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MADRAS RECORD OFFICE.

Government of Madras.

Public Works DEPARTMENT.

G.O. No. 75 Press Mis.

Dated 11 1 1868.

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No. 184. Read the following letter from the Consulting Engineer for Irrigation and Canal Company, to the Secretary to Government, Department Public Works, dated Madras, 19th December 1867, No. 123:—

1. I have the honor to forward, for the consideration of Government, a letter, No. 352, of the 18th ultimo, with its accompaniments as per margin,* transmitting for sanction revised estimates for the 10th section, Main Canal, including an anicut and head works on the Pennair at the head of the section.

* List of plans and estimates
Chief Engineer's report, dated 5th ultimo.
Do. do. Memorandum of the same date
Executive Engineer's report on the proposed terminus of the canal near Cuddapah

2. The amounts of the estimates now submitted are—

	Rs.
Anicut and head-works	1,88,600
Main Canal	1,97,560
	3,86,160

Proceedings Madras Government, 31st March 1864, No 889.

The original estimates amounted to Rupees 4,81,800.

3. The 10th section being a part of the canal, between Soonkasala and Cuddapah, included in the supplemental Contract of the 2nd October 1866, it would seem to be necessary that the works to which the present estimates relate should be carried out, although this section belongs not to the upper 9th section of the canal, but to the extension from Cuddapah, via Somaisweram and Nellore, to the coast. The 10th section, as formerly estimated for, was 10 miles and 28 chains in length, but the Chief Engineer now proposes to stop near the lower end of the eighth mile, so as to avoid the expense of the lower two and a half miles, in which there would be a bridge, a lock, and a large aqueduct, and other works. He shows that the present terminus is nearer to the Railway, though not to a Railway Station, and he proposes, though this work is not included in the estimates, to construct a tramway two miles long from the terminus to the Railway, which it would meet at 166 miles 6 chains. The Cuddapah Station is, however, at 162½ miles, and probably it would be necessary, at all events until the Railway line had been doubled, to continue the tramway rails down to the station. The Chief Engineer's reasons for stopping the canal near the Military lines are very good, and they are, in effect, that it would not pay to go on to the original terminus, and that this latter would be still further from the Railway. A similar argument may be applied to the whole section. It will not pay to construct it, and unless a reservoir be formed either at Parnapully on the Chithravuthy, or somewhere else above the site of the proposed anicut across the Pennair, it will be of very little use for irrigation, and almost, if not quite, useless for navigation. Reservoirs are not provided for in the contract, and therefore the time within which the outlay on the 10th section will be turned to account is altogether uncertain.

4. The area of land included between the canal, the Pennair, and the Booga, is about 11,360 acres, of which about 1,000 acres to the west of the Punkalwunkah are certainly not commanded, and it is uncertain how much of the remainder will be irrigated from the canal. Taking, however, existing irrigation into account, it is

probable that the canal irrigation under this section will never exceed 5,000 acres.

	RS.
These estimates amount to	3,86,160
Distribution may be taken at	29,840
	4,16,000
Establishments and Home charges 50 per cent.	2,08,000
Total .	6,24,000

The probable ultimate revenue will stand thus—

5,000 acres, at 6 Rupees	30,000
Deduct for maintenance at 5 per cent. on 4,16,000	20,800
Net Revenue .	9,200
Or per cent .	1·47

The allowance here for maintenance is, I think, not excessive, as the anicut and head-works will need a considerable yearly outlay, and the first few miles of a canal always absorb a good deal of money for silt clearance.

Therefore even supposing no supplemental sanction to be required, and it will be seen presently that the anicut estimate will require considerable additions, and supposing also that 5,000 acres could be irrigated, the returns would be under 1½ per cent.

5. Without reservoirs I do not see that there is a prospect of successful irrigation at all. The experience of a good many years has shown that direct irrigation from the Pennair, unless supplemented by tanks, cannot be depended upon; and if this be the case in the Nellore District, which has the first claim upon the Pennair water, it is evident that a canal in Cuddapah, which can take water only when the supply is in excess of the wants of Nellore, has really no chance of ensuring successful irrigation. From the Registers in this office it would appear that on the average for the years 1861 to 1866 inclusive, on only forty-eight days during the year was the water level with or above the crown of the Nellore anicut, and consequently only for so many days would there have been any water at all available for this 10th section of the Company's canal. It is also quite certain that there will not be any surplus Toombuddra water; for, even if the Main Canal be made in the upper sections to carry 6,00,000 instead of 4,00,000 cubic yards an hour, the supply will still be inadequate to the demands of more than a very moderate proportion of the large areas commanded, and that too quite conveniently, by the canal to the north of the Pennair, that is in the first nine sections.

6. Again, in the absence of reservoirs by which both the Toombuddra and Pennair supplies can be augmented after the subsidence of the freshes, the 10th section of the canal will be of no use for navigation; for generally September, October, and part of November will be the only months in which navigation here will be practicable, and at that time the navigation above will just be becoming impracticable.

7. I have now to report on the project for the anicut and head-works, and for the canal in connection therewith, as submitted by the Company's Chief Engineer. After a preliminary examination of the plans and estimates, I went to Cuddapah

and saw the Executive Engineer of the Division, who went with me to Adamapully. As the Executive Engineer was not in possession of a survey of the river for some few miles above and below the proposed site for the anicut, and as the information regarding flood levels, fall of river bed, surface fall of water, &c., was insufficient to enable even an approximate estimate of the maximum discharge to be made, this Officer gave the requisite instructions for the collection of further information, and I proceeded to meet the Chief Engineer at Rajoly, and I have had the advantage of discussing with him the principal features of the project. On my return to Adamapully on the 12th instant, the survey of the river and seven cross sections had been taken, and these have proved of great use in judging what the requirements of the Pennair in connection with an anicut are.

Plans Nos 5A and 5B

8. It will be seen that the Chief Engineer proposes to construct the anicut in an oblique direction, in two branches, with an embankment between them The right branch, or Adamapully weir, is shown to be 800 feet in length, and the left, or Coteloor branch, 1,050 feet in length. The object of this arrangement is to make the construction of the weir as simple and inexpensive as possible. Here, on both sides of the river, there are extensive beds of blue limestone; and the dam is intended to be formed by simply building walls, 8 feet wide at top, vertical on the lower side, and with a batter of one in four on the upper side for the lengths above given; then, where the rock reaches a level* below which masonry walls could not be conveniently founded, wing-walls are proposed to be built, and the two branches of the anicut to be connected by a massive bank.

Plan No. 5.

* Abont 273, the ordinary deep bed of the river being about 281
Crest of anicut 293.
Sill of under sluices 282.
Sill of head-sluice 287.

9. I do not think there would be any great difficulty in carrying out such an arrangement successfully, or in securing the intermediate embankment from liability to breach. The design for this bank, as shown in plans No. 7 and 7A, is good, and the only additions and modifications which appear to me necessary or advisable are:—

* Left
† Right.

First.—At the upper left wings of both the north* and south† branches and at the upper right wing of the north branch, where there will be considerable action, it will be advisable to give a concrete backing to the revetment for some yards, so as to confine the action of the water to the surface.

Secondly.—To prevent scour along the toe of the up-stream face of the bank, groynes somewhat in the form shown in pencil on the elevation, plan No. 7, will be needed at about 60 feet from centre to centre, the tops of the groynes should be about 4 feet below anicut crest, at their junction with the revetment.

Thirdly.—The toe of the rear slope for a distance of 30 to 35 yards will need protection, to prevent its being undermined by the eddies. A sort of apron 10 yards wide and 18 inches to two feet thick will suffice.

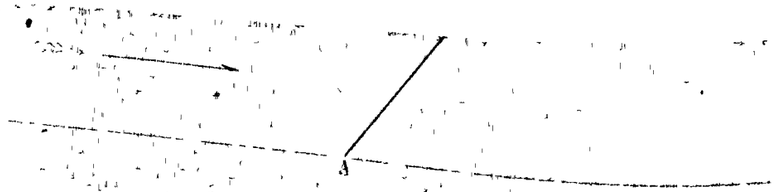
Fourthly.—The foundation puddle might as well be placed so as to give a minimum thickness of 8 feet, instead of 5½ feet as shown.

