

(1) Number of pages 80

(2) Date of repair 10-2-44

(3) Initials of the Referencer _____

MADRAS RECORD OFFICE.

Government of Madras.

Public Works DEPARTMENT.

G.O. No. 2376	Press Mis.
23-25	
Dated 1-10-	1870.

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Trans
[Signature]

*Proceedings of the Madras Government, Public Works Department,
1st October 1870.*

Read the following letters :—

No. 23. From the Acting Consulting Engineer, Irrigation and Canal Company, to the Secretary to Government, Department of Public Works, dated Madras, 31st August 1870, No. 56.

In continuation of my No. 50 of 18th ultimo, I have the honour to submit the further reports, as noted in the margin, on the damage sustained by the main canal from the floods of the 6th and 7th of August. The extent of the damage, the nature of each large breach, and the

immediate causes in each case, as far as they can be ascertained, are all clearly detailed in the Executive Engineer's letter, and I need only briefly summarize them.

One breach, Yedaroor tank, at 5th mile and 145th chain, is 100 feet long and 28 feet deep, going 4 feet into the ground.

One in same tank-bund, at 5th mile and 52nd chain, is 100 feet long and 17 feet deep.

In both these cases the breaches are attributed to large leaks, which increased until the earth above fell in, when the water topping the lowered part of the bank would rapidly complete the breach. The sections of the bank at these breaches are stated to exhibit good soil, free from stones, well consolidated; and the leaks are believed to have originated in holes made by vermin.

Third breach, at 9th mile and 6th chain, is 70 feet wide and 24 feet deep, going 6 feet into the ground.

Fourth breach, at 9th mile and 53rd chain, is 150 feet long and 27 feet deep, going at its central portion 9 feet into the ground.

In both the above cases the sub-soil is described as soft rough limestone, mixed with kunker, very brittle, and full of seams of clay, the banks present the appearance of having been formed without care and of inferior materials; and their failure is attributed to leakage between the stones, which caused a settlement, and allowed the canal-water to top the lowered portions of the banks.

Fifth large breach is in the lower bank, 350 feet below the wing-wall of Hindry aqueduct, where 140 feet in length of the masonry revetment, with its earth-backings, was swept completely away, and a channel, 8 feet below the surface of the ground, was scoured out. This accident is believed to have been caused by the water in the canal having risen so much as to flow over the top of the revetment wall and down the slopes, and the levels just taken would confirm this view; for it has been ascertained that the crest of No. 9 calingulah is 32.89 feet above the Hindry datum, and that the top of the revetment-wall was 30.88 feet above datum. The fall of the canal-bed from calingulah No. 9 to the Hindry aqueduct is 2.80 feet, whence, as the flood-water flowed one foot deep over the calingulah, even an hour after the breach occurred, it must have topped the revetment-wall which breached by at least 0.21 foot—

For 32.89 crest of calingulah.	
—	2.80 fall of canal.
	30.09
+	1. add depth of water over calingulah.
	31.09.
—	30.88 deduct height of revetment.
	0.21

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Sixth large breach is at the masonry wall No. 2 in the 24th mile where it adjoins the earthen bank, which carried away 80 feet in length of the wall, and scoured out a deep gulley, 67 feet wide. This breach is 230 feet long, and its depth 44 feet, and the rush of the water caused other serious damage to the neighbouring revetment and bank for a length of 160 feet. This breach is reported to have originated in a leak through the wall, but the Executive Engineer considers it more probable that it arose from a leak in the adjoining bank.

Seventh breach is at No. 13 calingulah in the 25th mile, 120 feet in length of the wall just below the emptying sluices, with its backing, being swept away to bed-level; accident owing to excessive leakage due to the very bad masonry.

Eighth breach is in No. 6 wall, which was built across a deep ravine in the 26th mile; the wall, with its rubble backing, for a length of 40 feet being carried away down to the rock foundation. This wall had a depth of 21 feet of water against it. It is supposed to have given way suddenly from leakage.

At Ulloor aqueduct, where the natural drainage course is provided with a water-way of 672 square-feet, the flood rose to a height of 26 feet, passing over the aqueduct, raising the water in the canal 2 feet above full level, and the only damage was that "the lower protection" was carried away, that is, some of the revetment to the water-cushion.

It will be observed that the head sluices at Soonkasala were not closed until 9 A.M. on the 7th August, or until after the damage was done; and that in some cases the calingulah-sluices were not opened until noon the same day, the explanation being that the Tindal in charge of the head sluices waited for orders by telegraph, but the storm had interrupted telegraphic communication. How much less the damage might have been, if, when it was found that such unusual heavy rain continued, say before midnight on the 6th, the head sluices had been closed, and all calingulah-sluices opened, it is impossible to say; but that those precautions were not taken until after most of the damage was done, shows a defect in administrative arrangements, and I would suggest that in future, during the rainy seasons, an intelligent European, capable of exercising discretion, should reside at Soonkasala, and be in immediate charge of the head works.

I need only further add on the present occasion, in reference to the closing paragraph of the Chief Engineer's covering letter, that the Consulting Engineer's suggestions, regarding the height to which face-walls in the 2nd Section should be carried, and which was approved of by Government in Government Order, No. 3,195, 15th October 1867, appears to have been treated as a dead letter; and now, after nearly three years have elapsed, the Chief Engineer records his opinion that it would have been very unsafe to raise the walls as suggested until the banks were well consolidated, and even then, it should only be done under protest at the risk of Government.

From the Agent and Manager, Madras Irrigation and Canal Company, to the Consulting Engineer, dated Madras, 27th August 1870, No. 364.

