Public Works (1897) Department.

Printed

G.O., No. 786-87

DATED 26 August 1897

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[Despatch Abstract.]

Kistna Anicut: Estimate for Rs. 58,770 for fitting Shutters to the Crest of the —, Approved with remarks and a copy of the Proceedings ordered to be forwarded to the Govt of India with request that early sanction may be accorded to the estimate.

Kistna Anicut: Forwarding Copy of Proc: requesting early Sanction to the estimate for Rs. 58,770 for fitting Shutters to the Crest of the —.

D.C. 2648

[P.W. 25. 500-8-11-96.]

Indexed.

BACK PAPERS.

G.O.	No.	Department.	Date.	G.O.	No.	Department.	Date.

FURTHER PAPERS.

G.O.	No.	Department.	Date.	G.O.	No.	Department.	Date.

IRRIGATION.

Government {1897} of Madras.

PUBLIC WORKS.

Recd. } 1897. *Enclosures*

Regd. } *Spare copies*

G.O., Nos. 786, 787 I., 26th August 1897.

AUGUST.

Kistna Anicut

Forwarding copy of Proceedings requesting early sanction to the estimate of Rs. 58,770 for fitting shutters to the crest of the —.

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

Irrigation.

READ—again the following paper :—

G.O., No. 75 I., dated 20th January 1897.

READ—also the following papers :—

From Major W. L. C. BADDELEY, R.E., Superintending Engineer, II Circle, to the Chief Engineer for Irrigation, dated Bezwada, 5th August 1897, No. 1320 K.N.

In reference to G.O., No. 75 I., dated 20th January 1897, I have the honour to forward complete proposals for fitting falling shutters to the crest of the Kistna anicut. The estimate is Rs. 47,200.

The following papers are forwarded :—

(i) Note by Captain Ellis, R.E., dated 4th July 1897, on various points raised in demi-official correspondence about the shutters.

(ii) Letter, No. 295 S.E. of 23rd July 1897, from the same officer forwarding—

4 Plans.	1 Data sheet.
1 D and A estimate.	1 Report.

(iii) Letter, No. 314 S.E. of 31st July 1897, from the same officer giving the results of his enquiries regarding the rates at which the shutters could be made.

2. Captain Ellis has worked out his proposals with much care, and in great detail, and the conclusions he arrives at regarding the advisability of procuring 237 shutters from Messrs. Burn & Co., and the balance, viz., 50, from the Bezwada workshops, have my strongest support.

3. The height of the Kistna anicut is at the present time insufficient for the large acreage of the system, and it is most essential that the shutters should all be fixed by next irrigation season.

4. If we rely on the Government workshops, I am certain that the shutters will not be ready in time, and I trust that I may receive very early orders to put the work in hand according to Captain Ellis' proposals.

5. I should be glad if orders could be sent to me by wire as soon as the estimate is approved, for every week's delay is of importance.

ENCLOSURE.

REPORT to accompany estimate for erecting falling shutters on the Kistna anicut.

The type of shutters proposed for adoption is similar in action to the 4 acres tumbler shutters erected on the Sone weir in Bengal. There are, however, differences in detail.

The shutter proposed is 10′ long by 3′ high with 1″ round connecting rods 3′ 1″ long from centre to centre of pivot bolts.

The material difference in the design from the shutters used on the Sone are two :

(*a*) The shutter travels on three plate iron ways 4″ wide fixed on the anicut, and on these ways curved plates fixed to the shutter slide ; whereas on the Sone weir the bottom angle iron was placed along the bottom edge of the shutter and the edge of this scrapes along the stone bed, on which the shutter rests throughout its whole length when the shutter falls or is lifted. This renders necessary a greater force to lift the shutter, and irregular action in falling.

(*b*) The joint to seal the escape of water between the anicut and length of the shutter is formed on the Sone by the angle iron resting on the stone sill as above mentioned.

The design for the Kistna shutters provides for a joint formed by the edge of the angle iron forming the lower stringer of the shutter butting against a continuous wooden blocks (backed by stone) which performs the double duty of stop block and water joint. The advantage of this is that the water pressure itself tends to close the joint, and the lower the water falls (within limits), the tighter becomes the joint.

Experimental shutters.—Three types of shutters were erected on the anicut in April and May last, viz. :—

(1) The Sone type with ∠ iron forming bottom stringer resting on a stone sill.

(2) A shutter, curved plates fixed at intervals to the bottom of the shutter and sliding on 4″ wide plate iron ways fixed on the anicut crest. This is the type now selected for adoption.

(3) Similar to (2) but with 3″ cast-iron rollers in place of curved plates. Details of all these shutters, 14 in number, and of various lengths from 8 feet to 19 feet, are given in the estimate for the erection of the work.

Notes regarding experiences with experimental shutters.—The drawings with this estimate give full details of the shutter selected as the best suitable, and the following notes give a few experiences with the experimental shutters, and by inference the reasons which have led to the present design.

Size of scantlings of frame.—Calculations were made to proportion these exactly to the work they had to do in order to cut down the weight as far as possible.

Experience has shown that the weight of the shutter bears a small proportion to the force required to lift it, as in addition to the shutter, the water laying on it must be raised.

For instance, two men can raise a 16′ × 3′ shutter without any water going over, but eight men are required to raise the same shutter with 9 inches of water passing over it.

There was noticed a great tendency for the shutters to buckle out of a plane which caused much trouble and delay when making.

The scantlings of the angle iron stringers have been increased from $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$ to $3 \times 2 \times \frac{3}{8}$ in consequence.

Force required to lift.—This has been tried with 9 inches of water passing over the shutters, by raising by hand, the men lifting in a row from the downstream side of the shutter :

19 ft. Sone pattern shutter—14 men raised with difficulty.
12 ft. Sone pattern shutter—10 men raised with difficulty.
16 ft. roller shutter—10 men raised, one easily, one with some difficulty.
16 ft. curved plate shutters—10 men raised with some difficulty.
8 ft. curved plate shutter—4 men raised.
14 ft. curved plate shutter—8 men raised with difficulty.

Force required to overturn.—When 1 foot of water was held up by the shutters, the numbers of men required to overturn the shutters were as under :

16 ft. roller shutters—4 men to one shutter, 3 men to another.
16 ft. curved plate—4 men with difficulty.
8 ft. curved plate—2 men.
14 ft. curved plate—3 men.

The Sone pattern shutters took one man for every 2 running feet to pull over.

Head required to overturn the shutters.—The depths of water required to overturn the various types of shutters as noted from actual observation is stated below:—

Depth of water in feet passing over shutter—

Sone pattern	1·1	1·3	1·3	1·4
	·65	1·25	...	·8

The general level for falling, say, about 1·25.

It is to be noted that two Sone shutters did not fall with a 6 ft. head, and fell only after several days of flood on a falling river with 5 feet of water passing over the shutter.

The cause of this is still unknown.

Depth of water in feet passing over shutter—

Roller pattern shutters	·35	·55	·15
	·25	...	...

Say ·35 as an average.

The rollers of the last two shutters mentioned were given much more play than those of the first two; this accounts for their falling so much easier.