10. The point of chief importance, however, is the sufficiency or otherwise of the length of the anicut as designed. The site for the anicut as originally designed corresponded very closely with the position of section No. IV on the river Survey, plan No. 5A, and its length was 2,376 feet, in a direction approximating very closely to the perpendicular to the stream of the river. The Chief Engineer's present design has a length of only 1,850 feet, and both branches have considerable obliquity, that of the right branch being very great.

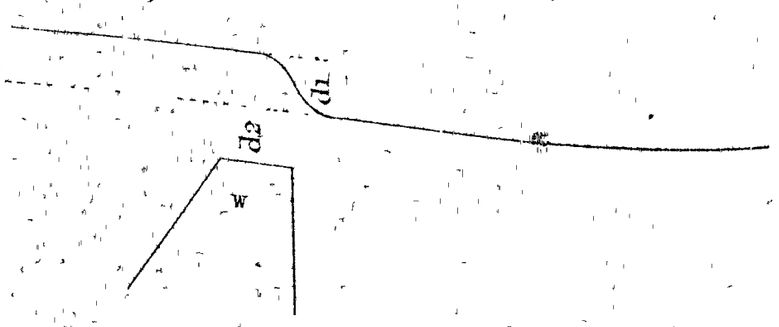
11. I have had much discussion with the Chief Engineer on the subject of the capacity for discharge of oblique anicuts when drowned, or having the water in the lower reach above their crest. And he appeared to consider that I much under-rate their value. I have just received a letter* expressing Mr. Latham's views on the subject, and I gather from this communication that he considers that the obliquity of an anicut affects only the velocity of approach, or that only the portion of this velocity which can be resolved into a direction perpendicular to the anicut should be taken into account. For the rest it would seem that he supposes that the discharge would be just the same as would be the case were the anicut at right angles to the general direction of the current of the river.

* Dated 14th instant, with Agent's No. 395 of the 16th instant.

12. If this be the Chief Engineer's view of the matter, I am unable to concur with him, and in order that I may be *able to show* clearly what I consider the effect of oblique anicuts to be, I will take an example to illustrate the case generally.



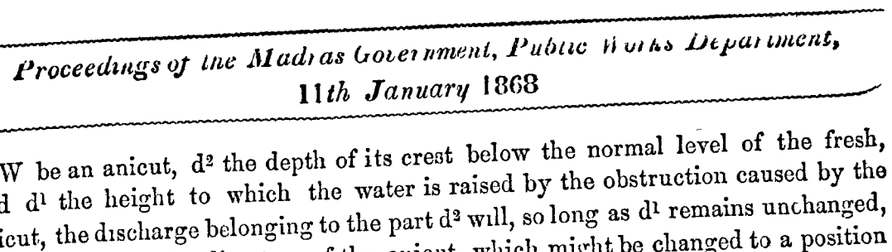
Let A B be an oblique anicut across a river in which the current is parallel with the banks. If, in considering its action with regard to any particular state of the river, the level of the crest from A to B be fixed so as to bear the same relation to the normal level of the river at that state, *i. e.*, if B be as much lower than A, as the difference of level of water in the river would be in such a fresh at those two points, then—



if W be an anicut, d^2 the depth of its crest below the normal level of the fresh, and d^1 the height to which the water is raised by the obstruction caused by the anicut, the discharge belonging to the part d^2 will, so long as d^1 remains unchanged, be unaffected by the direction of the anicut, which might be changed to a position of greater or less obliquity, provided the relative level of each part of its crest were preserved, without modifying the discharge. I refer of course to the practical effect of an anicut, so far as this need be considered in calculating its influence on a river in high floods. Every alteration in the position of an anicut would cause a greater or less diversion of the comparatively small portion of the discharge impinging against the upstream face of the dam, but this action need not be considered, and could only be deduced from experiments. It follows then that this portion of the discharge will be the product of the direct width of the river into the depth d^2, into the velocity generated by the head d^1 added to any further head due to velocity of approach.

On the other hand, the velocity due to the overfall d^1 is generated at right angles to the actual direction of the anicut, whatever that may be; and therefore this portion of the discharge will be the product of the full length of the anicut into d^1 into the velocity generated by the head d^1 added to the further head, if any, due to the velocity of approach.

13. To ascertain by construction the effective length of an oblique anicut, the velocity of the lower part of the discharge should be multiplied by the depth d^2 and laid down to scale from A in the direction of the current of the river, in the next place the velocity of the upper part of the discharge should be multiplied by the depth d^1 and laid down, to the same scale, at right angles to the direction of the anicut; completing the parallelogram and drawing the diagonal with A F perpendicular



thereto, and B F through B parellel to A E, A F will represent the effective length of the oblique anicut, or that length which is to be adopted, in calculating the discharge, for multiplication into the velocities of both the upper and lower portions.

On inspection of the above diagram will show that were there no overfall and therefore no d^1—A H the direct width of the river would be the effective length of the anicut A B; on the other hand, were there a clear overfall and consequently no d^2, the effective, would be the actual, length A.B.

14. I will now apply these conclusions to the project for the Pennair anicut.

15. The maximum flood on record is that of May 1852, and both in Cuddapah and Nellore it is still well remembered. The country on either side of the river was very generally inundated, but many of the villages near the river, being situated on sand hills or other exceptionally high ground, were not submerged, and at several of these the level of the flood has been pointed out, and I think generally with sufficient accuracy to admit of a safe approximation to the discharge of the river being arrived at.

16. The discharges at the several cross sections as calculated by me are—

Cross Sections	No.	I	cubic yards per hour	58,920,000
,,	,,	II	,,	58,880,000
,,	,,	III	,,	55,353,000
,,	,,	IV	,,	56,484,000
,,	,,	V	,,	45,876,000
,,	,,	VI	,,	44,290,000
,,	,,	VII	,,	28,300,000

For No. VII there is nothing to show what the fall below was. The differences between the others are not greater than might be expected in the absence of information as to the exact distribution of the fall; added to which some of the flood levels, such as that at Coteloor on the steps of the principal house, and that at Poospagherry where the points reached, according to the villagers, on either side of the river corresponded, when tested by the spirit level, very closely, are likely to be more correct than others for which there was no well defined mark capable of being noticed during the continuance of the flood. The average of the first six calculations is cubic yards 53½ millions, and probably therefore, taking into account the spill over the river banks which extended for a long distance, though no doubt with but a low velocity, it will be safe to consider 56 millions as the maximum discharge.

17. In the next place the extent to which the flood level may be raised at and by the anicut has to be determined, and five feet, the surface fall of the river per mile, will not occasion any great extension of protective works, such as stop banks, &c, and I therefore suggested this to the Chief Engineer, and he appeared to consider it reasonable.

18. Judging from the present average velocities at Sections Nos. II, III, and IV, I estimate the velocity of approach at about 9,000 yards an hour, which is equivalent to a head of two feet. The level of the crest of the anicut is intended to be 293, or 13 feet below normal flood level, at its southern end.

Cubic feet 666.

19. With the above data I find that the length of an anicut at right angles to the stream of the river should be 1,800 feet.

20. Were the crest of the Chief Engineer's proposed anicut to be thirteen feet below flood water level throughout, the effective length of the two branches would be 1,516* feet, instead of 1,850 feet, their actual length. When the river is low, however, which is the time at which an anicut is most wanted, the pond above the anicut will have a nearly horizontal surface, and the anicut crest must therefore have the same

* South branch, feet 540.
North ,, ,, 976.

absolute level throughout, and the relative level will vary considerably. It will be seen from the level, marked on the survey opposite Coteloor, that in extreme floods the crest of a horizontal dam at the north end would be three feet nearer the normal level of an extreme fresh than the same dam at the south end.

Plan No. 5 A.

21. The south branch will have its crest at 293, and the flood level may be taken at 306 throughout. It will then carry off $\frac{540}{1800}$ of the 56 millions cubic yards, or 16⅔ millions cubic yards To this may be added the discharge of the under-sluices which would be, the head being 5+2 = 7 feet, not 3¼ millions as mentioned in the Chief Engineer's letter, but 1,040,000 cubic yards, leaving 38,160,000* cubic yards to be passed by the north branch.

* 286 200 cubic feet per second

The level of the crest of this branch must also be 293, and the flood level may throughout be taken as 303. The velocity of approach will be somewhat less, say 7,855 yards an hour, equivalent to a head of 1½ feet. These data make the required length of an anicut at right angles to the stream 1,540 feet.

