the sum entered for special plant

7. The latest rough Estimate that I have formed of the cost of the ~~Lennar~~ Sennér bridge with 18 Spans of 100 ft with road way on top flange is -

1852

19 Piers and abutments at 15.000 Each
Rs 2,85,000-

18 Girders of 100 ft. each at 48 tons each 338 p. ton
Rs 2,85,120-

Pitching & protection works Say Rs 25,000

Total Say Rs 5,95,000

and this is what I would now recommend. There would be one well 20 ft in diameter to Each pier.

8. I would ask the favor that Copies of this & of my former letters might be sent to the Government for perusal.

I have the honor to be
Sir
Your most obedient Servant
(Signed) J. Tyrrell Major R.E.
Superintending Engineer
V. G. Ry.

Compared
R.

REGISTER
No. 65
FILE
No.

190

E.3
OM 1078/90

Note

The Villupuram-Gunta-kal State Railway Pen-ner Bridge case might I think with advantage receive further consider-ation at all events elucidation if there are other circumstances con-nected with it besides those which appear in the records.

It is of course im-possible to speak very confidently in the

absence

absences of Drawings.
The following appear
to be the principal points
in the cases.

The correspondence
shows that the Madras
Railway crosses the
Pennair river at a
point about 25 miles
lower down the river
than the point at
which the Villupuram
Guntakal State Railway
will cross it also that
the fall in the bed of
the river at the Mad-
ras Railway crossing
is about 6.36 feet
to the mile; while
at

at the Villupuram Gun-
takal State Rail-
way crossing the fall
is 9.6 feet to the mile.
The average depth of
the flood water at
the Madras Railway
crossing is shewn by
the correspondence to
be $\frac{1691}{1703}$ or about 9.9
feet. The average
depth at the Villu-
puram Guntakal State
Railway crossing is
assumed by the Chief
Engineer to be about
7 feet and by Major
Gracey to be 8 feet.
Mr. Lambert however
after

after careful inquiry ascertained as stated in para 3 of his Report No: 4430 of the 24th October 1885 that the Pennar rises "about 14 feet during the biggest floods". The bed of the river is sandy at both crossings with shales at a depth of 43 to 53 feet at the Madras Railway crossing and rock at a depths of 40 to 60 feet at the Villupuram Gurtakal State Railway crossing.

The mean velocity at the Madras Railway crossing

crossing is assumed by the Chief Engineer of the Madras Railway to be 9 feet per second.

The mean velocity at the Villupuram Gurtakal State Railway crossing is calculated by the Chief Engineer South Indian Railway in para 10 of his "Proposals for bridging the Pennar river near Pamidi" to be 3-95; but in para 11 he assumes that the mean velocity will be increased to 7½ feet when the Bridge is

constructed

after careful inquiry ascertained as stated in para 3 of his Report No: 4430 of the 24th October 1885 that the Pennar rises "about 14 feet during the biggest floods." The bed of the river is sandy at both crossings with shales at a depth of 43 to 53 feet at the Madras Railway crossing and rock at a depths of 40 to 60 feet at the Villupuram Gurtakal State Railway crossing.

The mean velocity at the Madras Railway crossing

is assumed by the Chief Engineer of the Madras Railway to be 9 feet per second.

The mean velocity at the Villupuram Gurtakal State Railway crossing is calculated by the Chief Engineer South Indian Railway in para 10 of his "Proposals for bridging the Pennar river near Pamidi" to be 3-95. but in para 11 of Times that the velocity will be increased to 7½ ing when the Brid[illegible] upon

continued.

Major Gracey in para 10 of his No: F.G. 50 of the 4th ultimo assumes that the velocity at the Villapuram Gumtakal State Railway crossing will be 16 feet per second but he is probably referring to surface and not mean velocity because he says that 16 feet per second "would appear to be under the actual greatest velocity in high flood."

In para 3 of his No: 3 of the 14th December 1889 at the

1889 Major Gracey takes the mean velocity at 14 feet per second. There is therefore a very great discrepancy between the mean velocity of 3-95 feet per second shown by the Chief Engineer's calculations and the velocity of 14 to 16 feet per second adopted by Major Gracey.

It seems impossible at first sight to reconcile estimates which differ so widely as these. Fortunately however there is something more reliable to go upon

continued.

Major Gracey in para 10 of his No: F.G. 50 of the 4th ultimo assumes that the velocity at the Villupuram Gudalkal State Railway crossing will be 16 feet per second but he is probably referring to surface and not mean velocity because he says that 16 feet per second "would appear to be under the actual greatest velocity in high flood."

In para 3 of his No: 3 of the 14th December 1889 Major Gracey takes the mean velocity at 14 feet per second. There is therefore a very great discrepancy between the mean velocity of 3-95 feet per second shown by the Chief Engineer's calculations and the velocity of 14 to 16 feet per second adopted by Major Gracey.