In continuation of my No. 351, dated 15th August 1870, communicating the Chief Engineer's report on the damage occasioned to the canal by the storm and heavy floods which occurred on the night of the 7th instant, I have the honour to forward a further communication from the Chief Engineer.

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A tracing of the masonry revetment and table of damages, referred to in Mr. Dodson's letter, have been called for, and will be forwarded on receipt.

From the Chief Engineer, Madras Irrigation and Canal Company, to the Agent and Manager, dated Kurnool, 18th August 1870, No. 1,253.

Storm of 7th August 1870.

I HAVE the honour to enclose a copy of Mr. Dodson's letter, No. 389, of 16th instant, just received, and of the section of the masonry revetment which accompanied that letter.

I have nothing to add, except that rain continues to fall almost daily, and another heavy storm might undoubtedly occur any day. I do not think that the operation of closing these breaches can be safely undertaken before the monsoon begins to break; generally, towards the end of September the closing of them may then commence, care being taken to provide sufficient egress for the October monsoon-showers.

The Collector expressed to me a strong opinion that this disaster will have a serious effect on the quantity of land taken up for irrigation for some years. My opinion is, it will simply defer returns for one year: thus, for instance, in 1874 we may expect a revenue such as we otherwise should have received in 1873. My estimates, asked for in the Secretary's No. 28 of 24th June, 1870, last paragraph but one (the rest of that letter has had my careful attention), have been drafted, but I have deferred them on account of this disaster, and have asked the Collector for his estimate of the probable demand he will make on the Company for water in the 1st and 8th Sections next year. So soon as I get his reply I will adjust my estimates and forward them. My impression is, that the revenue will not cover working-expenses next year, but may be expected to do so in subsequent years.

A vigorous cultivation was commencing at Singavaram (9th mile), where fresh fields have been prepared for rice. Temporary banks have been commenced with my approval, in order to provide water so far and prevent loss and discouragement. This the revenue is expected to cover, though, of course, it will not re-place the cost to capital account.

Mr. Dodson's account of the hour when the storm commenced differs from that of the Overseer at the Meteorological Observatory here, and from that of some officers who were caught in the beginning of it about 10 P.M., 6th instant. It seems to have begun and continued some three hours later at Soonkasala than at Kurnool.

I will just remind you that masonry has been employed in banks in three ways.—See paragraph 11 of Consulting Engineer's No. 76 of 23rd September 1867, accompanying G. O., No. 3,195 of 15th October 1867, viz. :—

I.—In wall as a substitute for bank previously sanctioned and built so far as I know, and then approved by Government, to a height of 2 feet above full water.

II.—In face-wall backed by earth, sanctioned and built to 2 feet above full water. But by that G. O., it was stated that it would be understood that all such walls should be raised 18 inches higher without other alteration.

This it would have been very unsafe to do until the banks were well consolidated; and even then, should be done under protest at the risk of Government.

III.—To revet banks, the height of which it did not affect, no rule has been suggested by Government for the height of such masonry, but it seems to have been built to a height of 1 foot above full water.

From the Executive Engineer, to the Chief Engineer, Madras Irrigation and Canal Company, dated Kurnool, 16th August 1870, No. 389.

It is my duty to report to you the particulars of a severe storm of rain, which occurred between the first hour of Sunday the 7th and noon of the same day, and its effects on our canal-works. During these twelve hours the rain-fall was far larger than any of which we have any record.

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it came from the south-west, and broke over the whole of 1st and 2nd and part of the 3rd Sections with great violence. At Soonkasala the total fall was 7.22 inches, and at Kurnool 12.009 inches as recorded at the Observatory.

As I was at Jupaud during this storm, I cannot speak from my own observation as to the effects at the time on our canal, but as far as I can gather from the reports of Mr. Crawford and my Assistants, the chief effects were as follow:—On the night of Saturday the 6th, the head sluices at Soonkasala were closed to within 5 feet of the sill, ensuring a depth of not more than 5 feet in the canal. By day-light on Sunday the Tindal in charge saw the water in the canal was rising, but waited for telegraphed instructions from me before shutting the head sluices. Unfortunately, as it was afterwards discovered, the storm had interrupted all such communication, and at 9 A.M., seeing that the water had risen in the canal to 8 feet, the Tindal closed the head sluices.

At the calingulah No. 4 A., in the 2nd mile the water rose to a greater height; for about 25 chains below it, the canal receives the flood-waters from a tank supplied from a large vagoo running from the south for several miles in the direction the storm came. These flood-waters rolled back along the canal, till they rose at this calingulah by 11 A.M. to 9 feet above bed-level, causing the water to flow over the crest 1 foot deep; the same wave must have flowed on towards the east, till it reached, and helped to raise the water on Yedaroor tank, which is also fed by three streams coming from the same direction as the storm. At No. 1 calingulah, situated at the western end of this tank, the water rose by noon of Sunday to 9.36 feet above bed, causing a flow 1.36 feet deep over the crest, although all the sluices were open. I have no witnesses to prove the heights to which the water rose at any of the calingulahs between Yedaroor and No. 9 near Kurnool, but on inspecting them on the 11th, I saw at most of them evident marks that the water had flowed over their crests. At Kurnool Mr. Crawford, Assistant Engineer, was out by 7 o'clock, and states that by 8 o'clock he saw the water flowing over the crest of No. 9 calingulah 1 foot deep. All the sluices in the calingulah were opened by 12 o'clock noon. I have no evidence on which I can rely as to the depth of water which passed over the calingulahs of the 2nd Section, but all the bankers and sluice-keepers agree in stating that they did discharge freely over their crests; and at Ulloor aqueduct in the 37th mile, I have the testimony of Mr. Wood, Conservancy Overseer, that the flood topped the parapet walls, which, according to the plan sanctioned in G. O. No. 739 of 17th March, 1865, are built 2 feet above top water-level, proving that the flood in this part of canal must have risen more than 10 feet above bed-level. Below Ulloor the storm seems to have been not so violent; for at Mullalya bridge it raised the water in our canal from 4.70 feet to only 7.40 feet above bed; at Nagatore bridge it was only 6.80 deep; and throughout the 4th Section, the rise did not exceed 2.10 feet above what it was on the previous day.