Curved plate pattern shutter—

Depth of water passing over shutter in feet ... ·75 ·8 1·0

This gives an average of about ·9 and a corresponding force of, roughly, 80 lb. per foot run applied at one foot above the pivot is required to overturn this pattern shutter.

Leakage under the shutters.—This was found to be less when the joint was made against the continuous stop block than in the Sone pattern shutter, and it could be still further reduced by more careful fitting against the wood stop block.

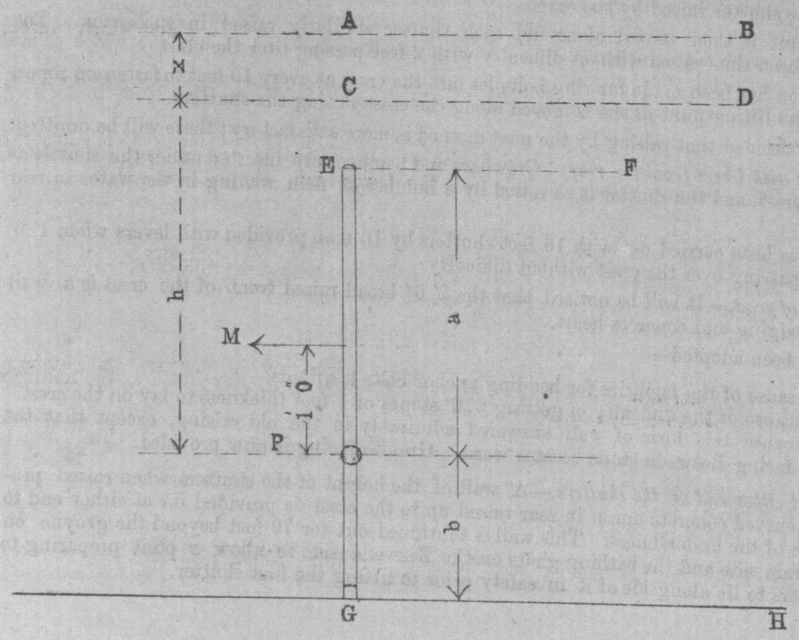
The roller shutters leaked round the rollers, whereas the curved plates are free from this defect.

Leakage at ends.—This was insignificant. On the adjacent ends of different shutters was bolted a block 5″ × 2″, and this was cut down the joint by a coarse saw. This seems satisfactory, but needs further trial; but in any case leakage here can be reduced to very small proportions.

Rollers.—The rollers make shutters a little easier to work than curved plates, but are more costly, leak more and will require more repairs.

The curved plate is consequently preferred.

Formulæ.—The formulæ used for calculating the position of the pivots are noted below; the proof of these formulæ are given with this report.



If A B be the level of water at which the shutter overturns when pivoted at P, C D the level of water which transmits such pressure to the shutter that the pressures on either side of the pivot are in equilibrium. $h = \frac{2(a^3 + b^3)}{3(a^2 - b^2)}$

If M lb. be the force per foot run applied at a level of 1 foot above the pivot tending to overturn it,

Then $X = \frac{M}{\frac{1}{2}(a + b)(a - b) \times 62{\cdot}5}$ feet, 62·5 lb. being taken as the weight of 1 cubic foot of water.

Pivots: height of—.It is proposed that the pivots of the shutters be so arranged that the central 700 feet of shutters should fall with a head of about 1 foot.

The 700 feet on both sides of this central length should fall with a head of about 1′ 3″ and the remaining shutters should fall with a head of about 1′ 6″.

The object of this is to introduce some uniformity into the order in which the shutters fall and to ensure the water level on a rising river never falling below the level of the top of the raised shutter which is sufficient to provide for all requirements of supply.

The way this will work is noted below:

When all the shutters are up the river rises to 1 foot over their top, the central 700 feet will fall (not altogether but before the other shutters fall).

The discharge of the notch 700 feet long so formed is when the water is at level of top of shutters, equal to the discharge of the anicut whole length 1 foot deep. The river will therefore fall to about crest level of shutter. No more shutters will then fall until the discharge increases, so that the water rises to 1′ 3″ above the shutters.

Two more lengths of 700 feet will then fall, and the water level will, in like manner, again fall to about crest level of the shutters.

The balance of the shutters will fall when the water rises to 1′ 6″ above the top of the shutters.

The discharge then will be about 64,000 cusecs, which is sufficient to maintain the water 3 feet deep on the crest of the anicut when all the shutters are down.

The calculated pivot heights to carry out the above are—

			Inches.
Shutters to fall with 1′ 6″ head, height of pivot	...	...	13½
Do. 1′ 3″ do.	...	...	13
Do. 1′ do.	...	...	12½

Lifting the shutters.—This has been successfully tried in two ways:

(*a*) *Lifting by floating crane.*—From a crane mounted on the bow of a punt. The punt is floated up in the slack water alongside the shutters already raised or a short length of crest wall to be built at each end of the anicut for the purpose. A bridle chain is hooked on to the shutter and the shutter raised by the crane.

The punt is then moved along and each shutter similarly raised in succession. The shutters have been thus raised without difficulty with 2 feet passing over the crest.

Provision has been made for ring bolts let into the crest at every 10 feet to fasten on ropes, &c., holding the lifting punt as she is moved along the crest raising the shutters.

If it is decided that raising by the next method is more satisfactory; these will be omitted.

Lifting with levers from the rear.—Crowbars and bamboos are inserted under the shutter as it lies on the crest, and the shutter is so raised by a number of men wading in the water in rear of the shutter.

This has been carried out with 16 feet shutters by 16 men provided with levers when 1′ 6″ of water was passing over the crest without difficulty.

Masonry of crest.—It will be noticed that the 2′ 6″ broad raised front of the crest is a wall with granite edging and concrete heart.

This has been adopted—

(1) because of the facilities for bedding anchor bolts it affords.
(2) because of the difficulty of getting 2′ 6″ stones of 1 foot thickness to lay on the crest.
(3) because this form of wall answered admirably in the old raising, except that the facing Bezwada stone became worn. Granite facing is now provided.

Flanks at either end of the shutters.—A wall of the height of the shutters when raised provided with a curved concrete apron in rear raised up to the crest is provided for at either end to join the slope of the undersluices. This wall is continued out for 70 feet beyond the groyne on the Sitanagaram side and the bathing ghâts on the Bezwada side to allow a punt preparing to lift the shutters to lie alongside of it in safety prior to lifting the first shutter.

Proof of formulæ given—

First Formulæ.