It seems impossible at first sight to reconcile estimates which differ so widely as these. Fortunately however there is something more reliable to go upon

upon these mere opinions; for the Madras Railway have had long experience of the floods in the Pennar in cyclones as well as in ordinary seasons and they have taken the mean velocity in the highest floods at their Pennar crossing at 8 feet per second. Mr. Lamberti in para 6 of his report No: 4430 of the 24th October 1885 says that the highest flood of which there is any recollection amongst the villages near the site of the proposed

1854

proposed Villupuram Gudtakal State Railway Bridge, occurred in 1851. It would not therefore be safe to assume that higher floods may not occur than any of which the Madras Railway have as yet had experience. But it may be assumed that it would not be safe to work with a lower velocity than that adopted by the Madras Railway after long experience.

Taking then 8 feet per

upon these mere opinions;
for the Madras Railway
have had long experi-
ence of the floods in
the Penner in cyclones
as well as in ordinary
seasons and they have
taken the mean velo-
city in the highest floods
at their Penner crossing
at 8 feet per second.
Mr. Lambert in para
6 of his report No: 4430
of the 24th October 1885
says that the highest
flood of which there
is any recollection
amongst the villages
near the site of the
proposed

proposed Villupuram
Guntakal State Railway
Bridge, occurred in
1851. It would not
therefore be safe to
assume that higher
floods may not occur
than any of which
the Madras Railway
have as yet had exp-
erience. But it may
be assumed that it
would not be safe
to work with a lower
velocity than that ad-
opted by the Madras
Railway after long ex-
perience.

Taking then 8 feet

upon these mere opinions;
for the Madras Railway
have had long experi-
ence of the floods in
the Penner in cyclones
as well as in ordinary
seasons and they have
taken the mean velo-
city in the highest floods
at their Penner crossing
at 8 feet per second.
Mr. Lamberti in para
6 of his report No: 4430
of the 24th October 1885
says that the highest
flood of which there
is any recollection
amongst the villages
near the site of the
proposed
1851

proposed Villupuram
Guntakal State Railway
Bridge, occurred in
1851. It would not
therefore be safe to
assume that higher
floods may not occur
than any of which
the Madras Railway
have as yet had ex-
perience. But it may
be assumed that it
would not be safe
to work with a lower
velocity than that
adopted by the Madras
Railway after long ex-
perience.

Taking then 8 feet
per

per second as the mean velocity at the Madras Railway crossing with a depth of about 10 feet and a fall of 6.3 feet per mile it would manifestly not be safe to take a lower mean velocity than 14 feet at the Villupuram Gingee Kail. way crossing with a fall of about 9.6 feet to the mile and a depth of 14 feet if Mr. Lambert is right.

I gather then from the correspondence that Major Gracey's estimate of the mean velocity is the lowest which can safely be taken.

In addition to this though (17) in the absence of all knowledge of the site and in the entire absence of drawings giving sections of the river bed I must speak with the greatest diffidence I gather from the correspondence also that the Chief Engineer's estimate of the mean velocity at the proposed bridge site is not so incorrect as appears at first sight

over

It is necessary to notice that while Major Gracey's estimate deals with a waterway 1800 feet in width only; the Chief Engineer's calculations deal with a main channel 2400 feet wide and a spill extending over a width of 2850 feet.

It is necessary to notice also that a reef of rock occurs at the village of Panidi about 1½ miles below the bridge site by which the channel of the river is contracted to 1700 feet according to the Chief Engineer (para 12 of this Report) or to 1670 feet according to Major Gracey (para 7 of his No: W.D. 50 of the 4th December 1899).

It appears possible therefore that the Railway crosses the river in the middle of a great pool filled with water headed up by the Panidi reef and that there is a strong current along the southern edge of this pool while the rest of the pool is back water or dead water.

Major

Major Gracey confines his inquiry to the portion of the pool affected by the current and that gets a high velocity confined to a small area.

The Chief Engineer deals with the whole pool including backwaters and therefore gets a very low velocity spread over a wide area.

In this way the discrepancy between the two sets of calculations can be reconciled.

If this is the right view it seems probable that the current will use a portion only of the wide Bridge proposed by the Chief Engineer and the rest of the bridge will carry back water.

Mr Lambert in para 8 of his report says that the sand in the Penner is "of a coarser description" than the sand in the rivers in upper India and that the scour is not so great as in those rivers; in

any

Major Gracey confines his inquiry to the portion of the pool affected by the current and that gets a high velocity confined to a small area.

The Chief Engineer deals with the whole pool including backwater and therefore gets a very low velocity spread over a wide area.

In this way the discrepancy between the two sets of calculations can be reconciled.

If this is the right view it seems probable that the current will use a portion only of the wide Bridge proposed by the Chief Engineer and the rest of the bridge will carry back water.

Mr Lambert in para 8 of his report says that the sand in the Penner is "of a coarser description than the sand in the rivers in upper India and that the scour is not so great as in those rivers; in

any

any case however a large amount of scour will apparently have to be ~~placed~~ faced with current velocities such as those indicated by the correspondences.

Apart from the considerations referred to above it is difficult to see why a bigger bridge should be provided on the Villupuram Gunlakal State Railway than is provided on the Madras Railway for the same river at a point

25 miles lower down in its course where the fall in the bed of the river is not nearly so great as at the Villupuram Gunlakal State Railway crossing. unless indeed there are large spill channels between the two sites by which the channel at the Madras Railway crossing is relieved of a portion of the discharge.