In the table appended to this report you will find in detail an account of the injuries done to our works by this storm; I will therefore now only describe the principal breaches, and endeavour to trace how they took place.

In the Yedaroor tank two breaches occurred, one at 5th mile and 45th chain, and the other at 5th mile and 52nd chain: the former is the largest, being at a deep part of the tank; it is 100 feet long and 28 feet deep, including 4 feet excavated into the soil.

The other breach is about 7 chains farther down, and though nearly the same width is not more than 17 feet deep. As this bank is fully 6 feet above the top water-line, and the water did not rise more than 1 foot 5 inches above at calingulah No. 1, there is no likelihood of these breaches having been caused by water topping the bank, but the villagers informed; as that there were several large leaks early in the morning, most likely these continued to increase until the earth above fell in, and then the water topping that low part would complete the breach rapidly; the sections of the bank at these breaches show good soil, free from stones, and it has been apparently well consolidated. I think therefore that the leaks most likely originated in holes made by vermin which abound in all our banks. The next and most important breaches in the 1st Section are two in the 10th mile. The first is at 9th mile and 6th chain; it is 70 feet wide and 21 feet deep, extending to 6 feet below the surface of the ground. The second one is at 9th mile and 53rd

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chain, and is 150 feet long and 27 feet deep, having a channel in its centre scoured out 9 feet below ground surface.

The sub-soil to both these breaches is a soft rough limestone, mixed with kunker, very brittle, and full of seams of clay, the soil of which the bank is composed is not good; the lower layers are of a reddish clay full of stones, and above the black cotton soil is much mixed with white soudoo and stones, and no care seems to have been taken to obtain any regularity in the arrangement of these soils.

I doubt not heavy leaks found their way among the stones surrounded by soft earth, quickly causing the bank above to settle down till the storm-waters topped the depressed parts and made the breaches.

I need not give any detailed account of the other failures in the banks of the 1st Section, as they are but few and slight, but will pass on to the far more serious misfortunes in the—

2nd Section.

In the lower bank just 350 feet below the wing-wall of Hindry aqueduct, a most serious breach took place at about 7 o'clock in the morning; a length of 140 feet of the masonry revetment, with its earth-backing, was swept completely away through some gardens into the Hindry, and the final rush of the waters scoured out a channel about 8 feet deep below the surface of ground.

During the rush of water out of this breach, the flood passing over the aqueduct became first a rapid over the inclined apron below the abutment, which it soon washed away, then a powerful water-fall, 90 feet wide and 20 feet deep, which quickly worked out the remains of the apron, and undermining the revetment wall when it joined on to the aqueduct wing-wall on the upper side, brought down a length of 50 feet, and scoured out the earth-backing till it came to the inside of the wing-wall; it also partially undermined the lower wing-wall, but none of it fell.

As soon as the pressure of the water was taken away from these revetment walls, those parts, which the heavy rains had most effected, began gradually to slip forward at the toe; and on Monday morning a length of 350 feet just at the commencement of the 19th mile slid down, rolling up the mud and earth in front of it like a carpet, and carrying with it about 10 feet of its earth-backing, but without causing any breach in the bank. In the back slope of the upper embankment, between the aqueduct and the end of the retaining wall* several deep ruts were cut out

* Revetment.—J. H. L.

by the rain-water which had accumulated between the wall and the bank as raised behind it. Between the 19th mile and the Kaderbagh aqueduct in the 23rd mile no serious injury has occurred, though some of the miles will require much attention to bring them again into a fit state for full water.

The works at Kaderbagh aqueduct stood the pressure of 9 feet water very well, though the sudden rush of water caused by the breach below carried away some of the revetment to the water-cushion.

At the masonry wall No. 2 in the 24th mile a very serious breach took place on the 7th just below the end of the wall, and the rush of water through it carried away 80 feet of the wall, and scoured out a deep gulley in the hollow 67 feet wide; the total width of this breach is 230 feet, and its depth to present bed of tank is 44 feet. At the upper end of this masonry wall the rush of water through the breach below carried away the small protection wall built to keep the stream away from the bank, and then the force of the water washed away the revetment, and scoured a large hollow in the bank, taking away fully two-thirds of the slopes for a length of 160 feet, but without making a breach through. At No. 13 calingulah in the 25th mile is a breach in the wall just below the emptying sluices of 120 feet in length; the whole masonry work and its backing was swept away to the bed-level.

In the 26th mile a breach took place in the masonry wall No. 6 across a deep ravine; it has been carried away with its rubble backing down to the surface of rock for a distance of 40 feet, about 6 feet of the wall stands up across the rest of the breach whose total width is 93 feet, and its depth 22 feet. No injury has been done to any of the other walls or banks of this section.

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Third Section.

The only injury of any consequence done to the works of this section is at Ulloor, where the lower stop-bank was carried away by the rush of flood-water down the vagoo, which passes under the aqueduct, but no injury was done to any of the masonry of that work, and, except a few slight slips in some of the banks, the whole of the works of this section stood the severe test of this flood remarkably well.