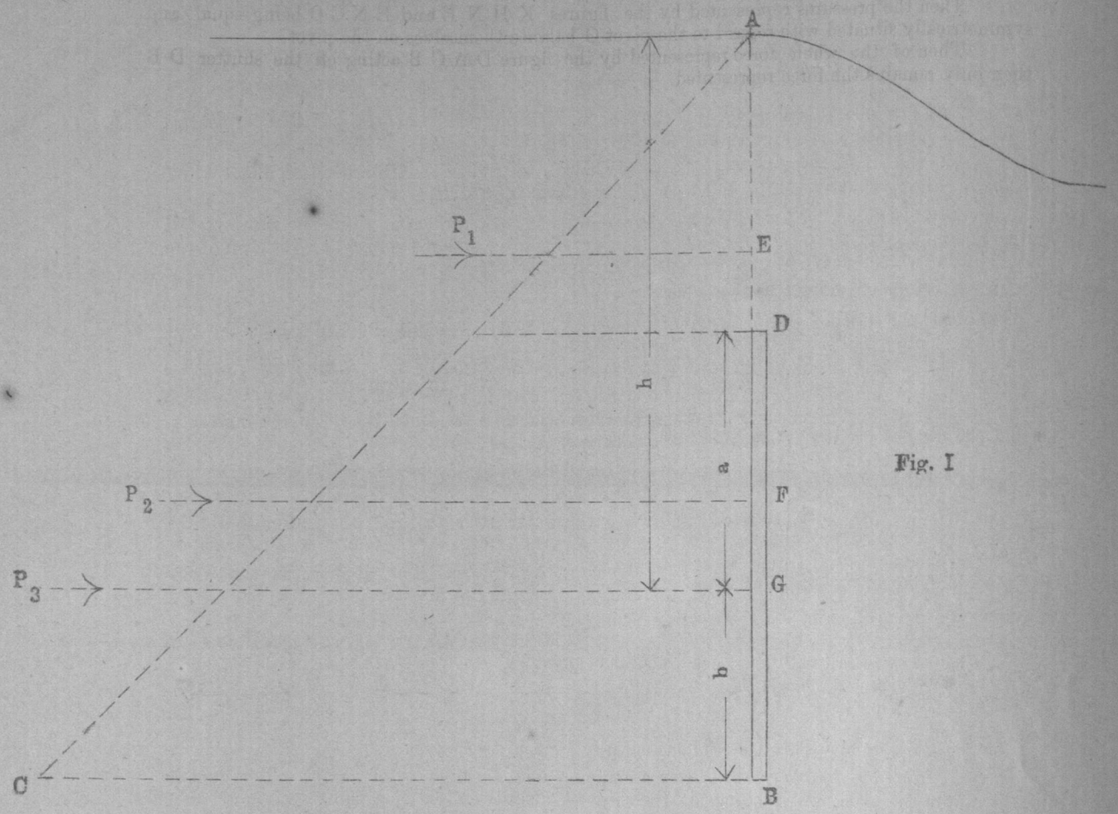


Fig. I

P_1 P_2 P_3 = water pressures on the surfaces A D, A B and D B, respectively, acting at their centres of pressure E, F, G, respectively.

G is the pivot, it being assumed that when the water is at height A, the pressure on the shutter on either side of the pivot G is in equilibrium.

Then $\frac{G F}{G E} = \frac{P_1}{P_2}$ (for the line G E is divided at F in the inverse proportion of the pressure P_1 and P_3)—

$$G F = B F - B G = \tfrac{1}{3}(b + h) - b.$$
$$G E = G A - A E = h - \tfrac{2}{3}(h - a).$$
$$P_1 = C \times A D^2 = C (h - a)^2$$
$$P_2 = C A B^2 = C (h + b)^2$$

C being a constant.

Therefore substituting—

$$\frac{\frac{1}{3}(b + h) - b}{h - \frac{2}{3}(h - a)} = \frac{(h - a)^2}{(h + b)^2}$$
$$\frac{h - 2b}{h + 2a} = \frac{(h - a)^2}{(h + b)^2}$$
$$h^3 - 3 h b^2 - 2 b^3 = h^3 - 3 a^2 h + 2 a^3$$
$$3 h (a^2 - b^2) = 2 (a^3 + b^3)$$
$$h = \tfrac{2}{3}\frac{(a^3 + b^3)}{(a^2 - b^2)}$$

Second Formulæ—*See* figure 2.

By Hypothesis—

Water press represented graphically by the figure D F E G, balances on the pivot G the press represented by figure G E O B.

Make G R = G B.

Draw R H parallel to G N.

Then the pressures represented by the figures K H N E and E N C O being equal and symmetrically situated with regard to the pivot G balance themselves on the pivot.

Then of the whole force represented by the figure D A C B acting on the shutter D B then only remains the force represented.

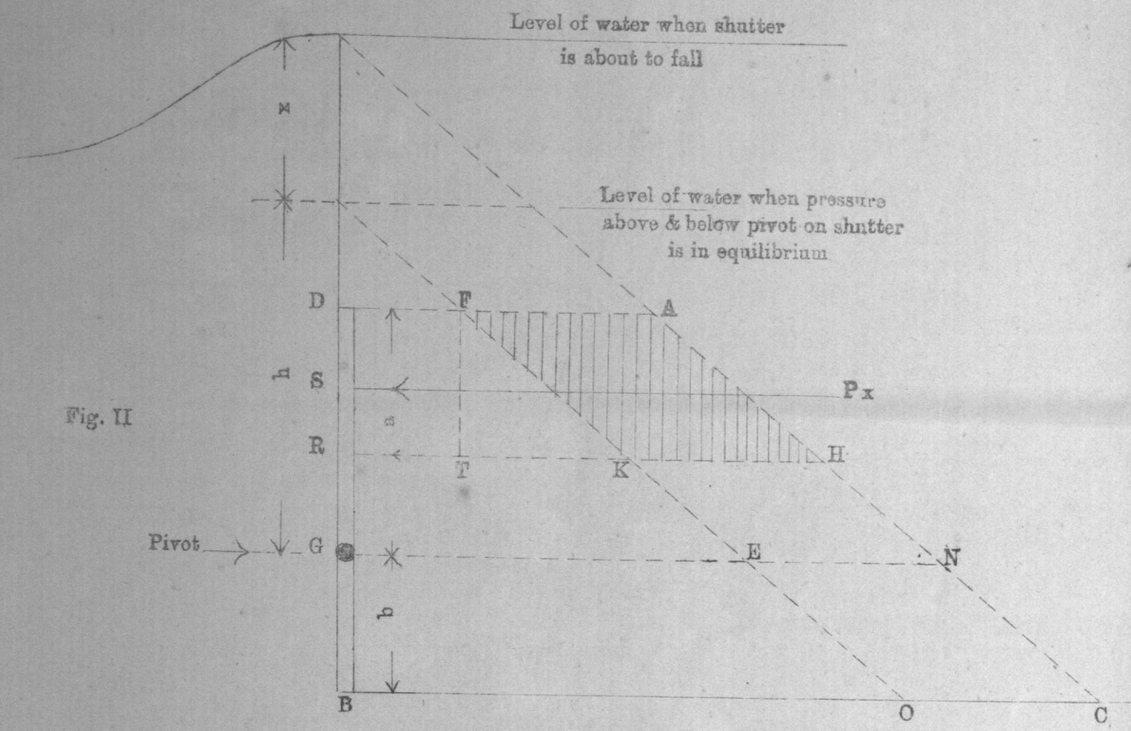


Fig. II

By the figure F A H K, which is not balanced around the pivot G, and this force acting through the centre of pressure of this figure is the force tending to overturn the shutter.

Let M be the number of lb. per foot run which will overturn the shutter if applied at 1 foot above the pivot.