At the same time it is necessary to notice that if Mr Lambert's

any case however a large amount of scour will apparently have to be ~~paced~~ faced with current velocities such as those indicated by the correspondences.

Apart from the considerations referred to above it is difficult to see why a bigger bridge should be provided on the Villupuram Gudalkal State Railway than is provided on the Madras Railway for the same river at a point

25 miles lower down in its course where the fall in the bed of the river is not nearly so great as at the Villupuram Gudalkal State Railway crossing unless indeed there are large spill channels between the two sites by which the channel at the Madras Railway crossing is relieved of a portion of the discharge.

At the same time it is necessary to notice that if Mr Lambert's

is

is right as to the occurrence of 14 feet floods in the Punjab Major Gracey's proposals in para 4 of this No: V-G. 173 of the 14th ultimo to reduce the formation level will apparently require reconsideration.

W.J.

P.S.

I think it would be well to study the discharge at the Pamidi village 1½ miles below the site of the proposed bridges

bridge where the channel is contracted to a width of about 1,700 before finally deciding the question of the amount of waterway to be allowed. This need not delay in any way the construction of the bridge to a minimum of 1,800 feet. By using a pier abutment on the north side an additional span of 150 feet could be put in at any time.

W.J.
30-1-90

Note

The nett result of Major Gracey's investigation does not differ largely from that arrived at by Mr. Logan.

The former recommends 18 spans each of 100 feet. 1800 lineal feet in all.

Mr. Logan recommends 13 spans each of 150 aggregating 1950 lineal feet.

I incline strongly to the larger provision - first, because, as may be gathered from Mr. Lamberti report No: 4430, dated 24th October 1885, where it is stated that the river rises to a depth of 14 feet, as against 7 feet estimated by Mr. Logan and 8 feet as estimated by Major Gracey, we know very little for certain about the floods in the Panjir river at Panidi.

2ndly. because I do not know of a single river

river in Southern India, of which we have fairly accurate statistics extending back to say 30 years that is not shown to be likely to beat its record.

3rdly. because as shown at the site of the Panjir bridge lower down, the river is liable to breaching banks, which, although in this case some of the large ones are situated below the site of the proposed bridge, might very materially affect the level of the flood at this bridge.

is no spill and allow an ample margin for the fierce obstruction.

I have no doubt in my own mind judging by the floods of 1874 and 1889 that the Railway bridge over the Pennier on the Madras Railway would be far less severely tried if it were larger by several spans and it ought not to be accepted as any guide in designing the Bridge over the same river at Pamidi.

I would also remark that the sections of the Pennier river vary to my personal knowledge from 600 yards to 2 miles and that any attempt to deduce the surface fall of a flood when it attains its highest point from the fall of the river bed as ascertained by level, would be futile.

This river relieves itself by scouring away the bed to a depth in one place, of 20 to 30 feet and, as is well known, opens out its

section

section during a high flood - by clearing away islets and accumulations to such an extent and so surely that no deductions from sections of the bed taken after a decade of light or no floods, can in any way be relied on.

Almost any possible flood can be forced through a bridge, if formation be high enough and inundation of surrounding property can be tolerated but there is a limit of risk to which the

the foundation ought to be exposed and in my opinion this limit should be lower with masonry cylinders - which can only with difficulty be firmly and truly bedded on shelving rock, than with iron cylinders that can be truly seated

do.

My own view is that 13 - 150 feet spans give the minimum aggregate lineal waterway that ought to be provided for the Perrier at Pamidi - that with this waterway the rock,

under the masonry cylinders should be carefully levelled by divers - and that if this cannot be thoroughly done, the piers should be specially protected by loose stones thrown in round them.

That masonry cylinders resting on shelving rock are insecure, the fall of the Vikravandi bridge on the South Indian Railway, proved beyond doubt; and that 40 feet of local scour in the coarse sandy beds of the Pennier river and its affluents is by

no

impossible

no means ~~unlikely~~

is now generally allowed

C. Smith Col. R.E.

Consg. Engr: for Rys

I see no necessity to forward this correspondence to the Govt of India;

At all events I would await the views of Mr. Lyon's proposal which I consider prudent and sound.

C.S.
24.1.90

I of course have two opinions on the points involved and cannot appreciate the importance of Major Francis views or arguments.

But in sending the papers to me what it was within Mr. Lyon's discretion to refuse, must he not be considered to evince a desire that they should be before the person who has to decide the question: that is, as he must know, the professional advisers of the Govt of India. And if they can't be before such, would it not be [illegible] must

they chuse to suspend the decision
thereafter it? I however leave
the matter to S.R.
Hes
1 Feb.

Submit to Govt. with SR
Endorsts. in continuation.
7 previous papers.

order

2 to forward to the Govt
7 Endsc. in continuation
CSH.
3 2. 90

Hon. the Sec. to G.

P.W. Cct. dt. 1/20

Rect. 30-1-90
Encs. 4.