I will now endeavour to describe the manner in which these serious accidents occurred in the 2nd Section at 7 o'clock on Sunday morning the 7th; the breach through the retaining wall below Hindry aqueduct had commenced; this is proved by Mr. Chase, the Collector, who said he saw about that time a violent rush of water into the Hindry opposite to his house, and close to our aqueduct; Ethakasha, the owner of the gardens through which the flood rushed, also says that he saw the breach commence between 6 and 7 A.M. on that day. At about 8 o'clock A.M., Mr. Crawford was at calingulah No. 9, and saw the water running one foot deep over the crest, although the breach had been open for more than an hour. Ethakasha also informed me that he saw the water running over the top of the revetment-wall down the slopes; that this topping of the wall caused the breach is also, I think, proved by the accompanying longitudinal section taken by Mr. Crawford, showing that the level of No. 9 calingulah crest is 32.89 above Hindry datum, while the top of the revetment-wall is 30.88.

The fall of canal-bed from calingulah No. 9 to the Hindry aqueduct is 2.80 feet, and the top of the wall close to the site of the breach is 30.88 above datum; it follows therefore even if the flood-waters had taken the same inclination as the normal bed of the canal that the 1 foot above the calingulah crest, would have brought them to a height of 31.09 feet above datum, or 0.21 foot above the top of the wall at the breach site; and we may justly conclude that, before the breach took place, the water must have been higher than when Mr. Crawford saw it an hour after.

From these facts I think there is no doubt this breach and the scourings in the slopes of the upper bank were all caused by the flood flowing over the walls and the banks raised behind them.

It is more difficult to account for the breach in the 21th mile built in 1861-65. The relative levels of the masonry wall crest and the flood-marks on the adjacent bank show that it did not commence by flowing over either wall or bank. A banker who saw the breach take place (at 7-15 A.M. on the 7th instant), says it commenced with a leak through the wall, but I do not think any leak would have breached the wall, and believe that the flow of water he saw most likely came from some leak through the bank close to the wall, which causing a settlement, allowed the flood to top it which it would have done if a settlement of 3 feet had taken place.

**(Sic.)*

The breach in No. 13 calingulah built in 1864 took place at 7 o'clock A.M. on the 7th instant, and the under-slucies were not open. The Lascar in charge of them was there, but says having no orders to open them, he was afraid to do so, the water was flowing 6 inches deep over the crest when the breach occurred. On examination of the masonry of this structure I consider that the breach was caused by the excessive leakage due to the very bad quality of the masonry.

The wall in the 26th mile which was built in 1864-65 had 21 feet of water against it on the 7th instant, and apparently gave way all at once; most likely the leakage had caused the stone backing previously to slip away from it, but I have no reliable witness of the event. Mr. Wood, the Overseer in charge, was anxiously watching the Ulloor aqueduct and the high banks at Sultanpore, and did not see this breach till after it occurred.

At Ulloor aqueduct built in 1865 the flood in the vagoo, which runs under it, came down so violently that though it has provided for it a water-way of 672 feet *super*; it rose to a height of 26 feet, and ran over both the parapets of the aqueduct, and, of course, raised the canal-water to the same height, being 2 feet more than full water-level. I do not wonder at the lower protection being carried away, and think that the masonry stood this serious test in a very satisfactory manner.

The *Water Gazette* for the 6th instant (the day before this flood show that the depth of water in the canal below the head sluices was only 5 feet, at calingulah No. 1, 5.76 feet,

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at calingulah No. 9, 5.40 feet, and at Hindry aqueduct 5.50 feet. As the rain commenced at midnight and by 7 o'clock A.M. on the 7th, the depth at calingulah No. 9 must have been over 9 feet; it follows that a rise of 3.60 feet took place in seven hours, and no doubt was greater before the breach took place. So rapid a rise is more than the works were intended to stand, and I think the present state of the 1st Section is entirely owing to this unprecedented storm, and not to the incapability of the works to stand the amount of water-pressure they were built to retain.

(True Copy.)

(Signed) J. H. COX,
Assistant to Chief Engineer.

No. 24. From the Acting Consulting Engineer, Madras Irrigation and Canal Company, to the Secretary to Government, Public Works Department, dated Madras, 1st September 1870, No. 58.

I HAVE the honour to submit, for the consideration of Government, the correspondence as per margin on the subject of testing the stability of the main canal.

To Agent, No. 243, 22nd Nov. 1869.
From „ „ 402, 8th Dec. „
To „ „ 117, 18th July 1870.
From „ „ 369, 29th Aug. „

2. On the 22nd November 1869 I suggested to the Company's officers that

the canal should be tested by allowing the water to pass down at a depth of 2 feet above full water-level, to which the Chief Engineer replied on the 3rd December that it would be impossible to do so, as the water would pour out over the masonry walls in many places and be dangerous; also, that the tops of the dry rubble puddle-cored banks was only two feet above full water. On the 18th of July, 1870, I again addressed the Agent, pointing out to him that it was because from the nature of its construction, that the canal was liable when full to have its level raised considerably by an unusual fall of rain, that I advocated the measure, and that until the banks had been subjected to such a test for the greatest practicable height the canal could not be considered to have been put in a safe and efficient working state; and I further remarked that the Chief Engineer's objections did not seem applicable to some of the sections, and that certain precautionary measures had long since been specially authorized to be taken for ensuring the tops of the walls in the 2nd and 3rd Sections being raised to suitable heights.

3. I fully expected that the test would be followed by some serious breaches, but I held that it would be true economy and prudence to expose all weak parts in good time, when the necessary remedial measures might be taken, than to run the risk of a like test being supplied by floods hereafter, when the same damage to the canal would have to be made good, in addition to heavy compensation for the loss of crops, and the still greater loss of public confidence in the stability of the works.

4. The test which I proposed was very shortly after applied in a most severe form by a wholly unprecedented fall of rain, and it resulted in the disastrous damage which was communicated to Government in my report No. 50 of 18th August 1870.