Then M represents the moment required to overturn the shutter expressed in feet and lb.

$$\therefore M = Px \times G S$$
$$Px = F T \times A F \times 62{\cdot}5 = (a - b) \times x \times 62{\cdot}5$$
$$G S = a - \tfrac{1}{3}(a - b) = \tfrac{1}{2}(a + b)$$
$$\therefore M = \frac{x}{2}(a + b)(a - b) \times 62{\cdot}5$$
$$x = \frac{M}{\frac{1}{2}(a + b)(a - b) \times 62{\cdot}5}$$

62·5 lb. is taken as the weight of 1 cubic foot of water.

Calculation for height of pivots.—The total depth required to pass over the shutter before it overturns is made of (1) head required to produce equilibrium on the pivot; (2) head required to overturn the shutter.

Suppose the pivot to be $13\frac{1}{2}$ inches high.

Then (*see* Formulæ).

$a = 22\frac{1}{2}$, $b = 13\frac{1}{2}$

$h = 28{\cdot}5$. Head for equilibrium 6 inches.

Again, head for overturning—

$$x = \frac{M}{1\frac{1}{2} \times 62{\cdot}5 \times \frac{9}{12}} \text{ feet} = \left(\frac{80 \times 12 \times 12}{1\frac{1}{2} \times 62{\cdot}5} \times \frac{1}{9}\right) \text{ inches.}$$

$$= \frac{122{\cdot}88}{9} = 13{\cdot}65 \text{ inches.}$$

Head for overturning = 13·65.
Total head = 19·65 inches.

Similarly, with pivot at 13 inches—
$a = 23$ $b = 13$
$h = 26{\cdot}6$. Head for equilibrium = 3·6.

$$\text{Head for overturning} = \frac{122{\cdot}88}{10} = 12{\cdot}288 \text{ inches.}$$

Total head = 15·88 inches;

and when pivot is at 12½ inches—
$a = 23\frac{1}{2}$, $b = 12\frac{1}{2}$
$h = 25{\cdot}1$. Head for equilibrium = 1·6.

$$\text{Head for overturning} = \frac{122{\cdot}88}{11} = 11{\cdot}17 \text{ inches.}$$

Total head = 12·77 inches.

(Signed) W. M. ELLIS, Captain, R.E.,
Executive Engineer.

No. 162 I.

Note by the Chief Engineer for Irrigation.

It was decided last year, in consultation with the Inspector-General of Irrigation, to recommend the lowering of the crest of the Kistna anicut 2 feet and fit falling shutters. An estimate for the latter was called for in G.O., No. 75 I., dated 20th January 1897, and is now submitted.

2. It is believed the designs will be found in every way suitable. They have been prepared after experiments with shutters of different lengths and patterns described in the report printed with G.O., No. 641 I., dated 12th July 1897. The Executive Engineer reports on these experiments and his discussion of various points of the designs contain much information which will be found of value in preparing designs for similar work elsewhere.

3. The upper 2 feet of the anicut were removed in last hot weather and it is therefore of the utmost importance that the shutters should be fitted with the least practicable delay. The work should be completed without fail by the middle of May next and, to ensure this, it is necessary to enter into contracts at once as the Bezwada workshops cannot turn out many shutters, and the Madras workshop is likely to be fully occupied in preparing shutters for works in the Southern districts. Permission is requested to purchase iron (about 12 tons) locally for the shutters which it is proposed to make at Bezwada.

(Signed) W. HUGHES,
Chief Engineer for Irrigation.

13th August 1897.

ORDER—No. 786 I., dated 26th August 1897.

Kistna Delta System.
Kistna Northern Division.
1. Head Works.
3. Works.
Fitting shutters to the crest of the Kistna anicut.

	Rs.
I. Works	47,200
II. Establishment	10,856
III. Tools and Plant	714
Total Estimate ...	58,770

The estimate submitted by the Chief Engineer for Irrigation for the marginally-noted work is approved.

2. Fifty shutters should be made at the Government workshops, and for these the material may be purchased in India, if necessary. The remaining shutters may be obtained on contract from selected firms in India.

3. Ordered that a copy of these Proceedings, together with the plans and

estimate for the work, be forwarded to the Government of India, with a request that early sanction thereto may be accorded under "49. Capital Expenditure not charged to Revenue," Kistna Delta System.

[Here enter No. 787 I., dated 26th August 1897.]

(True Extract.)

(Signed) W. HUGHES,
Joint Secy. to Government,
Irrigation Branch.

To the Chief Engineer for Irrigation.
„ Superintending Engineer, II Circle.
„ Examiner, Public Works Accounts.
All Supts. Engrs.

ENDORSEMENT—No. 787 I., dated 26th August 1897.

Forwarded.

(By order.)

(Signed) W. HUGHES,
Joint Secy. to Government,
Irrigation Branch.

Exd. W. D'Moss.

Public Works (189) Department.

Print 200

CURRENT No. 852/

Order

From

The Chief Engineer for Irrigation

No. 162 I

78/87 39

Dated 13. 8. 97

Received 26. 8. 97

Enclosures 1 + (4 plans)

Spare copies

SUBJECT.

Fitting shutters to the Cut of Kotri Aqueduct - Note recommended for sanction the estimate for —

BACK PAPERS.

No.	Date.

FURTHER PAPERS.

No.	Date.

PUBLIC WORKS DEPARTMENT,

IRRIGATION BRANCH.

PROCEEDINGS OF THE MADRAS GOVERNMENT.

Estimate for fitting falling shutters to the Kistna anicut.

UNDER date the

READ the following

Proceedings of Govt. P. W. D. } (Ms. No 75. I. dy 20th January 1897)

Letter from the Supg Engr II. } (Ms. No 1320. K. N. dy 5. 8. 97)

Note by the Chief Engineer for Irrigation ..... } (Ms. No 162 dy 13. 8. 97)

It was decided last year in consultation with the Inspector General of Irrigation to recommend the lowering of the crest of the Kistna Anicut 2 feet and fit falling shutters. An estimate for the latter was called for in G.O. No 75. I. dated 20th January 1897, and is now submitted.

2. It is believed the designs will be found in every way suitable. They have been prepared after experiments with shutters of different lengths and patterns described in the report printed with

G.P.

21.8.97 I notice that the Draft G.O. makes no mention of the provision of 237 in Indian, of 237 of the total number of 287 shutters, which is advocated by Mr. Baddeley. Perhaps, it is intended to submit a further draft Order about this.

A.H.H. 13.8.97

The shutters are of the class of articles which it is permitted to obtain in India from selected firms. See P.W. Code II, appendix IX pp. cxxiv – cxxxii.

17.8.97

It does not seem that the portion of the Code quoted by Mr. Hughes is exactly to the point. The Code refers

G.O. No. 641. I. d/ 12 July 1897. The Executive Engineer reports on these experiments and his discussion of various points of the designs contain much information which will be found of value in preparing designs for similar work elsewhere.