The formula used is $D = c\ l\ \sqrt{2g}\ \{d_2\ \sqrt{d^1 + h_a} + \frac{2}{3}(d^1 + h_a)^{\frac{3}{2}} - (h_a)^{\frac{3}{2}}\}$ in which D is the discharge in cubic feet per second and h_a is the head corresponding to velocity of approach
C. has been taken as ⅔ or $C \times \sqrt{2g} = 5\,35$.

22. The effective length of the north branch in its present position is, for a fresh of this magnitude, and with its crest so circumstanced, 983 feet; consequently it is very much too short.

23 When discussing the subject with the Chief Engineer, that officer appeared to think that whatever increased length might be demonstrated to be necessary, could be obtained by prolonging either or both branches with some modification of direction, thus securing the same general arrangement, and avoiding the construction of any part of the weir proper where rock for its foundation is not available. It will be noticed that the anicut, as designed, would interfere considerably with Adamapully; and Coteloor, on the opposite side of the river, would need the protection of a wall carried up well above flood level; and moreover, in continuation of this wall, an embankment would be necessary to connect with the left bank of the lower end of the 9th section, Main Canal, which it will be seen reaches the river a little west of Bakrapoorum. Any lengthening of this anicut would necessitate the removal of Coteloor, and the addition of a strip of land, some four hundred feet in width near that village, to the river bed.

Plan No 5.

24. Whatever arrangement be adopted, the head-works if kept at or near their present position will need raising. The roadways of both the under and head-sluices should be at least 4 feet above raised flood level, or 315 with reference to original flood level 306; the under-sluice road is now 310, and that of the head-sluice 306.

25. There is no other site near Adamapully at which an anicut, with two branches on rock and an intermediate bank, could be constructed; but from a little below Coteloor to a little above Metapully there is a good site for an anicut 2,000 feet

in length, more than half of which would be on rock. Probably the head-works would have to be built on wells. At Poospagherry hill there is an unlimited quantity of quartzite, so the construction of an anicut with a sloping apron would not be difficult, and not very expensive, though of course the cost of a sloping apron cannot be compared with that of a simple wall built on rock.

26. The rock on which the Chief Engineer intended building the anicut estimated for is blue limestone. The beds on the Coteloor side are very good, and were the foundations of the body wall carried down a moderate depth below the surface, I have no doubt they would be beyond the risk of injury for many years to come, if not permanently. On the Adamapully side the reef is apparently not so good; but, until the surface shall have been removed, and the character of the lower strata ascertained, which would be done in founding a wall, I cannot say what the effect of the overfall would be likely to be.

27. The stop bank will need modification. At present it is shown as terminating at a small nullah, a short distance from the Bellary road. Probably the Railway embankment would be the best terminus; but the information at present available, regarding the distance to which flood-waters extend, is insufficient to enable the point to be properly decided. Provision for passing several irrigation channels will have to be made in the stop bank estimate.

28. The capacity of the under-sluices, as designed, will be sufficient to pass all the water required for the irrigation in the Nellore District. The head-sluice vents will pass cubic yards 42,840 an hour with the water flush with anicut crest.

Cubic yards 9,62,910 per hour, when water is level with crest of weir.

29. The plans of the navigation head, and head-lock of this section have not yet been sent in.

30. The canal has been designed with a depth of 5 feet, a breadth at sole of 50 feet, and at surface of 70 feet. Fall 1½ inches a mile. It will carry about 25,000 cubic yards an hour, which will be likely to suffice for all the irrigable land between Adamapully and Somaisweram.

31. The masonry works included in the canal estimate are—

Miles.	Chains		RS.
2	55	Scouring Sluice	3,530
2	63	Aqueduct, 7 arches 30 feet span for Punkalwankah	22,630
5	10	Culverts, 3 vents 4 feet span	2,250
5	40	Bridge, 2nd class	4,630
6	1	Aqueduct, 4 arches of 10 feet span	6,010
6	45	Culvert, 2 vents of 10 feet . . .	5,990
7	20	Culvert, 3 feet span	1,520
		Discharging sluice at Terminus	3,530
		Lock and Bridge at Adamapully	19,000

Of these, the first, the scouring sluice, seems to be unnecessary and, were it built, the apron would need modification or protection, otherwise the Punkalwunkah close by being on so much lower a level, it would soon be undermined. The aqueduct allows a clear water-way over it of 25 feet. The current will be hardly perceptible in

the wider part of the canal, and this construction will probably not be productive of inconvenience by causing too strong a current. The discharging sluice at the terminus could not be used, unless a masonry work of similar capacity were built under the road, which has at present a diminutive culvert for side channel drainage, as the only vent for the whole of the canal water. If any such work be necessary, and with a fall of only a few inches from one end to the other, I think it is not so, it would be better to carry the canal beyond the road, and then, though a bridge would be necessary, there would be no money wasted in the construction of a culvert which would be superseded on the extension of the canal. The head lock, of which the plan has not been received, is likely to require modification, so as to keep it above flood level.

32. Three crossings have been provided.

1st. At the Head-sluice.
2nd. At the Punkalwunkah Aqueduct ... Miles 2 Chains 62
3rd. Second class Bridge . .. . „ 5 „ 40

It is probable that the culvert at 6 miles 45 chains may be used as a cattle crossing.

In the absence of a map showing the village boundaries, I cannot say whether any additional crossings will be needed, but I am inclined to think that this will not be the case.

33. The sheet of cross sections does not show any arrangement for keeping the tow-path, as far as may be possible, at about 3 feet above water level. This point should be attended to in carrying out the work.

34. The rates for earthworks are—

A.	P.	
1	2	for alluvial soil.
2	5	for stony „
4	9	for kunkur.
8	5	for rocky soil.

those for masonry are—

	RS.	A.	P.
Rubble masonry	3	12	0
	3	8	0
Limestone coping	15	0	0
	9	4	0
Arch-work	6	0	0
	6	8	0

additional rates are allowed for dressed work. All the rates are moderate, and probably the minimum rate for earth-work will be found too low. Excellent building stone is abundant, and there will be no difficulty in executing very good work at moderate rates. The cost of a bungalow at Adamapully has been included in the estimate, as directed in Proceedings Madras Government, No. 1,753, dated 12th June 1867.

35. There appears to be no objection to sanction being given for the canal estimate Rupees 1,92,450,* but it will, I think, be advisable that the Chief Engineer should leave the upper 1½ to 2 miles of the canal untouched, until the anicut and head-works, with the stop banks and other protective works on either

* Estimate for canal and stop bank	1,97,560
Deduct stop bank	5,110
	1,92,450

side of the river, shall have been re-considered, and so designed as to afford a reasonable assurance that they will neither occasion, nor suffer, damage in the event of the occurrence of another extreme flood.

From the Agent and Manager of the Madras Irrigation and Canal Company, to the Consulting Engineer of the Madras Irrigation and Canal Company, dated Madras, 18th November 1867, No 352

I have the honor to transmit, for the sanction of Government, the accompanying revised estimates and plans of the 10th Section, with copy of the Chief Engineer's report, dated 5th November 1867, and its accompaniments.

10th Section Estimates

1. The most suitable termination for the canal at Cuddapah requires first attention Mr. Higginson's Report of 19th July gives a comprehensive view of the matter (copy enclosed)

2. The canal enters Cuddapah at the Cantonment end, and at the 8th mile reaches the fork of the Bellary and Kurnool roads, about 2½ miles from Cuddapah Civil bazaar, 1½ miles from the railroad, and close by the Military lines and bazaar. A branch from the railroad of 2 miles, total length including junction, and a quarter of a mile along the canal quay, could be readily constructed here, to join the Madras Railway close by the 166th mile. The difference of level would be overcome by an inclination of 1 in 606, without interfering seriously with private property.

3. By running farther to the Civil bazaar, we only get farther from the Railway, and place that bazaar and town and the rice lands between our terminus and the Railway, which would be 2½ miles distant.