E.I
P.W. 1078/90

No. 31-2 R dy 11-1-90
" 161 R / A - 15-2-86

Corr. 31-1-90 R. 3-2-90

FORM No. 1.

PUBLIC WORKS DEPARTMENT.

OFFICE OF CONSULTING ENGINEER FOR RAILWAYS,

Madras, 3d February 1890.

Letter from the Agent Southern Indian
Railway, No. 64 dated 15th January 1890 with
Enclosures.
Note, Herewith by the Consulting Engineer for Railways
dated 24th January 1890 No. 83

SUBMITTED to Government.

in continuation of this office.
Endorsement No. 9 dated
8th January 1890.

358

R.D.S. Shelley Lieut R.E
for Cor: Engr: for Rys

Form No. 3.

B No 201 R 97 - 7th July/90

Sent 36P

Ordered to be
forwarded to the Government
of India in continuation
of Prop: of this Govt: No
31-32 R, dated 11th Janu: 1890.

H.E. No. 202 R dt 7th July: 1890.

Forwarded
C.S.
3.2.90
R

D 7/2

No 31.2 R. 11-1-90.
167/a R. 19.2.86.

22 e 12/2.

From THE CONSULTING ENGINEER FOR RAILWAYS, MADRAS,

No. 83

Dated 3
Received 3 } February 1890.

No. of Enclosures. 5

Subject.

Submitting the correspond-
-ence regarding the investi-
-gation by Major Gracey R.E.,
Sup^g Engr., V.Z.S. Ry: of the
northern portion of that
railway, received from
the Agent, S.I. Ry:.

B
No 201/202 R 97 - 7th July/90.

R

D 7/2

359 R dt 13th March/90

PUBLIC WORKS DEPARTMENT,

03089

F C²

Class. DD	INDIAN TELEGRAPH	Local No.
To (Station) Madras		From (Station) Calcutta

Words.	Day.	Hour.	Minute.	OFFICIAL INSTRUCTION.
36/8	7	18	30	Dft

To (Person) Engr to Rly

From (Person)

1 C 15 your
2 of 22 January and
3 forwarding plans for
4 Guard protection should be
5 sanctioned until complete
6 plans and estimates have
7 been sanctioned letter follows
8
9
10
11
12
13

C.S.
8.3.90

RECD. FROM	L. N.	SENT TO	L. N.
AT Hrs.	Mts., By	AT Hrs.	Mts., By

Date MADRAS 8-3-90

Telegraph Master.

To Railway Engineer Ry.
" Engr S Ry: accts: D 14/3.

February 1890.

CS
8.3.90

R

No. 238 R. C.

GOVERNMENT OF INDIA.

PUBLIC WORKS DEPARTMENT.

RAILWAY CONSTRUCTION.

To

THE JOINT SECRETARY TO THE GOVERNMENT OF MADRAS,
P. W. DEPT. (RAILWAY BRANCH).

Calcutta, the 14th March 1890.

SIR,

I am directed to acknowledge the receipt of your letters marginally noted, submitting for orders proposals for bridging the Penner River near Pamidi, on the Villupuram-Guntakal State Railway.

No. 32 R., dated 11th January 1890.
„ 202 R., dated 7th February „

2. It is observed that the Chief Engineer of the South Indian Railway recommends the adoption of 13 spans of 150 feet girders for this bridge, and proposes to sink wells 20 feet in diameter, one for each pier; the wrought iron well-curbs being procured in India.

3. The Government of Madras concurs generally in the Chief Engineer's proposals, and immediate sanction is asked to the construction of the well-curbs in this country with a view to save time.

4. You were informed in Public Works Department telegram No. C. 15, dated 7th March, that no work should be commenced until complete plans and estimates had been sanctioned, and that further orders would follow by post.

5. I am now to say that it does not appear to the Government of India that the site selected for the bridge is beyond doubt the best that could be chosen, and, as the river is broader here than it is higher up, I am accordingly to suggest that a site, about 600 yards up-stream which seems to present certain advantages, may with the concurrence of the Governor in Council be examined as an alternative crossing. If the foundations here are not worse than those at the down-stream site the upper site would appear the better, as the channel is narrower, and one side at least would be perfectly protected by the rocky hill there, while the other could be protected by a training bund with pitching.

6. As regards the size of spans, the Government of India considers a short bridge with comparatively long girder spans preferable to a long bridge with short spans, as the former would obstruct the waterway less. The Government of India therefore desires that eleven spans of 150 feet each may be adopted.

7. Further it seems probable that the velocity of the Penner River in flood is more likely to be 14 feet per second as calculated by Lieutenant-Colonel Gracey than 4 feet as calculated by the Chief Engineer. With the former velocity the river would in flood scour down to the rock, and for this reason the Government of India prefers two wells each of 12 feet diameter to one of 20 feet as proposed, as the double wells would obstruct the waterway less, and with 11 spans of 150 feet girders would give 88 feet more waterway than could be provided with 20 feet wells.