3. The upper 2 feet of the Anicut ~~was~~ work removed in last hot weather and it is therefore of the utmost importance that the shutters should be fitted with the least practicable delay. The work should be completed without fail by the middle of May next and to ensure this it is necessary to enter into Contracts at once as the Bezwada workshops cannot turn out many shutters and the Madras workshop is likely to be fully occupied in preparing shutters for works in the Southern Districts. Permission is

Flagged D

refers to the purchase in India of articles usually obtained from Europe. In this particular case, it is proposed to purchase in the open market articles usually made in the P.W. workshops. The Supdt. Engineer asked that 50 of the shutters should be made in the workshops, and that the rest, 237, should be bought locally. I think this should be specifically observed in the G.O.

A.S.H
19.8.97

Para 4 (p. cxxvii) and the appendix (pp cxxx & cxxxi) were considered to permit the purchase of the shutters. The desired alteration has been made in the G.O.

W.H
20.8.97

G.O. now adopted.

A.S.H
20.8.97

Kistna Delta System
Kistna Northern Div.

1 - Head works
3. Works.

A.S.H
13.8.97

Fitting ~~Experimental~~ Shutters to the crest of the Kistna anicut -

	Rs.
I. Works ...	47,200
II. Establishment	10,856
III. Tools & Plant.	714
Total Estd Rs.	58,770.

2. 50 shutters should be made at the Government workshops and for these the material may be purchased in India if necessary. The remaining shutters may be obtained on contract from selected firms in India.

2nd S.E. W.H

To
The Chief Engineer for Irrign.
" Supdg. Engineer. 2 Circle
" Exr of P.W. accounts
" All Supdg. Engrs. Sd

This F.N. W.H 13/8/97 to be printed + debated 14/8/97

is requested to purchase iron (about 12 tons) locally for the shutters which it is proposed to make at Bezwada

No. 7863. d 26-8-97

order thereon

The estimate submitted by the Chief Engineer for Irrigation for the marginally noted work is approved ~~as~~ Iron not exceeding 12 tons may be purchased in India if necessary

32. Ordered that a copy of these Proceedings, together with the plans and estimate for the work, be forwarded to the Government of India, with a request that early sanction thereto may be accorded under "49 Capital Expenditure not charged to Revenue," Kistna Delta System.

13.8.97 W.H
No. 7873. d 26-8-97
Forwarded.

W.H
copies with enclosures and details & plans

E. I. Form No. 1—500—3-12-96.

Letter from Captain Wm. Ellis R.E. Exec Engineer, Kistna Northern Div. to the Supdg Engineer, 2nd Circle, dy 23.7.97, No. 295 S.E.

I herewith forwarded for your approval an estimate for the Falling Shutters, Kistna Anicut, amounting to Rs 46,700. The cost of each Single Shutter 10'x3' in the Beyvada work shops is estimated at Rs 90/-

I would point out, however, that this estimate supposes that iron of the most suitable ordinary trade sizes and lengths are used.

For instance if instead of sheets 10'x3' Sheets 8'x3' are supplied, the cost will be increased owing to extra labour involved and the outturned Shutter will not be so satisfactory.

A similar remark may be taken to apply to the other iron sizes shewn.

2. The rapidity of construction as well as the satisfactory outturn of the work will depend a good deal on the absolute uniformity in construction of each shutter and I would protest against an attempt to work in different sizes of iron into different shutters in order to avoid ordering locally the proper sizes or to utilize the existing

* corrected in S.E.'s Office to Rs 47,200.

* — do — 1892.

existing stock. I do not mean that I would offer any objection to a general change of scantlings such as say 3" × 3" angle iron for 3' × 2" or 7/8 sheet instead of 3/16 sheet, but I maintain that whatever scantlings are selected, uniformity of construction should be insisted on.

3. I estimate the shops here could turn out 15 shutters complete per month from the date of Iron being available and I am informed demi-officially that the madras shops can turn out 20 shutters a month.

I have written to the General Superintendent to find out for how many shutters he has a stock of materials.

4. I would suggest with reference to the construction that permission to purchase locally the necessary material not available be obtained from Government the matter being one of great urgency and also that orders be given to private firms for such shutters as cannot be turned by the madras and Bezwada Shops by the 31-1-'98.

I have called for tenders from Messrs. Richardson & Cruddas and from Messrs. Bara & Co but I have not yet received a reply.

5. I would urge on you the danger of ordering the material for the shutters not available in the Government Stores from England through the India Office, owing to the urgency of the matter and the great importance of every month remaining to us if the shutters are to be erected next working season.

6. I have already with your approval made contracts for the supply of the necessary granite stone and propose to take this or to my stock when received pending sanction of the estimate and provision of funds.

(True Copy)

Mr Baddeley
Major R.E.

Supdg Engr 2nd I. Circle.

No 8/3/97.

Letter from Messrs Burn & Co, Howrah to the Executive Engineer Kistna Northern Division No. H.Q./9029 d/ 24-7-97.

Your No. 726 of 15th instant, with drawing of Sealing Shutters.

We understand that we do not include the way plates or the stop blocks with their bolts - all other iron work to be supplied by the Contractor We Estimate the weight of each 10 ft Shutter complete at 4½ cwts and in 1000 ft there will be 450 cwts or in 2000 ft 900 cwts.

Rs 64 per Shutter

We have much pleasure in offering to undertake this work delivered in Bezwada at Rs 14-4 per cwt. With reference to time, 4½ months delivered at Bezwada means about 3½ months here. This time is ample if we could be sure of having or being able to procure locally sufficient raw material of the sizes required. It is doubtful if 2000 sheets of iron one size or even 1000 would be available. We are quite willing to ensure the material being all in stock if you will let us know as soon as possible that our rate is approved of and that the order will ultimately be sent us.

In that case we could guarantee delivery within the time & on the penalty of Rs 26. (Rs twenty five) per 10 ft. Shutter short delivered. The penalty is quite 50 % of value of shutter. We could guarantee a first class job, as we have splendid plant for this class of work, including plate and angle, straightening machines and hydraulic riveters &c. We hope to hear that you approve of our Estimate when we will at once take steps to ensure having sufficient material of correct sizes. We can supply the shutters either made of mild steel or iron and would like to know which you prefer.

(True Copy)

Wm. Mc Cabe
30/7
Executive Engineer
Kistna Northern Div.

30/7/97

O.W.S.G. 85-27/87

SUPG. ENGINEER'S OFFICE, No. 31 JUL. 97 RUD SECTION

CHIEF ENGINEER FOR IRRIGATION. 2 AUG. 1897

Letter from Captain W. Mc Ellis R.E. Executive Engineer, Kistna Northern Div. to the Supg Engineer, 2nd Circle, dy 31st July 1897, No. 314 S.E.

In continuation of this Office letters No. 247 S.E. dy 5.7.97 and 295 S.E. dy 23.7.97 submitting a note and an Estimate with report for the Falling Shutters, Kistna Anicut, I have the honor to report that I have now received quotations of rates for the outturn of the Shutters from every quarter from which a quotation was asked and submit the same for your information and request early orders.

2. The quotations for one shutter complete with 3 connecting bars 6 turned bolts, and 3 forged jag bolts with jaws to fit end of connecting rods are as under.