5. Since that occurrence the Chief Engineer has replied to my last letter on the subject, and he is still opposed to the application of the test. His objections may be briefly described as follows:—

1st.—That it would be necessary to raise all the calingulahs two feet, when only one foot would remain between the new crest and the superstructure carrying

the tow-path over the calingulah, when, if a storm occurred, the water might be raised another foot and the canal would be unsafe; to this objection I would reply that a time for applying the test should be selected when a storm was not probable, and that the calingulahs should be raised by banks of earth only, which would be readily removable by one or two men in charge of each in the event of a heavy fall of rain occurring.

2ndly.—That it is not to be supposed that when the sanctioned designs of banks are 3, 4, and 6 feet above water-level, they were ever intended to be subjected to the test proposed; that the works were originally designed to meet a maximum flood of one foot above full water-level where the canal is single banked, and at most 6 inches in other cases; also, that in his opinion no bank should be tested with water of a greater depth than one foot above full water-level; and he adds that the top breadth of the banks would vary, but should be made at the new level of corresponding breadth, or thickness, to what had formerly been designed at lower heights for less depth of water, thereby implying the necessity for a considerable addition to the earth-work in the existing banks. Recent occurrences have shown that the level of the water in the canal when full is liable to be raised 18 inches, and there can be no question that the banks and walls should be capable of withstanding this pressure; but as the late fall of rain, equivalent to 12 inches in one night, did not raise the level in the canal more than 18 inches, notwithstanding the omission to close the head sluices at Soonkasala, and to open all the calingulah-sluices, I have so far modified my opinion as to consider that an excess depth of 18 inches instead of 2 feet would be a sufficient test.

3rdly.—The Chief Engineer considers that the canal should be able to stand a pressure of 8 feet depth of water which it was intended for, but that it is more than a fair test to fill it 2 feet higher, in fact over the brim of all the single and face-walls as originally sanctioned; and that the Consulting Engineer in his letter on the 2nd Section walls gave his opinion that dry rubble puddle banks would not be safe if exposed to water within 2 feet of their tops.

I do not recognize the letter here referred to, but I find that in his No. 76, 23rd September 1867, regarding the 2nd Section, the Consulting Engineer remarked in his paragraph 11 that "the core sections as proposed would not be safe," and that "when he proposed to make the top of a masonry revetment "2 feet above full canal-level, it was intended, that leaving a berm for a towing path, "the embankment in rear should be made up to the full level of 6 feet above "water," and "that the wall should be carried up 3½ feet above water," that is, 1½ higher than had been proposed, "or, that the earth-work should be carried up at least 4 feet above that level;" and it was on the understanding that these precautions for safety were adopted that Government sanctioned the revised estimates for the 2nd Section in Order No. 3,195, 15th October 1867, but no attention appears to have been paid to this, and the Chief Engineer in a recent communication, remarks that it would have been unsafe to do so until the earthen banks were well consolidated, and that even then it should only be done under protest and at the risk of Government.

4thly.—The Chief Engineer remarks that the most dangerous time for a breach after fresh exposure is from the tenth to the twentieth day, and that banks, which would stand a natural test of 2 feet for a few hours, might not stand a pro-

longed one, artificially made; and that if such an artificial test is required, special provision should have been made in the contract for it. I have, however, never contemplated, and do not advocate any greater test than nature may be expected to furnish under exceptional circumstances, and I do not propose that the increased depth of water should be passed down the canal for a prolonged period.

6. The Chief Engineer in his closing paragraph remarks that it would be necessary to raise all the banks and walls before the canal is tested, and that to do so 18 inches only would cost from Rupees 8,500 to Rupees 9,000 for each of many miles. How much more altogether he is unable to say without making calculations which will require some time, but he supposes the cost might be three lacs if Government will supply the land free of expense. If this is really so, there has been a great want of appreciation during the last eleven years of the damage which a canal, carrying 8 feet depth of water above bed-level, and receiving the monsoon drainage of large tracts of country, was liable to; and the wonder is that the injury from the floods of the 6th of last month was not very much greater.

From the Acting Consulting Engineer, Madras Irrigation and Canal Company, to the Agent and Manager, dated Madras, 22nd November 1869, No. 243.

In the course of our recent tour of inspection I expressed to you a hope that the Chief Engineer would not lose the opportunity of the present season to test the banks and sundry works of the canal as far as it is open by allowing the full depth of water to pass down as far as the end of the 5th Section. I would be glad to be assured not only that such is the Chief Engineer's intention, but that he purposes going much farther, and will test the work to fully 2 feet above ordinary full water-level. It is by no means improbable that such a course of action will lead to more than one serious breach, but it is highly desirable that any weak points which may exist should now be detected when measures can be taken for strengthening them, rather than, at later periods when the canal-water is being utilized, and similar accidents would then be followed by large pecuniary loss for damage done to property and the failure of crops.

From the Chief Engineer, Madras Irrigation and Canal Company, to the Agent and Manager, dated Kurnool, 3rd December 1869, No. 1,058.

YOUR No. 691 of 24th ultimo.

It would be impossible to test the canal with water to a height of 2 feet above full water-level as defined by the calingulah crests and the sanctioned plans; because in that case, the water would pour out over the masonry wall in many places and be dangerous. The level of the top of the dry rubble puddle cored banks is also only 2 feet above full water. I do not expect the testing of the banks of first five sections to be completed this season. We have had within 6 inches of full water-level in some parts however.

No. 402.

COPY forwarded to the Consulting Engineer, with reference to his No. 243 of 22nd November 1869.

MADRAS,
8th December 1869.

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

From the Acting Consulting Engineer, Madras Irrigation and Canal Company, to the Agent and Manager, dated Madras, 18th July 1870, No. 117.