P. W. Coll. 3155

8. The difficulties of sinking two small wells as compared with one large one may, in this case, be neglected, as the wells would have to go down only about 40 feet, and judging by the experience gained at the Chenab Bridge at Sher Shah, where the double wells were easily sunk to a depth of 80 feet, the foundations at the Penner Bridge should give but little trouble. Two wells would also be safer perhaps than a single well with the pier overhanging the up and down-stream sides, and, as rock is met with at a moderate depth, with fairly large spans no possible velocity in the river could be dangerous to good foundations. The wells resting on rock should be carefully underpinned with Portland cement concrete and protected by stone pitching, as the stability of any well resting on shelving rock will depend on the care with which it is underpinned.

I have the honour to be,

SIR,

Your most obedient Servant,

R M Sankey *Colonel, R.E.,*

Secretary.

Documents accompanying.
Nil.

Rd 27-3-90.

36 S.C.

26 J.C.

36 J.C.

No. 359 R dy 13-3-90
" 201-2R - 7-2-90
" 31-2R - 11-1-90
" 117 R - 21-1-90
" 161R/A - 19-2-86

Government of India Cetral Printing Office.—No. 157 P. W. D.—20-3-90.—10£

Hen. 28-3-90 R 31-3-90

B

No. 464 R

PUBLIC WORKS DEPARTMENT,

RAILWAY BRANCH.

PROCEEDINGS OF THE MADRAS GOVERNMENT.

UNDER date the 2d April 190

READ again the following

Progs: of the Madras Govt. P. W. Depto: — } Ltr. No. 359 R dy 13th March 1890

Read also the following:

Letter from the Govt. of India P.W.D. } Ltr. No. 238 R.C., dy 14th March 1890

Communicated to the Consulting Engineer for Railways in continuation of Proceedings No. 359 R dated 13th March 1890.

Ld 31-3-90

Issd 29 Mar

2. The alternative site proposed in para 5 of letter from the Govt. of India P.W.D. read above should be investigated and a report of the result of such investigation should be submitted for the information of Government.—

To
The Consg. Engr for Rys with 20
— " Exr Gl. Rly Circls. with 58 Cs

D 3/4

Ld 27-3-90
D. R

Hms. Ry. Dept. Rec'd

Plans under f. noted

B

No. 464 Ry 2c april/90.

Hm. 28-3-90 R3T-3-90

Rec'd 10/4/90

Vide further letter from Agent dated 26.6.90

No 757

Dupl

South Indian Railway,

AGENT'S OFFICE,

TRICHINOPOLY, 28th May 1890.

418

From

The AGENT,

SOUTH INDIAN RAILWAY,

To

The CONSULTING ENGINEER FOR RAILWAYS,

MADRAS.

Sir,

Your letter No. 399 of the 5th ultimo. The Chief Engineer reports that the Executive Engineer has this work (investigation of site for the Penner bridge) in hand, but it will take some time yet to complete. It has been delayed by the prevailing sickness, but it is being pushed as rapidly as possible.

I am
Sir
Your most obedient Servant,

William Betts
Agent.

R.A.

707

PW Rec 3
5965/90

From

The AGENT,
SOUTH INDIAN RAILWAY,

To

The CONSULTING ENGINEER FOR RAILWAYS,
MADRAS.

Dated 20th May 1890.
Received 30th 5th 90
No. 1948
Enclosure. 355

R. Penner bridge.

No 884

South Indian Railway,
AGENT'S OFFICE,
TRICHINOPOLY, 20th June 1890.

428

Sir,

Your letter No 399 of the 5th of April
last. I forward herewith copy of a report from
the Chief Engineer giving the result of a
investigation as to the most suitable site
the proposed bridge across the Penner.
Will you please obtain the order
Government hereon as soon as possible.

I am
Sir,
Your most obedient
William
A

(2 - Enclo)
Rec'd

to it as suggested by the Government of India in para 5 of letter No. 238 R.C. for this bank (right) is already completely under the protection of the hill referred to for a considerable distance below the original alignment - and no change in the bank which is of a sandy nature is known to have taken place for many years during which heavy floods have been experienced, and one abnormally high flood is stated to have occurred only last year.

4. Under the circumstances there does not appear to be any advantages on the side of the alternative (upstream) alignment to justify the abandonment of nearly 2½ miles of Railway embankment already known up from the North bank of the river towards towards Guntakal, and I recommend that the original alignment selected by Mr Lambert and approved by Sir Guilford Molesworth after examination of the ground be adopted.

5. With reference to the size of the wells for the foundations of the bridges experience on the South Indian Railway has been confined to wells of 12 feet in diameter and under, of which we have sunk a good many in the deep sandy beds of our South rivers, and other things being the same, I prefer that diameter (12 feet) of well to larger one, but under the conditions at the Penner - a rock substratum and the probability of meeting with boulders in sinking foundations to this rock, that Colfnet Gracey's recommendation to use one well of 20 feet in diameter, in preference to two of 12 feet diameter for each pier carries much weight.

45 SP

* Taken by Executive Engineer Section now sent to you Colonel Cracky Major Wpte R.E. writes:-

6. In forwarding to me the survey and d

"I cannot see that the proposed new
"crossing offers any advantage commensurate
"with the cost of shifting the approaches
"on the North bank of the river - I am,
"therefore, of opinion that the crossing originally
"proposed should be adhered to."