(1) P.W. Workshops, Madras, inclusive of Cartage Charges and delivered in Madras. Rs 85

Carriage - Madras to Bezwada - 500 lbs — 3 " 2

Total Madras Workshops. 87

2.

2. Bezwada, P.W. shops. Rs 85

3. Messrs. Richardson & Cruddas (Bombay) delivered in Bezwada } 75

4. Messrs. Burn & Co. (Calcutta) delivered in Bezwada Rs 14/4 per Cwt. 4½ Cwt. = 64

I have written to Messrs. Burn & Co and Messrs. Richardson & Cruddas to make at once and despatch to me one Shutter complete as a sample.

3. The tenders of private firms are, it will be seen, much less than the cost of making the Shutters in Government Shops.

This was anticipated in my note referred to but the difference is even greater than I thought it would be. It is to be noted that both private firms are willing to bind themselves to a reasonable time limit with a penalty for failure.

4. I cannot give any detail regarding the estimates of other establishment but I note below the details of the Estimate of the Bezwada workshops from which it will be seen that the actual estimated cost of labour and material is Rs 69/8, the balance being made up by Establishment charges which are in a fashion returned to Government.

The return however is made to Provincial Funds, whereas the charges would be made to the Krishna Delta System.

1 Shutter	Rs 50 – 0 as.
3 Connecting rods	6 – 8
3 Jagged bolts	5 – 5
6 Steel turned bolts	5 – 7
Sundries —	2 – 4
	69 – 8
General Charges 1½%	1 – 0
Establishment T & P.	14 – 8
	85 / –

5. The total number of Shutters required is 287 and I most strongly recommend that 237 Shutters be got from a private firm (Messrs. Burn & Co, if the Sample Shutter is satisfactory) leaving 50 to be constructed in the

the Beypore workshops; this with the way plates stop blocks and bolts will give the Work shops quite sufficient work to prevent stagnation.

The Madras P.W. Shops have, I believe, already a lot of work and in view of the high rate quoted I do not recommend that we should get any shutters from there.

The Saving on the estimate rate of getting these shutters from Burn & Co will amount to Rs 18/- per shutter, a total for 237 Shutters Rs 4266.

The extra cost of getting Shutters from Madras Workshops on the estimated rate would be Rs 2/- per shutter.

6. It is a matter of importance that orders be passed early on this subject as there may be some difficulty as regards material. I enclose the letter of Messrs: Burn & Co which represents matters clearly.

I most strongly recommend that I be authorized to place an order with Messrs: Burn & Co subject of course to a Satisfactory and binding agreement being entered into by that firm.

/True Copy/

W. Baldwin
Major R.E.
Supg Engr: II Circle.

D.
3/8/17.

CHIEF ENGINEER'S OFFICE
FOR IRRIGATION
7-DEC 1897
No. 209 KS

III

3

Print

1894

Report to accompany Estimate for erecting Falling shutters on the Kistna Anicut.

RECEIVED IN THE SURVEY OFFICE
ON
7-SEP 97
MADRAS

The type of shutters proposed for adoption is similar in action to the Hourdons Tumbler shutters erected on the Sone weir in Bengal, there are however differences in detail :—

The shutter proposed is 10 foot long by 3 ft high with 1" round connecting rods 3' 1" long from Centre to Centre of pivot bolts.

The material difference in the design from the shutters used on the Sone are two.

(a) The shutter travels on 3 plate Iron ways 4" wide fixed on the anicut, and on these ways, Gunmetal plates fixed to the shutter slide, whereas on the Sone weir the bottom angle iron was placed along the bottom edge of the shutter and the edge of this scraped along the stone bed, on which the shutter rests, throughout its whole length when the shutter falls or is lifted.

OL 5.5
83-91 (17)

This renders necessary a greater force to lift the shutter, and irregular action in falling

(b) The joint to seal the escape of water between the anicut and length of the shutter is formed on the sone by the angle iron resting on the stone sill as above mentioned.

The design for the Kistna Shutters provides for a joint formed by the edge of the angle iron forming the lower stringer of the shutter butting against a continuous wooden block (backed by stone) which performs the double duty of stop block and water joint. The advantage of this is that the water pressure itself tends to close the joint and the lower the water falls (within limits) the tighter becomes the joint.

Experimental Shutters

Three types of shutters were erected on the anicut in April and May last viz:-

(1) The Sone type with L iron forming bottom stringer resting on a stone sill

(2) a shutter, curved plates fixed at intervals to the bottom of the shutter and sliding on 4" wide plate iron ways fixed on the anicut crest. This is the type now selected for adoption.

(3) Similar to (2) but with 3" cast iron rollers in place of curved plates. Details of all these shutters. 44 in number and of various lengths from 8 ft to 19 ft are given in the Estimate for the erection of the work

Notes regarding experiences with experimental shutters.

The drawings with this Estimate give full details of the shutters selected as the best suitable, and the following notes give a few experiences with the experimental shutters, and by inference the reasons which have led to the present design.

Size of Scantlings of Frame.

Calculations were made to proportion these exactly to the work they had to do in order to cut down the weight as far as possible.

Experience has shewn that the weights of the shutter bears

a small proportion to the force required to lift it as in addition to the shutter, the water laying on it must be raised.- For instance a men can raise a 16 ft x 3 ft shutter without any water going over, but 8 men are required to raise the same shutter with 9 inches of water passing over it.

There was noticed a great tendency for the shutters to buckle out of a plane which caused much trouble and delay when making.

The Scantlings of the angle iron Stringers have been increased from $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$ to $3 \times 2 \times \frac{3}{8}$ in Consequence.

Force required to lift.

This has been tried with 9 Inches of water passing over the shutters, by raising by hand, the men lifting in a row from the down stream side of the shutter.

19 Foot Sone Pattern shutter
14 men raised with difficulty
12 Foot Sone Pattern shutter
10 men raised with difficulty

16 Foot Roller shutters
10 men raised one easily, one with some difficulty.

16 Foot curved plate shutters
10 men raised with some difficulty.

8 Foot curved Plate shutter.
4 men Raised.

14 Foot — do — do —
8 men raised with difficulty.

Force required to overturn.

When 1 foot of water was held up by the shutters the numbers of men required to overturn the shutters were as under

16 Foot Roller shutter
4 men to one shutter 3 men to another.

16 Foot curved plate.
4 men with difficulty

8 Foot — do — do —
2 men

14 Foot — do — do —
3 men

The Sone pattern shutters took one man for every 2 running feet to pull over

Head required to overturn the Shutters.

The depths of water required to overturn the various types of shutters as noted from actual observation is ~~noted~~ stated below.

Depth of water in Feet passing over Shutter.

Sone Patton	1·1	1·3 — 1·3	— 1·4
	·65	1·25	·8

The general level for falling ~~same~~ say about 1·20.

It is to be noted that 2 Sone shutters did not fall with a 6 feet head and fell only after several days of flood on a falling river with 5 feet of water passing over the shutter.

The cause of this is still unknown

Depth of water in Feet Passing over shutter

Roller pattern shutters	·35	·5 ·5	·15
	·25		

Say .35 as an average.