In my letter No. 243 of 22nd November 1869 I brought to your notice the expediency of testing the canal by allowing the water to pass down as far as the canal was completed to a depth

*Proceedings of the Madras Government, Public Works Department,
1st October 1870.*

of 2 feet above ordinary full water-level, to which the Chief Engineer replied that it would be impossible to test the canal with water to a height of 2 feet above full water-level, as defined by the calingulah crests and the sanctioned plans, because in that case, the water would pour out over the masonry wall in many places and be dangerous, and because the level of the top of the dry rubble puddle cored banks is also only 2 feet above full water.

2. Now, it is because the canal, from the nature of its construction, is liable in some places to have the level of the water considerably raised by an unusual fall of rain, in consequence of the large drainage which it receives, that I urged, and must continue to impress on you and on the Chief Engineer, the necessity for testing the banks to the greatest practicable height; and until this is done the canal cannot be said to be put in a safe and efficient working state, for it is obvious that if the only test it is subjected to is the ordinary full depth of water, most disastrous consequences may follow from the increased depth of water that would result from any unusual flood.

3. The Chief Engineer's objection does not appear to be applicable to the 4th and 5th Sections, in the former of which such a test is especially necessary. In the 1st Section the escapes are so ample that if the water was raised 15 inches above normal full level, it would probably suffice; and in the 2nd and 3rd Sections, where I conclude the walls are to which the Chief Engineer refers, the water should be raised in each part to the greatest extent possible, for if the construction of the canal is unequal to anything in excess of the intended ordinary full depth, there can be no doubt of the propriety of altering those arrangements in good time before hand, particularly with respect to the level of the core-walls. In reference to this subject I invite your particular attention to the 11th paragraph of Major Mullins's letter to Government, printed with G. O., No. 3,195, 15th October 1867. On condition of the precautions therein suggested for the safety of the revetments and banks being adopted, it was that the Government sanctioned the revised estimates for the 2nd Section. The Consulting Engineer therein remarked that the walls and banks connected with them were proposed to be only 2 feet above full canal-level, which under no circumstances would be a safe margin for a wall with a bank in rear. The core-sections, he added, as proposed to be completed would be quite unsafe, for the water can pass freely through the dry wall, and would have to get through a few inches only of the soil to reach the roadway between the masonry parapets, and so find its way to the rear; and he then remarked that when he proposed to make the top of a masonry revetment 2 feet above full canal-level, it was intended that, having a berm for a towing-path, the embankment in rear should be made up to the full level, 6 feet above water; and that, therefore, the wall should be carried up 3½ feet above the water-level, or that the earthen bank should be carried up at least 4 feet above the top of the walls as shown in the cross sections. In testing the canal as proposed, it might be divided into lengths of a few miles by bunds across, which could be easily thrown up at the cuttings below the escapes, when, in the event of a breach occurring, the body of water would be small, and could be drained off in a short time, or on the discovery of a weak place, the water could be lowered until the defect was made good.

From the Chief Engineer, Madras Irrigation and Canal Company, to the Agent and Manager, dated Kurnool, 23rd August 1870, No. 1,274.
Your No. 657 of 12th August, 1870.

In reference to the testing of the canal with 2 feet of water above the full water-level, i.e., above the crest of calingulahs, will require the following difficulties to be surmounted:—

1. The first step in the actual process of testing will be to raise all the crests of calingulahs 2 feet, leaving 1 foot open between them, and the superstructure carrying the tow-path.
2. The canal will, of course, not then be safe, in the event of a storm occurring at any part of it, since such a storm might at events locally raise the canal another foot. However, by placing a Maistry and some watchers at each sluice, this danger would be diminished. The calingulahs in the first five sections are mere walls 4 feet thick, some of them 10 feet high, and none too strong already. It would on their account alone be advisable to prevent the water rising more than 2 feet above full water.

*Proceedings of the Madras Government, Public Works Department,
1st October 1870.*

4. It is impossible to suppose that where the sanctioned design of banks is 3, 4, and 6 feet above water, they were ever intended to be subjected to the test proposed. So far as I am aware the original design was to meet a maximum flood of 1 foot above full water where the canal is single banked, and at most 6 inches where it has no single banks. In the first five sections the tank surveys were taken to a contour 1 foot above full water, and where the introduction of the Terragopully aqueduct was expected to raise the full water-level, the banks were raised as well as the tank contour (subsequently countermanded). The 6th, 8th, 9th, and 10th Sections are the only ones which admit no land drainage (to speak of) into the canal; I think no bank should be tested with water higher measuring down from their top than they were intended to stand, i.e., for the first three sections 5 feet below the top, in the 4th, 5th, and 7th, three feet below the top of banks, and 1 foot below any single wall or face-wall. The top breadth of banks would vary, but should be made at the new level, what breadth it was designed to be previously.

5. The cheapest way of arranging for the tanks would be to stop the cultivation for one year on the part outside the Company's land likely to be damaged, until the test were over. It would not cost much in any tank in the first 40 miles. Such villagers' houses as would be damaged I should think would be best removed; they would lie chiefly in Tangadancha and Lutchma-poorum. The test would swamp an average of 4 chains breadth of land round the margin of the tanks in the 4th and 5th Sections, judging from the cross sections of the canal there, and at a level of 2 feet above the present contour, or 2 feet 6 inches above full water.

6. The test is not as if a bridge were to be tested by a heavy engine or train of engines, which it was built to carry.

7. The canal should be able to stand all the water that it is intended for, but it is more than a test of this, to fill it 2 feet higher than it was built to be filled; and, in fact, over the brim of all single and face-walls as originally sanctioned. Major Mullins, in his letter on the 2nd Section walls, stated that he did not consider the dry rubble puddled bank safe, if exposed to water within 2 feet of the top. These will need raising to more than 3 feet above water, and widening, like other banks, from top to bottom.