"It must be borne in mind that the
"water which is shown as overflowing the
"bank on the north side of the river does
"not run with any velocity. This was
"proved last year by the fact that the
"bank which has been thrown up was
"hardly cut into at all by the flood wa
"although the material of which it is
"composed is very sandy."

"I am still of opinion that the pi
"should each be founded on one well
"20 feet diameter as the beds of the riv
"in this part of the country have all la
"boulders overlying the rock. It will,
"my opinion, be possible to deal with
"boulders in a well 20 feet in diameter
"with wells 12 feet in diameter the who
"the internal space at the bottom of
"well may be plugged up with one l
"sized boulder which it will be almos
"possible to remove. Moreover the sto
"can be procured is not suitable for
"wells with thin steining."

7. I shall be glad to receive
orders as to (1) the site and (2) th
of well to be adopted so that the
required by Government for the Per
may be completed.

8. The boring operations at the

45-58

* Taken by Executive Engineer section now sent to you Colonel Cracky Major to the R.E. writes:-

6. In forwarding to me the survey and

"I cannot see that the proposed new
"crossing offers any advantage commensurate
"with the cost of shifting the approaches
"on the North bank of the river - I am,
"therefore, of opinion that the crossing originally
"proposed should be adhered to."

"It must be borne in mind that the
"water which is shown as overflowing the
"bank on the north side of the river does
"not run with any velocity. This was
"proved last year by the fact that the
"bank which has been thrown up was
"hardly cut into at all by the flood wa
"although the material of which it is
"composed is very sandy."

"I am still of opinion that the pi
"should each be founded on one well
"20 feet diameter as the beds of the riv
"in this part of the country have all la
"boulders overlying the rock. It will
"my opinion, be possible to deal with
"boulders in a well 20 feet in diameter
"with wells 12 feet in diameter the who
"the internal space at the bottom of
"well may be plugged up with one
"sized boulder which it will be almo
"possible to remove. Moreover the sto
"can be procured is not suitable for
"wells with thin steining."

7. I shall be glad to receive
orders as to (1) the site and (2) th
of well to be adopted so that the
required by Government for the Per
may be completed.

8. The boring operations at the

(up-stream) alignment are going on, and the result will be reported as soon as possible but I trust that sufficient data have now been submitted to enable Government to decide on the points under reference. The borings have hitherto been delayed owing to scarcity of labour and sickness in the locality.

/True Copy/
Chooppooranum Pillay
Chief Clerk.

Agent's Office
Trichinopoly
20th June 1890.

REGISTER
No 820
FILE
No

P W Enc 2
5965/90

FORM No. 1.

PUBLIC WORKS DEPARTMENT. OFFICE OF CONSULTING ENGINEER FOR RAILWAYS,

Madras. 24th June 1890.

Letter from the Agent, South Indian Railway, No 757, dated 28th May 1890.

—— Do —— No 884, dated 20th June 1890,

with Enclosures.

No. 442

SUBMITTED —— to —— Government for transmission to the Government of India with reference to its letter No. 238 R.C., embodied in Proceedings of Government No. 464 R, dated 2nd April 1890.

Subject.—

2. The Agent, South Indian Railway, submits copy of a report from the Chief Engineer giving the result of a further investigation

as to the most suitable site for the proposed bridge across the Penner River on the Villupuram Gmntakal Stake Railway.

3. The Chief Engineer does not consider that there would be any advantage in the alternative alignment suggested by the Government of India to justify the abandonment of nearly 2½ miles of Embankment already thrown up, and recommends that the original alignment be adopted.

4. Colonel Gracey R.E, recommends that 20' wells as originally proposed instead of 12' wells should be adhered to, on account of the probability of meeting with large boulders when sinking the foundations. The Chief Engineer concurs in this opinion, and recommends their adoption.

5. Early orders are solicited regarding the site, and the diameter of well to be adopted, in order that the Estimate for the Penner bridge may be completed.

Sidney Smith
Major R.E,
offg: Consg: Engr: for Rys.

Form No. 3.

Ev. Bus 464R dy 2.4.90
. . . 359R dy 13.3.90
. . . 201-2R dy 7.2.90
. . . 31-32R dy 11.1.90
R. 117R dy 21.1.90

P W C No 5-965R

From

THE CONSULTING ENGINEER
FOR RAILWAYS,
MADRAS,

No. 442

Dated 24th
Received 24 } June 1890

No. of Enclosures. 5 (+ 2 plans)

Subject.

Submitting, for transmission to the Govt. of India, correspondence giving the result of a further investigation as to the most suitable site for the proposed bridge across the Penner river on the S. I. Ry.

B

No. 930-931R dy 27th June 90

B

No. 930R

PUBLIC WORKS DEPARTMENT,
RAILWAY BRANCH.

PROCEEDINGS OF THE MADRAS GOVERNMENT.

UNDER date the 27th June 1890
again
READ the following

Progs: of the Madras Govt: P. W. Dept:- } M.E. No. 464R dy 2nd April 90

Read also the following.