4 I, therefore, propose that the terminus be at the meeting of the three roads from Kurnool, Bellary, and Cuddapah, close to the Military bazaar, and about the same distance from the Civil bazaar as the present Railway station is, and I do not think it will at all pay to incur the expense of 2½ miles of canal, a lock of 6 feet drop, a public road bridge, an aqueduct of 20 arches of 30 feet span, and other works for the accommodation merely of the local trade of the Cuddapah Civil bazaar

5 The point of next importance is the anicut The object is to place an anicut so as to permit the canal traffic to be passed over the river. Mr Clarkson proposed an anicut 36 chains long, having its northern end 6 chains below the entrance of the canal from the north, and the southern end 20 chains below the southern entrance towards Cuddapah. It was chiefly founded on sand, and was estimated (at the rate of Rupees 2-8-0 a cubic yard for rubble masonry, and other rates in proportion) to cost Rupees 1,85,000. It included two under-sluices The pond thus formed in the river would scarcely be navigable when the water stood level with the anicut crest, that is 6 feet on the lock cills, and when the water sank to 3 feet below the anicut crest, probably 25 chains of dry sand bank would rise between the locks

6. I propose another site for the anicut, having the north end a mile below the northern entrance, and the south end 26 chains below the southern entrance, with one set of large scouring sluices of 585 square-feet opening with cills at summer water level, 11 feet below crest and near *the present low water channel.* It will be in two portions, 800 and 1,050 feet long, respectively, making a total length (including sluices as before) of about 30 chains About 24 chains of bank connect the two portions which are entirely on solid lime-stone flag foundation With this arrangement, there will probably be more open water at lock cill level, between the two locks, than before of raising banks across sandy river beds

7. The behaviour of the intermediate bank will afford useful experience regarding the safety

8. The total estimate (with rubble masonry rated at Rupees 3-12-0, and the rest in proportion) is Rupees 1,72,900 only, and the work is much more simple and certain to execute. There would be no advantage in having two sets of sluices, since the natural course of the water, and present summer course of the water, is parallel to, and in front of, the proposed line of anicut.

9. The back of the connecting bank is shown at a slope of 4 to 1; most likely the rear will silt up

10. The canal to the Cantonment is only altered in some of the works. It is unavoidable to increase the earth-work estimate by Rupees 18,695, unless the dimensions of the canal were decreased I have also increased the allowance for depreciation of tools, plant, &c., from Rupees 5,000 to Rupees 30,000. Centering was not provided for The smaller centering may be executed without special allowance, except for shifting it, but for the Punkal Wunka, I have inserted Rupees 2,000, total for centering before omitted Rupees 2,390 I have inserted three new works, viz., a bridge at 5½ miles for all kind of traffic Rupees 4,630, an irrigating siphon at 7½ miles Rupees 1,530, and a set of terminal emptying sluices Rupees 3,530, apart from these items the total estimate for masonry exceeds the former estimate by Rupees 1,373. This shows a great saving if the increased rates are taken into account; but it is effected without rendering the works less efficient. On the contrary, I believe, every alteration will increase the efficiency of the works.

11 I have omitted ferries. The road from Adamapully to Cuddapah lies wholly north of the canal, and only one cross-road, a short cut, from Chennoor on the road from Dhoor to Wulloor on the Gooty road, requires a bridge Poospagherry is accessible by the head-sluice, or by the Punkal aqueduct Perhaps, some village may need a boat for occasional use

12. The land plans prepared by Mr. Clarkson do not show the Cantonment beyond the Wulloor road I believe they are incorrect; the large pillars of demarcation, since put down, cross the road, and include some length of the canal.

13. The fourth number, four-feet siphon culvert (5 miles 20 chains), must be arched. I send this in the form of a revised estimate, since the former estimate was approved by Government, though not acted on.

Memorandum to accompany the copies of estimates of 10th Section, kept at Central and Division Offices, dated Kurnool, 5th November 1867.

1. Nothing extra is to be paid "for *coursed rubble*" masonry, except Rupee 1 per square yard in abutment, and piers of Punkal Wunka aqueduct, nor for "*arch-work*" *in inverts* beyond the ordinary price for "rubble masonry."

2 No "puddle" need exceed Rupee 1 a cubic yard.

3 Fourth number, four-feet siphon (5 miles 20 chains) slabs, will not do to cover a siphon, a flat one foot six inches arch should be used instead and with haunches filled with masonry it will be cheaper If the rock be good, care must be taken not to *waste money* in excavating it merely to re-build masonry in its place. This should be reported upon.

The rate for rubble masonry should not exceed Rupees 2-12-0

4 Over bridge 5½ miles "Rubble masonry" should not exceed Rupees 3.

5 Fourth number, ten-feet aqueduct 6 miles, and second number, ten-feet culvert 6½ miles. The lower retaining wall should go down six-feet, unless it gets to hard soil, and should be well fronted by dry rubble.

(Signed) J. H. LATHAM,
Chief Engineer.

Report on the Canal Termini at Cuddapah.

In accordance with the instructions received from the Chief Engineer in his letter No. 13 of 20th April 1867, relative to the proposed terminus of the canal, I have made careful examination of the different sites, and arrived at the following conclusions —

1st —That by fixing the terminus near the Cantonments, we save the cost of constructing 2½ miles of canal, comprising a lock of six feet drop, a public road bridge, an aqueduct over the river Boogga of 20 arches 30 feet span, and another over the supply channel to Cuddapah tank of 3 arches 15 feet span each

No. 395.
Communicated to the Consulting Engineer.

MADRAS,
16th December 1867.

(Signed) F. H. HENSLOWE,
Agent and Manager.

No. 185.

ORDER THEREON, 11th January 1868, No. 95.

IRRIGATION, No. 9.

1. In the original estimate of Rupees 4,81,800 for the portion of the Madras Irrigation and Canal Company's Canal which extends from the Pennair to Cuddapah, a sum of Rupees 1,85,000 was included for the construction of an anicut to pass the canal across that river. The site selected was immediately below the termination of the 9th section on the left bank of the river near the village of Bakrapooram. The anicut was to be 2,376 feet in length, and, having to be built mostly on sand, would have required more massive proportions than if rock for foundations had been available. For this reason, and because he is of opinion that navigation could not be easily kept open in front of an anicut in the position chosen for it, the Chief Engineer of the Company objects to the site, and has selected another somewhat lower down where the presence of a ledge of hard blue limestone rock in the bed of the stream along either bank offers, what he considers, facilities for the construction of the dam, although in the intermediate space no other foundation than sand is obtainable.

2. The Consulting Engineer now submits plans and estimates for an anicut as proposed to be constructed by Mr. Latham on the new site, and for the completion of the canal to Cuddapah, a distance of eight miles. The estimate amounts to Rupees 3,86,160, as under :—

Anicut with head-works		
Stop banks		
Canal	Rupees	1,88,600
.. .. ..	,,	5,110
.. .. ..	,,	1,92,450

3. As the completion of the canal as far as Cuddapah is stipulated for in the Company's supplemental contract, and as it is very desirable that whatever means of navigation the canal may afford should not stop short of the neighbourhood of the railway, the Government do not question the propriety of carrying out the works now proposed, so far as they may be shown to be suitable, although it may be more than doubtful whether the returns to be derived from them by irrigation will be remunerative. The Government approve generally of the direction of the canal and of the terminal point selected for it, as well as of all the arrangements for disposing of drainage and irrigation water and for providing for road crossings. They accordingly sanction the estimate amounting to Rupees 1,92,450, as recommended by the Consulting Engineer, on the understanding that the upper 1½ or 2 miles be not touched till the site of the anicut, with the plans for it and its head and protective works, has been fully re-considered with reference to the objections which the Consulting Engineer has raised to the adoption of the site between Adamapully and Coteloor.