The rollers of the last 2 shutters mentioned were given much more play than those of the 1st two — this accounts for their falling so much easier.

Curved plate pattern Shutter.

Depth of water passing over shutter in Feet.

·75
·8
1·0

This gives an average of about .9 and a corresponding force of roughly 80 lbs per foot run applied at one foot above the pivot is required to overturn this pattern shutter.

Leakage under the Shutters.

This was found to be less when the joint was made against the Continuous stop block than in the Sone pattern shutter and it could be still further reduced by more careful fitting against the wood Stop block.

Leakage at Ends.

The roller shutters leaked round the rollers where as the curved plates are free from this defect.

Leakage at Ends

This was insignificant. — On the adjacent ends of different shutters was bolted a block 5"×2". and this was cut down the joint by a coarse saw. This seems satisfactory but needs further trial but in any case leakage here can be reduced to very small proportions.

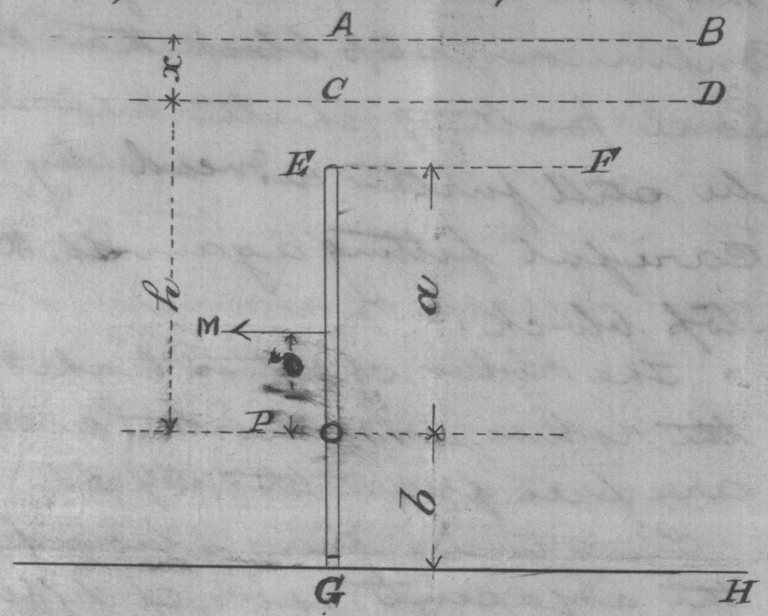
Rollers.

The rollers make shutters a little easier to work than curved plates but are more costly — ~~need more repairs~~ leak more and will require more repairs.

The cupped plate is consequently preferred.

Formulae

The formulae used for calculating the position of the pivots are noted below — the proof of these formulae are given with this report.



If A B be the level of water at which the shutter over turns when pivotted at P, C D the level of water which transmits such pressure to the shutter that the pressures on either side of the pivot are in equilibrium. $h = \frac{2(a^3+b^3)}{3(a^2-b^2)}$

If M lbs be the force per foot run applied at a level of 1 foot above the pivot tending to overturn it

Then $x = \frac{M}{\frac{1}{2}(a+b)(a-b)\times 62.5}$ feet.

lbs 62.5 being taken as the weight of 1 c.f. of water

Pivots. Height of—

It is proposed that the pivots of the shutters be so arranged that the central 700 feet of shutters shall fall with a head of about 1 foot. The 700 feet on both sides of this central length should fall with a head of about 1'-3" inches and the remaining shutters should fall with a head of about 1-6".

The object of this is to introduce some uniformity into the order in which the shutters fall and to ensure the water level on a rising river never falling below the level of the tops of the pivoted shutter which is sufficient to provide for all requirements of supply.

The way this will work is noted below.

When all the shutters are up the river rises to 1ft over their top, the central 700 ft will fall — (not all altogether but before the other shutters fall.)

The discharge of the notch 700 ft long so formed is when the water is at level of tops of shutter

equal to the discharge of the
Amicut whole length 1 foot deep.
The river will therefore fall to
about crest level of shutter.
No more shutters will then fall
until the discharge increases
so that, the water rises to 1-3
above the shutters.
2 more lengths of 700 feet will
then fall and the water level
will in like manner again fall
to about crest level of the Shutters.
The balance of the shutters
will fall when the water
rises to 1'6" above the top
of the shutters.
The discharge then will
be about 64000 cusecs. which
is sufficient to maintain
the water 3 feet deep on the
crest of the amicut when all
the shutters are down.
The calculated pivot heights
to carry out the above are

Shutters to fall with	Height of pivot
1'6" head	Inches 12½
1-3"	13
1	12½

Lifting the Shutters.

This has been successfully

409

Lifting by Floating Crane.

tried in 2 ways.
(a) From a crane mounted on
the bows of a punt. The punt
is floated up in the slack water
along side the shutters already
raised or a short length of
crest wall to be built at each
end of the Amicut for the purpose.
A bridle chain is hooked on to the
shutter and the shutter raised
by the crane.
The punt is then moved along
and each shutter similarly
raised in succession. The
shutters without difficulty have been thus raised
with 2 feet passing over the crest.
Provision has been made
for ring bolts let into the crest
at every 10 feet. to fasten on ropes
to holding the lifting punt
as she is moved along the crest
raising the shutters.
If it is decided that raising
by the next method is more
satisfactory these will be
omitted.

Lifting with levers
from the rear.

Crowbars and bamboos
are inserted under the shutter
as it lies on the crest, and the

shutter is so raised by a number of men wading in the water in rear of the shutter.

This has been carried out with 16ft shutters by 16 men provided with levers when 16" inches of water was passing over the crest without difficulty.

Masonry of crest

It will be noticed that the 2'-6" broad raised front of the crest is a wall with granite edging and concrete heart. This has been adopted

(1) Because of the facilities for bedding anchor bolts it affords.