Endorsement from the Consg Engr for Rys- } M.E. No. 442 of 24th June 90

49

Ordered to be forwarded for the early orders of the Government of India with reference to its letter No. 238 R.C., dated 14th March 1890.-

M.E. No 931 R 27th June 1890

Forwarded.

Rueda
26.6.90 Wpt

M.E.
26/6/90

Info despd to India with two tracings 27/6/90.

R 30/6

0
25/6
Ackn. 26/6 R 27.6.90

R 30/6

R

All communications should be addressed to the Secretary

No. 668 R.C.

GOVERNMENT OF INDIA.

PUBLIC WORKS DEPARTMENT.

RAILWAY Construction

To

The Joint Secretary to the Government of Madras

(Railway Branch) Public Works Department.

Simla the 30th July 1890

Despatched 7th Aug.

Sir,

I am directed to acknowledge the receipt of your No. 931 R dated 27th June 1890, forwarding correspondence from the Agent of the South Indian Railway Company enclosing a report by the Chief Engineer on the result of the further investigations made with a view to find the most suitable site for the proposed bridge over the Pennet river near the Kallurn Station, Villupuram Guntakal State Railway.

2. It is observed that the Chief Engineer does not consider that there would be any advantage in adopting the alternative alignment

alignment suggested by the Government of India in Public Works Department letter No. 238 R.C. dated 14th March 1890, to justify the abandonment of nearly 2½ miles of embankment already thrown up; and that he apparently concurs in Lieutenant Colonel T. Gracey's recommendation that 20 feet instead of 12 feet wells be adhered to.

3. I am to enclose for information a copy of a note by the Consulting Engineer to the Government of India for State Railways on the subject, and to request that the several points raised therein may be carefully considered, especially that relating to the probability of finding a layer of boulders overlying the rock in the bed of the river; and that the project and estimate for the Bridge may be drawn up in accordance with the decision which, after consideration of the views expressed in this note may be arrived at by the Company's Engineers, and approved by the Government of Madras.

I have the honour to be,
Sir,
Your most obedient servant

F. S. Talbot
Offg Under Secretary

Document accompanying
Copy of Note by the Consulting Engineer for State Railways dated 10th July 1890.

PW Cdo 7663

Rd 14-8-90

Let us ad here to the present alignment & ten 20' pells as bk Col: Gracey & the togan engineer of the enquiry

A8/8/90

Put up former letters in sundry enquiry at office

14/7

Note by the Consulting Engineer to the Government of India for State Railways, dated 10th July 1890.

There is nothing in the information now furnished which induces me to alter the opinions previously given that double wells are more suitable for the foundations for the piers of the Pennair bridge than single wells, and that the upper site is the preferable one.

The cost of sinking a single well is certainly less than that of a pair of wells, but if the work is done by experienced men, the difference is hardly a matter of moment.

Sir Guilford Molesworth's opinion is quoted more than once, but I know that he strongly objected to single wells in other cases. A perusal of the notes on Mr. Lambert's estimate for the Guntakal-Hindupur line shows his remarks on the Pennair bridge as follows:—"At the Pennair bridge I should prefer spurs with protected ends running out at right angles from the main bund rather than a continuous bund pitched with stone. The ends of the spurs should run out with a flat slope of say 1 in 10, with a broad deposit of loose stone at the foot of the slope."

Mr. Lambert had proposed double wells 12½ feet diameter, and the presumption is that Sir Guilford Molesworth agreed, as he does not mention the subject.

If well foundations are decided on, and bricks are not procurable for well steining, I would much prefer Portland cement concrete to rubble masonry as being far stronger, and, if the stones have to be dressed and summered, as being cheaper.

Rubble masonry is by its nature little fitted for any stresses except direct compression, while wells have to endure many different strains while being sunk into position.

If concrete is used, it should either be moulded into blocks, to be afterwards set in place, or moulded *in situ* so that the wells may be monoliths. I have used concrete in both ways and found it most successful.

It is an easy matter to keep the sinking and the building up of wells progressing simultaneously. Much of the difficulty experienced in sinking wells is due to the loading and unloading system in which the sinking is stopped for days while the wells are being loaded. This stoppage allows the sand or silt to settle round the well and grip it, making the restarting troublesome.

By keeping the well "alive" and using the late Mr. Brunlees' system of forcing jets of water through the curb just above the cutting edge very little, if any, extraneous weighting is necessary in sinking through ordinary sand, the weight of the well itself being sufficient if it is kept always on the move, both night and day.

But in the matter of these foundations another question arises. In the last report of the Chief Engineer, South Indian Railway, the probability of meeting boulders overlying the rock is brought forward more prominently. Mr. Logan says "isolated boulders"—Colonel Gracey says "large boulders overlying the rock."

In building the bridge over the same river for the Madras Railway, 25 miles lower down, a thick boulder bed was met with, necessitating the use of iron cylinders and pneumatic apparatus to sink them. This is a matter which should, I think, be carefully considered, for large boulders are very difficult to deal with in any well, large or small. Again, the proper bedding of wells on shelving rock is no easy operation, whether the wells be twelve or twenty feet diameter, and can only be done by underpinning with bags of cement concrete laid by divers.