4. As the ledges of rock which offer good footing for an anicut at the site selected by Mr. Latham do not extend across the bed of the river, but are separated by a space where sand only can be found for foundations, the length of an

anicut, if built in two portions on the rock in a straight direction across the river, and connected by an embankment in the centre of the stream, would be far too short to give sufficiently free passage to floods. The expedient has therefore been resorted to of proposing to make the anicut very oblique. This would give length to the dam in proportion to the extent of obliquity, but it is to be disputed whether the sectional area of the space left free for the discharge of flood-water would thereby be sensibly affected. Mr. Latham seems to think that the obstruction of a river-channel by a weir is diminished by the additional length that may be gained by making it oblique, but the Consulting Engineer differs from him, and calculates that a much greater length than Mr. Latham has allowed for the work is necessary. In this the Government quite concur, and if Mr. Latham's letter of the 14th December 1867 is to be accepted as containing a serious exposition of his views of the action of an oblique anicut, the Government see no occasion to pursue the controversy further. An inspection of the plans of the work as designed, with a careful perusal of the Consulting Engineer's observations on them, has satisfied the Government that, whatever may be the effect of an oblique, as compared with a direct anicut, the obstruction caused by the former will not differ materially from that of the latter, and they are of opinion that the aggregate length of the two sections of the work, as Mr. Latham proposes to construct it, is far too small, or, in other words, that too much of the river-channel is occupied by the proposed intermediate connecting embankment. But this embankment, raised for 1,600 feet in length in mid-stream, and in a position to be exposed to the full force of the powerful current directed upon it by the combined action of the unfavorable bend of the river immediately above Adamapully and of the inclination of the anicut, would itself be a source of continual weakness and extreme danger. The toe of its upper slope, protected only by rough-stone pitching, would always be liable to be undermined, and the slightest disturbance there would inevitably cause the destruction of the entire embankment, and, with it, the fall of the abutting wing-walls and of the adjacent sections of the anicut.

5. It is possible that the "behaviour" of the embankment under such trying circumstances might afford, as Mr. Latham believes,* "useful experience "regarding the safety of raising banks "across sandy river beds," but, in the opinion of Government, the present aspect of the Company's affairs is not such as to warrant costly experiments of this nature being made at the expense either of the shareholders, or of the State which has so large a stake in the success of the Company's operations, and the Government cannot refrain from expressing their surprise at being asked to approve of a large outlay on a work for which no assurance of stability is even affected to be afforded.

* See paragraph 7 of Chief Engineer's No —, dated 5th November 1867.

(True Extract.)

(Signed) CHARLES A. ORR, Colonel, R. E.,
Secretary to Government.

To the Consulting Engineer for the Madras Irrigation and Canal Company, with thirty Enclosures.
" Manager for do. do.

Exd F. R Bantleman.

No. 395.
Communicated to the Consulting Engineer.

MADRAS,
16th December 1867.

(Signed) F. H. HENSLOWE,
Agent and Manager.

No. 185. ORDER THEREON, 11th January 1868, No. 95.

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2. The Consulting Engineer now submits plans and estimates for an anicut as proposed to be constructed by Mr. Latham on the new site, and for the completion of the canal to Cuddapah, a distance of eight miles. The estimate amounts to Rupees 3,86,160, as under :—

Anicut with head-works	Rupees	1,88,600
Stop banks	,,	5,110
Canal	,,	1,92,450

3. As the completion of the canal as far as Cuddapah is stipulated for in the Company's supplemental contract, and as it is very desirable that whatever means of navigation the canal may afford should not stop short of the neighbourhood of the railway, the Government do not question the propriety of carrying out the works now proposed, so far as they may be shown to be suitable, although it may be more than doubtful whether the returns to be derived from them by irrigation will be remunerative. The Government approve generally of the direction of the canal and of the terminal point selected for it, as well as of all the arrangements for disposing of drainage and irrigation water and for providing for road crossings. They accordingly sanction the estimate amounting to Rupees 1,92,450, as recommended by the Consulting Engineer, on the understanding that the upper 1½ or 2 miles be not touched till the site of the anicut, with the plans for it and its head and protective works, has been fully re-considered with reference to the objections which the Consulting Engineer has raised to the adoption of the site between Adamapully and Coteloor.

4. As the ledges of rock which offer good footing for an anicut at the site selected by Mr. Latham do not extend across the bed of the river, but are separated by a space where sand only can be found for foundations, the length of an

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* See paragraph 7 of Chief Engineer's No —, dated 5th November 1867.

(True Extract.)

(Signed) CHARLES A. ORR, Colonel, R. E.,
Secretary to Government.

To the Consulting Engineer for the Madras Irrigation and Canal Company, with thirty Enclosures.
" Manager for do. do.

Exd F. R. Bantleman.

Consulting Engineer's Office
Irrigation and Canal Co.
Madras 19th December 1867

№ 123

From

Captain John Mullins R.E.
Consulting Engineer Irr.l and Co.

To

The Secretary to Government
Department of Public Works

Sir,

I have the honor to forward for the consideration of Government a letter, № 352 of the 18th Ultimo with its accompaniments as per margin transmitting for sanction revised Estimates for the 10th Section Main Canal, including an Anicut and Head works on the Pennair at the head of the Section.

List of Plans & Estimates.
Chief Engineer's report dated 5th Ultimo.
Chief Engineer's Memo. of the same date.
Executive Engineer's report on the proposed Terminus of the Canal near Cuddapah

2 The amounts of the estimates now submitted are

Anicut and Headworks	188,600
Main Canal	197,560
	386,160

P.W.D. 31st March 1864 № 889.

The original estimates amounted to Rupees 4,81,800.

3 The 10th Section being a part of the Canal between Soonkasala and Cuddapah, included in the supplemental Contract of the 2 October 1866, it would seem to be necessary that the works to which the present estimates relate should

should be carried out, although this Section belongs not to the upper 9 Section of the Canal, but to the extension from Cuddapah, viâ Somaiswaram and Nellore, to the Coast. The 10th Section, as formerly estimated for, was 10 miles and 28 Chains in length, but the Chief Engineer now proposes to stop near the lower end of the 8th Mile, so as to avoid the expense of the lower 2½ Miles, in which there would be a Bridge, a lock, and a large Aqueduct and other works. He shows that the present terminus is nearer to the Railway, though not to a Railway Station, and he proposes, though this work is not included in the estimates, to Construct a tramway 2 miles long from the terminus to the Railway, which it would meet at 166 miles 6 Chains. The Cuddapah Station is however at 162½ miles, and probably it would be necessary, at all events until the Railway line had been doubled, to continue the tramway rails down to the Station. The Chief Engineer's reasons for stopping the Canal near the Military lines are very good, and they are, in effect, that it would not pay to go on to the original terminus, and that this latter would be still further from the Railway. A similar argument may be applied to the whole Section - It will not pay to construct it, and unless a reservoir be formed either at Parnapully on the Chitthravathy or somewhere else above the site of the proposed Anicut across the Pennair, it will be of very little use for irrigation, and almost, if not quite, useless for navigation. Reservoirs are not provided for in the Contract, and therefore the time within which the outlay on the 10th Section will be returned to account is altogether uncertain.

4 The area of land included between the Canal, the Pennair, and the Boggâ, is about 11,360 acres, of which about 1000 acres to the west of the Punkalwunkah are certainly not commanded, and it is uncertain how much of the remainder will be irrigated from the Canal - Taking however existing irrigation into account it is probable that the Canal irrigation under this Section will never exceed 5,000 acres - The estimates amount to Rs. 3,86,160

Distribution may be taken at — 29,840

4,16,000.

Establishments and home charges 50 P Cent — 2,08,000

Total Rupees 6,24,000

The probable ultimate Revenue will stand thus

5,000 acres at 6 Rupees — 30,000

deduct for maintenance at 5 per Cent on 4,16,000 — 20,800

Net Revenue 9,200

or per Cent — 1.47

The allowance here for maintenance is, I think

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Net Revenue 9,200

or per Cent — 1.47.

The allowance here for maintenance is, I think,

think not excessive, as the Anicut and head works will need a considerable yearly outlay, and the first few miles of a Canal always absorb a good deal of money for silt clearance.

Therefore even supposing no supplemental sanction to be required, and it will be seen presently that the Anicut Estimate will require considerable additions, and supposing also that 5,000 acres could be irrigated the returns would be under 1½ per Cent.—

5 Without reservoirs I do not see that there is a prospect of successful irrigation at all. The experience of a good many years has shown that direct irrigation from the Pennair, unless supplemented by Tanks cannot be depended upon; and if this be the case in the Nellore District, which has the first claim upon the Pennair water, it is evident that a Canal in Cuddapah, which can take water only when the supply is in excess of the wants of Nellore has really no chance of ensuring successful irrigation. From the registers in this office it would appear that on the average for the years 1861 to 1866 inclusive, on only 48 days during the year was the water level with or above the Crown of the Nellore Anicut; and consequently only for so many days would there have been any water at all available for this 10th Section of the Company's Canal.