8. The most dangerous time for a bank after fresh exposure to water is from the tenth to the twentieth day. Banks that would stand a natural test of 2 feet for a few hours might not stand a prolonged one artificially made, and therefore I think special provision should have been made in the contract for such an artificial test. The once most dangerous banks above Sultanpoor must have stood the 2-feet test, while the water was flowing over Ulloor aqueduct, but I suppose that did not last more than six hours.

9. To build up the crests of all our waste weirs 2 feet before we had raised all the banks and walls to a corresponding height seems to me a suicidal measure. If the test be postponed till October; the middle of the cultivating season, it would be safe to raise all banks and walls 18 inches only, I cannot say how much this would cost without calculations involving some time, but we have many miles of 30 feet bank for which it would cost about Rupees 8,500 to Rupees 9,000 a-mile. The average double banked canal in 4th and 5th Sections would scarcely cost half this. The expense to the Company might therefore be about 3 lacs (allowing for cuttings). I presume Government would bear the expense of extra land.

No. 369.

Copy forwarded to the Consulting Engineer, with reference to his No. 117, dated 18th July 1870.

MADRAS,
29th August 1870.

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

No. 25.

ORDER THREON, 1st October 1870, No. 2,376.

IRRIGATION, No. 5.

In the first of the letters above recorded the Acting Consulting Engineer for the Madras Irrigation and Canal

Proceedings of the Madras Government, Public Works Department,
1st October 1870.

Company submits a second report on the damages which the Company's canal sustained in consequence of the filling of the canal beyond its full water-level by the unprecedentedly heavy fall of rain that occurred on the night of the 6th ultimo.

2. The damages as yet ascertained principally consist of eight large breaches at various points of the embankments, occasioned, it would appear, in all but one instance, by leaks arising from the indifferent material and loose construction of the earthen embankments, or from the bad workmanship of the masonry revetments which at some places take the place of earthen banks. In the exceptional case it appears that, in consequence of no precautions having been taken to shut off water from the Toombodra at Soonkasala, and to open the sluices of all the waste weirs, the water was allowed to rise to such a height in the canal as to top the masonry revetment, with its earthen backing, a short distance below the Hindry aqueduct, and there to cause a large breach of 140 feet in length and of great depth.

3. As it is clear from the letter from the Company's Chief Engineer, forming an enclosure to the second of the letters from the Consulting Engineer at the head of these Proceedings, that the danger of allowing the canal to be even slightly over-filled was quite understood, the Government must express their surprise that arrangements for preventing such an occurrence, so far as the exclusion of river-water at the head of the canal and the opening of all surplus sluices would tend to effect that object, have never been established. Had the necessary precautions been taken to ensure the shutting of the head sluices, and the opening of those in the waste weir, it is not likely that the water in the canal, slowly as it would appear to have risen, would have attained such a height as to have caused the failure of the work at a time when its stability was of so much importance not only to maintain the irrigation of the lands now watered from it, but also to give to the people that confidence in the permanence of the supply which, shaken by repeated accidents, will have to be established before any material extension of wet cultivation can be looked for, or any returns of moment be expected on the great outlay the Company have incurred.

4. The test by which the Consulting Engineer very properly considered it desirable that the embankments of the canal should be tried having thus by the recent flood been applied, and with such disastrous results, the Government trust that the officers of the Company will recognize the necessity of taking measures for strengthening those embankments wherever they may appear not to be of ample stability, and His Excellency the Governor in Council will look to the Consulting Engineer to assure himself that this is being done. Meanwhile, the breaches should be closed in anticipation of the sanction of estimates which should be submitted without delay.

(True Extract.)

Colonel, R.E.,

Secretary to Government.

To the Acting Consulting Engineer for the Madras Irrigation and Canal Company.
,, Agent and Manager,
Exd. F. R. Bantleman.

Consulting Engineer Office,
Irrigation & Canal Company,
No. 56, Madras 31 August 1870.
-Jany

Colonel J. Carpendale R.E.

Acting Consulting Engineer, No. 56.

To
The Secretary to Government,
Department of Public Works.

In continuation of my letter No. 50 of 18th
Ultimo, I have the honor to submit the
further reports as noted in the margin
in the damage sustained by the main
canal from the floods of the 6th & 7th of
August. The extent of the damage, the
nature of each large breach, and the
immediate cause in each case, as
far as they can be ascertained, are
all clearly detailed in the Consulting
Engineer's letter, and I need only briefly
summarize them.

One breach (Ye daroor tank) at 5 miles
and 45 chains, is 100 feet long and
28 feet deep going 1 foot into the ground.

One in same tank but 5 miles and
52 chains, is 102 feet long & 17 feet deep.

In both these cases the breaches are
attributed to large leaks which increased
until the earth above fell in, when the
water topping the lowered part of the
bank would rapidly complete the
breach. The sections of the bank at

From the Consulting Engineer
Hindry Carpendale
7th Aug 70 No. 289
From the Chief Engineer
7th Aug 70 No. 1253
with covering letter
from the Agent, 9
27 Aug 70 No. 364

these breaches are stated to exhibit good soil, free from stones, well consolidated and the leaks are believed to have originated in holes made by Vermin.

3rd breach at 9 Miles and 6 Chains is 70 feet wide and 24 feet deep, going 6 feet into the ground.

1st breach at 9 Miles 53 Chains is 150 feet long, and 27 feet deep, going at its central portion 7 feet into the ground.

In both the above cases the subsoil is described as soft rough lime stone mixed with Runkers, very brittle, and full of seams of clay; the banks present the appearance of having been formed without care and of inferior material, and their failure is attributed to leakage between the stones, which caused a settlement and allowed the Canal water to top the lowered portions of the banks.