The Engineer can know nothing as to the actual way in which this is done, having to take on trust what the diver tells him. A subsequent inspection reveals nothing, for the concrete will have been filled close up to the top of the well curb, and the real underpinning may have been scamped.

For these reasons I much dislike shallow wells bedded on any thing except clay, and would, in the case of the Pennair bridge, prefer iron cylinders sunk to the rock and then properly bedded by having the rock cut level to receive the cylinder. This can be done if the pneumatic system is used, and the work can be inspected by the Engineer in full light before concrete or other filling is placed in the cylinder. Absolute certainty as to the stability of the foundations is thus insured.

The Madras railway have close by all apparatus for sinking such cylinders which can no doubt be made available for use by the Pennair bridge Engineer.

Regarding the site for this bridge, I can find no reference to it in Sir Guilford Molesworth's note other than the general remark referring to the whole line that "I satisfied myself that the line had been laid out with great skill and care."

A good deal has been made of the quantity of earthwork to be abandoned if a change of site is determined on. I have calculated this out from the sections sent with the report now being noted on, and find it amounts to just 30 lakhs of cubic feet, which, at Rs. 4 per thousand, will cost twelve thousand rupees, hardly sufficient to cause the site for a work which may cost six lakhs to be considered a fixture.

Still, as I have been only once on the ground, I will not press my own ideas regarding the actual site, for Colonel Gracey, while Superintending Engineer on the district, has no doubt studied the question at length on the spot and taken more matters into consideration than he has given in his report; but a study of both plans and sections does not alter my preference for the upper site, which would bring the bridge square with the stream, and would afford absolute protection to one abutment.

Whichever site is eventually adopted, I strongly recommend that the river may be guided to the bridge by training bunds on Mr. J. R. Bell's system.

To recapitulate—

I prefer the upper site, but the difference between the two sites is not sufficiently great to induce me to press my opinion on the local Engineers, and I recommend—

(*a*) 12½ feet diameter wells instead of 20 feet built (if bricks are not available) with Portland cement concrete;

(*b*) the use of iron cylinders instead of wells if many boulders are likely to be met with, or if the rock is very shelving;

(*c*) that training bunds on Mr. J. R. Bell's system be constructed to guide the river through the bridge.

F. L. O'CALLAGHAN.

Pw Encl 763/90

G. C. Press, Simla.—No 731 P. W. D.—7-8-90.—75.

No 1236 R

PUBLIC WORKS DEPARTMENT,

RAILWAY BRANCH.

OF THE MADRAS GOVERNMENT.

UNDER date the 21st August 1890.

again
READ the following

} A.E. No: 930-31R dy 27th June 1890

Also the following:

A.E. No: 668 R.C. dy 30th July 90

Communicated to the Consulting Engineer for Railways with reference to his endorsement No. 4442 dated 24th June 1890.

2. This Government having considered the further suggestions of the Government of India forwarded with the letter read above, would prefer to adhere to the proposals originally submitted regarding the

538

24/8/90

issued
28/8/90

the alignment of the Power
Bridge and its construction
on wells of 20 feet diameter
as both the Consulting Engineer
for Railways & the Chief
Engineer South Indian Railway
are in favour of these ar-
rangements.

3. A copy of these Prop.
will be forwarded for the
information of the Govt. of
India.-

Spencer

Print

A

No. 1237/R dt 21st Augt-90

Forwarded.

D 8/9/90

Dy
Offg: R

No. 1226-37 S C dt 21st Augt/90.

D 8/9

To The Consulting Engr for Rys
& Engr Govt Rys Madras.

Dft 14/8
Ltr. 20/8 R 21/8

52

7883.

Govt. of 18 Madras.

PUBLIC WORKS.

Dated 21st August 1890 Rd. 4/9/90

Recd. Encl.

G.O., 21st August 1890, No. 1236 R
1237 R

Spencer Bridge.

Letter from the Govt of Bombay: enclosing suggestions for the alignment & construction of the — over the Kallanai station V. G. & Ry and to the Govt of Kyp with reference to

Do — do.

Bombay: Copy of Bombay: according to the proposal originally submitted regarding the alignment & construction of the — on wells of 20 feet diameter.

12/2

12/2 8/2

R., PUBLIC WORKS.

ADRAS.

ARTMENT.

d Madras, 9th August 1890,

ulting Engineer for Railways,
, No. 1102.

ultimo.]

of India in para. 4 of letter,
neer has reported to me as

the cost of drilling four holes

es no holding down bolt.
ation because the work for the
es where work is going on all
nts occurring."

ia with reference to para-
in Proceedings of Govern-

ORDE

O ks.

graph with reference to para-

1890.)

To the Co .-Colonel, R.E.,
" Ex y. to Govt., P.W.D.,
Railway Branch.

ENDORSEM

Works.

Exd. A. Auber -Colonel, R.E.,
Spare Copies Govt., P.W.D.,
Railway Branch.

Copied & sent to the Govt of India this 4th Sept 1890

Copy sent for information and disposal to India - Please return the late / depositor / the Copied Copy Thanks the Secd Spare Copies

2.9.90