It is also quite certain that there will not be any surplus Soombuddra water; for, even if the main Canal be made in the upper Sections to carry 6,00,000 instead of 4,00,000 Cubic yards an hour, the supply will still be inadequate to the demands of more than a very moderate proportion of the large areas commanded, and that too quite conveniently, by the Canal to the North of the Pennair, that is in the first 9 Sections.—

6. Again in the absence of reservoirs by which both the Soombuddra and Pennair supplies can be augmented after the subsidence of the freshes, the 10th Section of the Canal will be of no use for navigation, for generally September October and part of November will be the only months in which navigation here will be practicable, and at that time the navigation above will just be becoming impracticable.

7 I have now the honor to report on the project for the Anicut and head works and for the Canal in connection therewith as submitted by the Company's Chief Engineer. After a preliminary examination of the Plans and estimates, I went to Cuddapah and saw the Executive Engineer of the Division who went with me to Adamapully. As the Executive Engineer was not in possession of a

Survey of the river for some few miles above and below the proposed site for the Anicut, and as the information regarding flood levels, fall of river bed, surface fall of water &c. was insufficient to enable even an approximate estimate of the maximum discharge to be made, this officer gave the requisite instructions for the collection of further information, and I proceeded to meet the Chief Engineer at Rajoly, and I have had the advantage of discussing with him the principal features of the project. On my return to Adamapully on the 12th Instant the Survey of the river and 7 Cross Sections had been taken, and these have proved of great use in judging what the requirements of the Pennair in connection with an Anicut are.

Plans Nos. 5A & 5B

8 It will be seen that the Chief Engineer proposes to construct the Anicut in an oblique direction, in two branches with an embankment between them — The right branch or Adamapully weir is shown to be 800 feet in length, and the left or Coteloor branch 1050 feet in length — The object of this arrangement is to make the construction of the weir as simple and inexpensive as possible. Here on both sides of the river there are extensive beds of blue limestone, and the dam is intended to be formed by simply building walls, 8 feet wide at top, vertical on the lower side, and with a batter of 1 in 4 on the upper side for the lengths above given; where the rock reaches a level below which masonry walls could not be conveniently founded, wing walls are proposed to be built, and the two branches of the Anicut to be connected by a masonry bank.

Plan No 5

× about 273 the ordinary deep bed of the river being about 281
Crest of Anicut 293
Sill of Undersluices 282
Sill of Head sluice 287

9 I do not think there would be any great difficulty in carrying out such an arrangement successfully, or in securing the intermediate embankment from liability to breach. The design for this bank as shewn in Plans Nos 7 and 7A is good, and the only additions and modifications which appear to me necessary or advisable are.

1st At the upper left wings of both the North and South Branches and at the upper right wing of the North Branch, where there will be considerable action, it will be advisable to give a concrete backing to the revetment for some yards so as to confine the action of the water to the surface.

× left.
* right.

2nd to prevent Scour along the toe of the upstream face of the bank, groynes somewhat in the form shown in pencil on the elevation, Plan No 7, will be needed at about 60 feet from centre to Centre —

the

the tops of the groynes should be about 1½ feet below Anicut Crest at their junction with the revetment.

3rdly. The toe of the rear slope for a distance of 30 to 35 yards will need protection, to prevent it's being undermined by the eddies - a sort of apron 10 yards wide and 18 inches to 2 feet thick will suffice.

4thly. The foundation puddle might as well be placed so as to give a minimum thickness of 8 feet, instead of 6½ feet as shown.

10 The point of chief importance however is the sufficiency or otherwise of the length of the Anicut as designed - The site for the Anicut as originally designed corresponded very closely with the position of Section No. III on the river survey, plan No. 5A and its length was 2376 feet, in a direction approximating very closely to the perpendicular to the stream of the river. The Chief Engineers present design has a length of only 1850 feet, and both branches have considerable obliquity that of the right branch being very great.

11 I have had much discussion with the Chief Engineer on the subject of the capacity for discharge of oblique Anicuts when drowned, or having the water in the lower reach above their crest. And he appeared to consider that

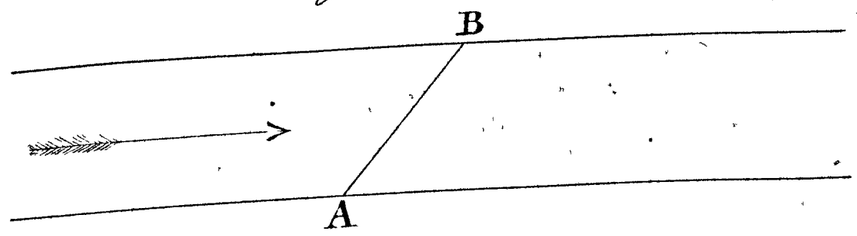
2376 feet

800 + 1050

I much underrate their value - I have just received a letter expressing Mr. Latham's views* on the subject, and I gather from this communication that he considers that the obliquity of an Anicut affects only the velocity of approach, or that only the portion of this velocity which can be resolved into a direction perpendicular to the Anicut should be taken into account - For the rest it would seem that he supposes that the discharge would be just the same as would be the case were the Anicut at right angles to the general direction of the Current of the river.

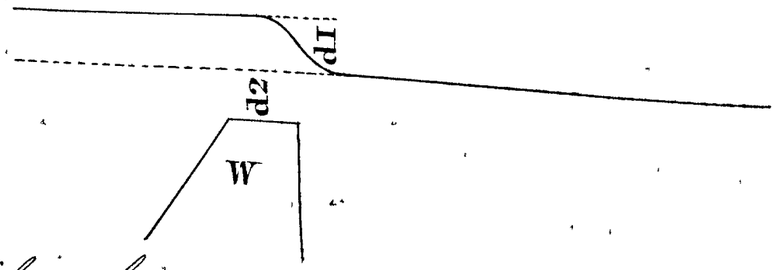
* dated 11th Instant with Agents A/c 395 of the 16th Instant.

12 If this be the Chief Engineer's view of the matter I am unable to concur with him, and in order that I may be able to show clearly what I consider the effect of oblique Anicuts to be, I will take an example to illustrate the case generally



Let AB be an oblique Anicut across a river in which the Current is parallel with the banks. If, in considering its action with regard to any particular state of the river, the level of the crest from A to B be fixed so as to bear the same relation to the normal level of

of the river at that state, i.e. if **B** be as much lower than **A**, as the difference of level of water in the river would be in such a fresh at those two points, then

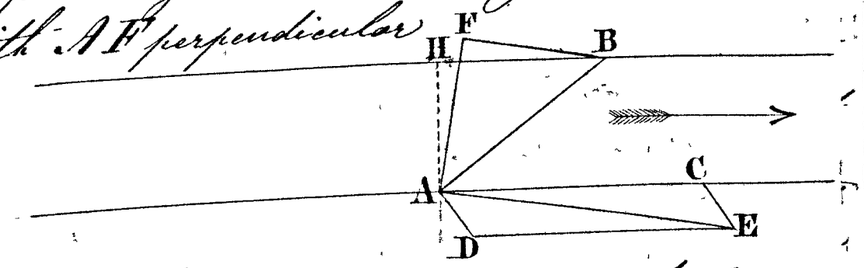


if **W** be an Anicut, d_2 the depth of its crest below the normal level of the fresh, and d_1 the height to which the water is raised by the obstruction caused by the Anicut, the discharge belonging to the part d_2 will, so long as d_1 remains unchanged, be unaffected by the direction of the Anicut, which might be changed to a position of greater or less obliquity, provided the relative level of each part of its crest were preserved, without modifying the discharge. I refer of course to the practical effect of an Anicut, so far as this need be considered in calculating its influence on a river in high floods. Every alteration in the position of an Anicut would cause a greater or less diversion of the comparatively small portion of the discharge impinging against the upstream face of the dam, but this action need not be considered, and could only be deduced from experiments. It follows then that this portion of the discharge will be the product of the direct width of the river into

the depth d_2 into the velocity generated by the head d_1 added to any further head due to velocity of approach

On the other hand the velocity due to the overfall d_1 is generated at right angles to the actual direction of the Anicut, whatever that may be, and therefore this portion of the discharge will be the product of the full length of the Anicut into d_1 into the velocity generated by the head d_1 added to the further head, if any, due to the velocity of approach.