5th large breach is in the lower bank 350 feet below the wing wall of Hindry Aqueduct where the bed in length of the masonry revetment with its earth backing was swept completely away and a channel 8 feet below the surface of the ground was secured and this accident is believed to have been caused by the water in the Canal having risen so much as to flow over the top of the revetment wall and

N. 15
slopes, and the levels just taken would confirm this view, for it has been ascertained that the crest of N. 9 Calingulah is 32.89 feet above the Hindry datum, and that the top of the revetment wall was 30.88 feet above datum. The fall of the Canal bed from Calingulah N. 9 to the Hindry Aqueduct is 2.80 feet, whence as the flood water flowed one foot deep over the Calingulah turn an hour after the breach occurred, it must have topped the revetment wall which breached by at least 0.21 foot.

For 32.89 Crest of Calingulah
- 2.80 Fall of Canal

30.09

+ 1 add depth of water over Calingulah
31.09

- 30.88 deduct height of revetment
0.21

6th large breach is at the masonry wall N. 2 in the 24th mile where it adjoins the earthen bank, which carried away 80 feet in length of the wall, and scoured out a deep gully 67 feet wide. This breach is 250 feet long, and its depth 46 feet, and the rush of the water caused other serious damage to the neighbouring revetment and bank for a length of 160 feet. This breach is reported to have originated in a leak through the wall, but the Resident Engineer considers it more probable that

it arose from a leak in the adjoining bank.

7th breach is at No. 13 Calingula in the 25th mile, 120 feet in length of the wall just below the emptying sluices, with its backing being some 15 ft away to bed level; accident owing to excessive leakage due to the very bad masonry.

8th breach is in No. 6 wall which was built across a deep ravine in the 26th mile, the wall, with its rubble backing for a length of 110 feet being carried away down to the rock foundation. This wall had a depth of 2 feet of water against it. It is supposed to have given way suddenly from leakage.

At 21st floor Aqueduct, where the natural drainage course is provided with a waterway of 672 square feet, the flood rose to a height of 26 feet, passing over the Aqueduct, raising the water in the Canal 2 feet above full level, and the only damage was that the lower portion of the carried away, the balance of the revenue to the water commission.

It will be observed that the Head sluices at Lunkhala were not closed until 6.45 AM on the 7th August; and until after the damage was done.

and that in some cases the Calingula sluices were not opened until noon the same day, the explanation being that the Sindab in charge of the Head sluices waited for orders by telegraph, but the storm had interrupted telegraphic communication; how much less the damage might have been, if when it was found that such unusual heavy rain continued day before midnight in the 6th, the Head sluices had been closed, and all Calingula sluices opened, it is impossible to say, but that those precautions were not taken until after most of the damage was done, ^{shows} a defect in administrative arrangements, and I would suggest that in future during the rainy seasons an intelligent European capable of exercising discretion should reside at Lunkhala and be in immediate charge of the Head works.

I need only further add on the present occasion, in reference to the closing paragraph of the Chief Engineer's covering letter, that the Consulting Engineer's suggestion regarding the height to which face walls in the 2nd Section should be

an intelligent
Native could do
as well
in.

carried and which was approved
of by Government in Government
order N^o 3,195-15th October 1867 appears
to have been treated as a dead
letter, and now, after nearly three
years have elapsed, the Chief
Engineer records his opinion that
it would have been very unsafe
to raise the walls as suggested
until the banks were well consoli-
dated, and even then it should
only be done under protection of the
risk of Government.

I have the honor to be,
Sir,

Yours most obedt Servt

Spokane Falls — Col. R.E.
Sawmilling Engineer.
24. 1874

Con.

P. Dr. 2.
 Proceedings of the Madras Government.
 No 2376 Under date the 1st Sept 1870
 Read the following 21

From
 The Acting Engineer
 S. & C. Co. } (H. E. No 56 of 31 Aug 1870)
 " Do " } (H. E. No 58 of 1 Sept 1870)

In the first of the
 letters above recorded the
 Acting Consulting Engineer for
 the Madras Irrigation and Canal
 Company submits a second
 report on the damages which
 the Company's Canal sus-
 tained in consequence of the
 filling of the Canal beyond
 its full water level by the
 unprecedentedly heavy fall
 of rain that occurred on
 the night of the 8th Ultimo.

The damages as yet
 ascertained principally
 con-

To No 1870 Sept.
 No 56 of 31 Aug 1870
 From
 The Acting Consulting Engineer
 S. & C. Co.
 To
 The Secretary to Govt
 (P. Dr. 2.)
 Dated 31 August } 1870
 Recd 32 Sept.
 Enclosure 3

No 2376- 1st October 1870.
 Submits further
 reports in continu-
 -ation of his No 50-18
 Ultimo on the damage
 sustained by the
 Main Canal from
 floods of 6th August 1870

Ch 23
 Reported by 20 Sept 1870 P. Dr. 21

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25
23
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W.B.

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Meanwhile the Breaches
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cipation of the sanction
of

To the Engineer for the
Madras Dy. Co. with three Encls. ✓
L. Agent & Manager - do - do - ✓
Desp. 4/10/70

Further Receipts 1-4-71
1089-15-4-71

Receipt to City 20: 1/1/70 26

ms 3473 P 35

Govt. of 1870 Madras.

PUBLIC WORKS.

To the Consulting Engineer
for the Madras Irrigation
and Canal Company

Detail

Recd.

1st Oct 2376

Nos. 22 275

Remarks —

Refer to the letter
from the Engineer to
Madras & Co. regarding
further on the drainage
divided in the Company's
local for the floods
in the District.