13 To ascertain by construction the effective length of an oblique Anicut, the velocity of the lower part of the discharge should be multiplied by the depth d_2 and laid down to scale from **A** in the direction of the current of the river, in the next place the velocity of the upper part of the discharge should be multiplied by the depth d_1 and laid down, to the same scale, at right angles to the direction of the Anicut; completing the parallelogram and drawing the diagonal with **AF** perpendicular



thereto, and **BF** through **B** parallel to **AE**, **AF** will represent the effective length of the oblique Anicut, or that length which is to be adopted, in calculating the discharge, for multiplication into the velocities of both the upper and lower portions.

An

On inspection of the above diagram will show that were there no overfall and therefore no d_1 - AH the direct width of the river would be the effective length of the Anicut A B; on the other hand were there a clear overfall and consequently no d_2, the effective, would be the actual length - A B.

14. I will now apply these conclusions to the project for the Tennair Anicut.

15. The maximum flood on record is that of May 1852, and both in Cuddapah and Nellore it is still well remembered. The country on either side of the river was very generally inundated, but many of the villages near the river, being situated on sand hills or other exceptionally high ground, were not submerged, and at several of these the level of the flood has been pointed out, and I think generally with sufficient accuracy to admit of a safe approximation to the discharge of the river being arrived at.

16. The discharges at the several Cross Sections as calculated by me are

Cross Sections	No. I	Cubic yards per hour 58920,000
"	" II	" " 58,880,000
"	" III	" " 55353,000
"	" IV	" " 56,484,000
"	" V	" " 45876,000
"	" VI	" " 44290,000
"	" VII	" " 28300,000

For No. VII there is nothing to show what the fall below was - The difference between the

others are not greater than might be expected in the absence of information as to the exact distribution of the fall, added to which some of the flood levels, such as that at Coteloor on the steps of the principal house, and that at Poospagherry where the points reached, according to the villagers, on either side of the river corresponded when tested by the spirit level, very closely, are likely to be more correct than others for which there was no well defined mark capable of being noticed during the continuance of the flood The average of the first 6 calculations is Cubic yards 53⅓ millions, and probably therefore, taking into account the spill over the river banks which extended for a long distance, though no doubt with but a low velocity, it will be safe to consider 56 millions as the maximum discharge.

17. In the next place the extent to which the flood level may be raised at and by the Anicut has to be determined; and 5 feet, the surface fall of the river per mile, will not occasion any great extension of protective works, such as stop banks &c., and I therefore suggested this to the Chief Engineer and he appeared to consider it reasonable.

18. Judging from the present average velocities at Sections Nos. II. III and IV, I estimate the velocity of approach at about 9,000 yards an hour,

hour, which is equivalent to a head of 2 feet. Civil Engr. 666

The level of the Crest of the Anicut is intended to be 293, or 13 feet below normal flood level, at its Southern end.

19 With the above data I find that the length of an Anicut at right angles to the stream of the river, should be 1,800 feet.

20 Were the Crest of the Chief Engineer's proposed Anicut to be 13 feet below flood water level throughout, the effective length of the two branches would be 1516 feet, instead of 1850 feet their actual length. When the river is low, however, which is the time at which an Anicut is most wanted, the pond above the Anicut will have a nearly horizontal surface, and the Anicut crest must therefore have the same absolute level throughout, and the relative level will vary considerably. It will be seen from the level, marked on the survey opposite Cotelour, that in extreme floods the crest of a horizontal dam at the North end would be 3 feet nearer the normal level of an extreme fresh than the same dam at the South end.

× South Branch 540. North " 976.

Plan No. 5A

21 The South Branch will have its Crest at 293, and the flood level may be taken at 306 throughout. It will then carry off 5 1/10 of the 56 Millions Cubic yards, or 1 6/10 Millions Cubic yards. To this may be added the discharge of the Under Sluices which would

× 286200 Cft. per second.

be - the head being 5+2=7 feet - not 3 1/4 Millions as mentioned in the Chief Engineer's letter, but 1,040,000 Cubic yards, leaving 38,160,000 Cubic yards to be passed by the North Branch. The level of the Crest of this branch must also be 293, and the flood level may throughout be taken as 303 - The velocity of approach will be somewhat less - say 7855 yards an hour, equivalent to a head of 1 1/2 feet. These data make the required length of an Anicut at right angles to the stream 1540 feet.

The formula used is $D = C.L.\sqrt{2g}\left\{d_2\sqrt{d_1+h_a} + \frac{2}{3}(d_1+h_a)^{\frac{3}{2}} - (h_a)^{\frac{3}{2}}\right\}$ in which D is the discharge in C.ft. per second and h_a is the head corresponding to Velocity of approach. C has been taken as $\frac{2}{3}$ or $C \times \sqrt{2g} = 5.35$.

22 The effective length of the North Branch in its present position is, for a fresh of this magnitude, and with its Crest so circumstanced, 983 feet; consequently it is very much too short.

23 When discussing the subject with the Chief Engineer, that Officer appeared to think that whatever increased length might be demonstrated to be necessary, could be obtained by prolonging either or both branches with some modification of direction, thus securing the same general arrangement and avoiding the construction of any part of the weir proper where rock for its foundation is not available.

Plan No. 5.

It will be noticed that the Anicut, as designed, would interfere considerably with Adamapully; and Cotelour, on the opposite side of

of the river would need the protection of a wall carried up well above flood level; and moreover, in continuation of this wall, an embankment would be necessary to connect with the left bank of the lower end of the 9th Section Main Canal, which it will be seen reaches the river a little West of Bakrapoorum. Any lengthening of this Anicut would necessitate the removal of Cotetoor, and the addition of a strip of land, some four hundred feet in width near that village, to the river bed.

24 Whatever arrangement be adopted, the head works if kept at or near their present position will need raising - The roadways of both the under and head Sluices should be at least 4 feet above raised flood level or 315 with reference to original flood level 306; the under Sluice road is now 310 and that of the head Sluice 306.

25. There is no other site near Adamapully at which an Anicut, with 2 branches on rock - and an intermediate bank, could be constructed; but from a little below Cotetoor to a little above Metapully there is a good site for an Anicut 2000 feet in length more than half of which would lie on rock - Probably the head works would have to be built on wells - At Poopagherry hill there is an unlimited quantity of quartzite so the Construction of an Anicut with a sloping apron would not

be difficult, and not very expensive though of course the cost of a sloping apron cannot be compared with that of a simple wall built on rock.

26 The rock on which the Chief Engineer intended building the Anicut estimated for, is blue limestone - The beds on the Cotetoor side are very good, and were the foundations of the body wall carried down a moderate depth below the surface, I have no doubt they would be beyond the risk of injury for many years to come, if not permanently. On the Adamapully side the reef is apparently not so good; but, until the surface shall have been pumped and the character of the lower strata ascertained, which would be done in founding a wall, I cannot say what the effect of the overfall would be likely to be.

27 The stop bank will need modification. At present it is shown as terminating at a small Nullah a short distance from the Bellary road - Probably the Railway embankment would be the best terminus; but the information at present available, regarding the distance to which flood waters extend, is insufficient to enable the point to be properly decided. Provision for passing several irrigation Channels will have to be made in the stop bank estimate.

28

28 The capacity of the Undersluices, as designed, will be sufficient to pass all the water required for the irrigation in the Bellary District. The Head Sluice vents will pass Cubic yards 42,840 an hour with the water fresh with Anicut Crest.

Cy[d]s 9,2910 per hour when water is level with crest of weir

29 The Plans of the navigation head, and head lock of this Section have not yet been sent in.

30 The Canal has been designed with a depth of 5 feet, a breadth at sole of 50 feet, and at surface of 70 feet - Fall 1⅝ inches a mile. It will carry about 25,000 Cubic yards an hour, which will be likely to suffice for all the irrigable land between Adamapully and Somaiswaram.

31 The masonry works included in the Canal estimate are

M.	Ch.		
2	55.	Scouring Sluice Rupees	3,530
2	63	Aqueduct 7 arches 30 feet span for Punkalwunkah	22,630
5	10.	Culverts 3 Vents 4' span	2,250
5	40	Bridge 2nd Class	4,630
6	1.	Aqueduct 4 Arches of 10 feet span	6,010
6	45	Culvert 2 Vents of 10 feet	5,990
7	20	Culvert 3 feet span	1,520
		Discharging Sluice at Terminus	3,530
		Lock and Bridge at Adamapully	19,000.

Of these the first, the Scouring Sluice seems to be unnecessary and, were it built, the apron would need modification or protection, otherwise the Punkalwunkah closeby being on so

10

much lower a level, it would soon be undermined. The Aqueduct allows a clear waterway over it of 25 feet - The current will be hardly perceptible in the wider part of the Canal, and this construction will probably not be productive of inconvenience by causing too strong a current.

The discharging sluice at the terminus could not be used unless a masonry work of similar capacity were built under the road, which has at present a diminutive Culvert for side Channel drainage as the only vent for the whole of the Canal water. If any such work be necessary, and with a fall of only a few inches from one end to the other I think it is not so, it would be better to carry the Canal beyond the road and then, though a bridge would be necessary there would be no money wasted in the Construction of a Culvert which would be superseded on the extension of the Canal.

The head lock of which the plan has not been received is likely to require modification, so as to keep it above flood level.

32 Three Crossings have been provided.

1st at the Head Sluice.

2nd at the Punkalwunkah Aqueduct - 2-62 M. Ch.

3rd 2 Class Bridge 5-40. M. Ch.

It is probable that the Culvert at 6-45 M. Ch. may be used as a cattle Crossing.

Sir

In the absence of a map showing the Village boundaries, I cannot say whether any additional Crossings will be needed, but I am inclined to think that this will not be the case.

33. The sheet of Cross Sections does not show any arrangement for keeping the tow path, as far as may be possible, at about 3 feet above water level. This point should be attended to in carrying out the work.

34 The rates for earthworks are.

1-2	for alluvial soil
2-8	for stony
4-9	for kunkur.
8-5	for rocky soil

these for Masonry are

Rubble Masonry	3	12
	3	8
Limestone coping	15	
	9	4
Arch work	6	
	6	8

additional rates are allowed for dressed work. all the rates are moderate and probably the minimum rate for earthwork will be found too low - Excellent building stone is abundant and there will be no difficulty in executing very good work at moderate rates. The cost of a Bungalow at Adimapully has been included in the Estimate as directed in Proceedings Madras Government No. 1753 dated 12th June 1867.

35 There appears to be no objection to sanction being given for the Canal Estimate Rupees* 1,97,460, but it will, I think, be advisable that the Chief Engineer should have the upper 1½ to 2 miles of the Canal untouched, until the Anicut and head works, with the stop banks and other protective works on either side of the river, shall have been reconsidered, and so designed as to afford a reasonable assurance that they will neither occasion, nor suffer, damage in the event of the occurrence of another extreme flood.

I have the honor to be,
Sir
Your most obedient servant,
John Dundas Captain R.E.
Consulting Engineer S.I.R.Co.

* Estimate for Canal 1,97560
+2% for bank 3900
deduct 5% for bank 5710
1,92,450

Copy
Consulting Engr's Report

Public Works Department

C.E. No 95

Proceedings of the Madras Government

Under date the 11th January 1868

Read the following

From The Cons. Engr. to Govt. C.E. No. 123 Dated 4th Dec. 67

In the accompanying letter
mate of Rupees 4,81,800
for the Restoration of the Madras
Irrigation and Canal
Canal from the Penner
extends from the Penner
to Cuddapah, a distance
Rupees 1,85,000 was voted
sheet for the construction
of an anicut to span the
canal across that river.
The site selected was
immediately below the
junction of the 9th
terminations of the left bank
section on the left bank
of the river near the village
of Bakrupuram - The
anicut was to be 2376 feet
in length, and having
to be built mostly on
sand, would require

P.W. 1867 Dec.
Rec'd 12th Jan. Ordinary
No. 4943
The Cons. Engr. &c &c
The Secretary to Govt.
P.W.D.

Dated 19th December/67
Rec'd 31st
C 30

Submits Plans & Estimate
for the 10th Section Main
Canal including an Anicut
& Head works on the Penner
at the Head of the Section.

No. 95 - 11th Jany 1868

Rs 1,84,

Jany 1868

more massive proportions than if rock for founda=tions had been available - For this reason, and because he is of opinion that navi=gation could not be easily kept open in front of an anicut in the positin chosen for it, the Chief Engi=neer of the Company objects to the site, and has selected another somewhat lower down where the presence of a ledge of hard blue limestone rock in the bed of the stream along either bank offers, what he con=siders, facilities for the construction of the dam, although in the interme=diate space no other foun=dation than sand is ob=tainable -

2 The Consulting Enge=neer now submits plans and estimates for an anicut as proposed to be constructed by Mr Latham on the new site, and for the completion of the canal to Cuddapah, a distance of 8 miles - The estimate amounts to

Rupees 3,86,160, as under

	Rs
Anicut with head works -	1,88,600
Stop banks ———	5,110
Canal ———	1,92,450

3. As the completion of the canal as far as Cudda=pah is stipulated for in the Company's supple=mental contract, and as it is very desirable that whatever means of navigation the canal may afford should not stop short of the neigh=bourhood of the Railway the Government do not question the propriety of carrying out the works now proposed, so far as they may be shown to be suitable, although it may be more than doubtful whether the returns to be derived from them by irrigatin will be remunerative. The Government approve generally of the direction of the canal and of the terminal point selected for it, as well as of all the arrangements for

disposing of drainage and irrigation water and for providing for road crossings - They accordingly sanction the estimate amounting to Rupees 192,450, as recommended by the Consulting Engineer, on the understanding that the upper 1½ or 2 miles be not touched till the site of the anicut, with the plans for it and its head and protective works, has been fully reconsidered with reference to the objections which the Consulting Engineer has raised to the adoption of the site between Adamapully and Cotelon - 4 As the ledges of rock which offer good footing for an anicut at the site selected by Mr Latham do not extend across the bed of the river, but are separated by a space where sand only can be found for foundations, the length of an anicut, if built in two portions on the rock in a straight direction across

across the river, and connected by an embankment in the centre of the stream, would be far too short to give sufficiently free passage to floods - The expedient has therefore been resorted of proposing to make the anicut very oblique - This would give length to the dam in proportion to the extent of obliquity but it is to be disputed whether the sectional area of the space left free for the discharge of flood water would thereby be sensibly affected - Mr Latham seems to think that the obstruction of a river channel by a weir is diminished by the additional length that may be gained by making it oblique, but the Consulting Engineer differs from him, and calculates that a much greater length than Mr Latham has allowed for the work is necessary - In this the Government quite concur, and if Mr Latham's letter of the 14th Decr 1867

1867 is to be accepted as containing a serious expression of his views of the action of an oblique anicut, the Government see no occasion to pursue the controversy further. An inspection of the plans of the work as designed, with a careful perusal of the Consulting Engineers' observations on them, has satisfied the Government that, whatever may be the effect of an obliquie, as compared with a direct anicut, the obstruction caused by the former will not differ materially from that of the latter, and they are of opinion that the aggregate length of the two sections of the work, as Mr. Latham proposes to construct it, is far too small, or, in other words, that too much of the river channel is occupied by the proposed intermediate connecting embankment. But this embankment, raised for

1600 feet in length in mid stream, and in a position to be exposed to the full force of the powerful current directed upon it by the combined action of the unfavorable bend of the river immediately above Adamant fully, and of the inclination of the anicut, would itself be a source of continual weakness and extreme danger. The toe of its upper slope, protected only by rough stone pitching, would always be liable to be undermined, and the slightest disturbance there would inevitably cause the destruction of the entire embankment, and with it, the fall of the abutting wing walls and of the adjacent sections of the anicut.

5. It is possible that the "behaviour" of the embankment under such trying circumstances might afford, as Mr. Latham believes, "useful

+ See para 7 of Chief Engr's No - 75 dated 1867

"experience regarding the
"safety of training banks
across sandy river beds"
but in the opinion of
Government, the present
aspect of the Company's
affairs is not such as to
warrant costly experiments
of this nature being made
at the expense either of the Shareholders, or of the
State which has so large
a stake in the success of
the Company's operations
and the Government
cannot refrain from
expressing their surprise
at being asked to approve
of a large outlay on a
work for which no assu-
rance of stability is even
offered to be afforded —

To Can Engr
To Manager

thirty

Despd 25/11/68.

Rd 7th January 1868

Copy pin P.W. Letter to Engr.
Dy 28th February No 8 of 1868

Pub. Works 1868 Dept.

Pro. of Govt. for January

No. 95

Pro. of the Madras Govt.

Dy 11th January 1868

Ap 184-185