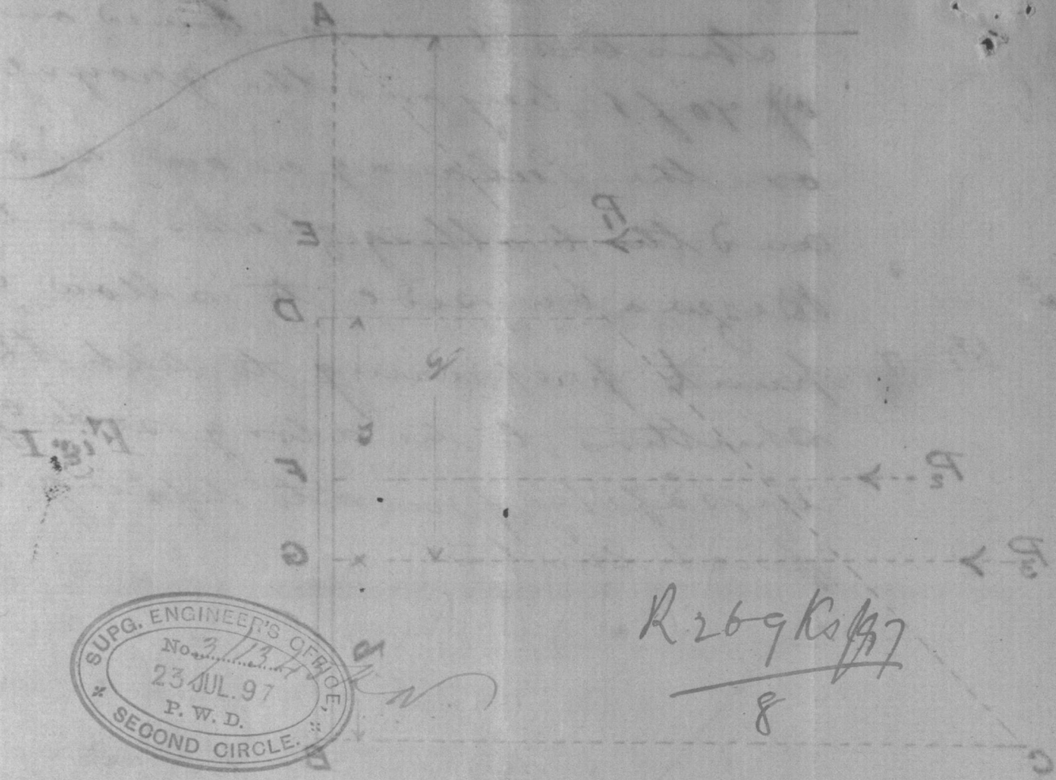
(2) Because of the difficulty of getting 2'6" stones of 1 foot thickness to lay on the crest.

(3) Because this form of wall answered admirably in the old raising except that the facing Bezwada stone became worn. Granite facing is now provided.

Flanks at either end of the shutters.

A wall of the height of the shutters when raised provided with a curved concrete apron in rear raised up to the crest is provided for at either end to join the slope of the undersluices.

This wall is continued out for 70ft beyond the groyne on the Pedavagrum side and the bathing ghats on the Bezwada side to allow a punt preparing to lift the shutters to lie along side of it in safety prior to lifting the first shutter.



SUPG. ENGINEER'S OFFICE,
No. 3113
23 JUL. 97
P. W. D.
SECOND CIRCLE.

R 269 Ks 87
8

Proof of Formulae given.

Sh Formulae.

Fig I

Page 6

P_1 P_2 P_3 = water pressures on the surfaces AD, AB and DB respectively acting at their centres of pressure E, F, G respectively

G is the pivot, it being assumed that when the water is at height A, the pressure on the shutter on either side of the pivot G is in equilibrium.

Then $\frac{GF}{GE} = \frac{P_1}{P_2}$ (for the line GE is divided at F in the inverse proportion of the pressures P_1 and P_3.)

$GF = BF - BG = \frac{1}{3}(b+h) - b$

$GE = GA - AE = h - \frac{2}{3}(h-a)$

$P_1 = C \times AD^2 = C(h-a)^2$

$P_2 = C\ AB^2 = C(h+b)^2$

C being a Constant.

$\int_0^a (h-x)x$

$= \int_0^b (h+x')x'$

$\frac{ha^2}{2} - \frac{a^3}{3} = \frac{hb^2}{2} + \frac{b^3}{3}$

$\therefore h = \frac{2}{3}\frac{a^3+b^3}{a^2-b^2}$

1. Substituting

$$\frac{\frac{1}{3}(b+h)-b}{h-\frac{2}{3}(h-a)} = \frac{(h-a)^2}{(h+b)^2}$$

$$\frac{h-2b}{h+2a} = \frac{(h-a)^2}{(h+b)^2}$$

$$h^3 - 3hb^2 - 2b^3 = h^3 - 3a^2h + 2a^3$$

$$3h(a^2-b^2) = 2(a^3+b^3)$$

$$h = \frac{2}{3}\frac{(a^3+b^3)}{(a^2-b^2)}$$

2nd Formula.

See figure 2

By hypothesis.

Water pressure represented graphically by the figure DFEG, balances on the pivot G the press represented by figure GEOB

make GR = GB

Draw RH parallel to GN

Then the pressures represented by the figures KHNE and ENOO being equal and Symmetrically situated with regard to the pivot G balance themselves on the pivot.

Then of the whole force represented by the figure DACB acting on the ~~forward~~ shutter DB then only remains the force represented by

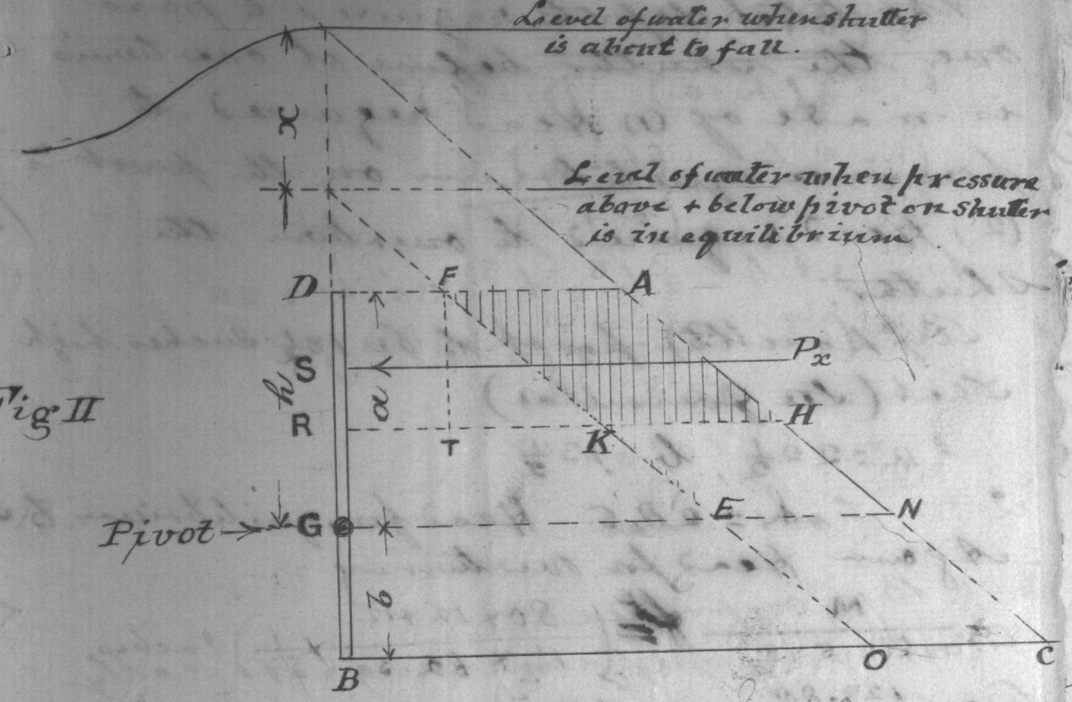


Fig II

By the figure FAHK which is not balanced around the pivot G and this force acting through the centre of pressure of this figure is the force tending to overturn the shutter.

Let M be the number of lbs per foot run which will overturn the shutter if applied at 1 foot above the pivot.

Then M represents the moment required to overturn the shutter expressed in feet + lbs.

$$\therefore M = P_x \times G_1S$$

$$P_x = FT \times AF \times 62.5 = (a-b) \times x \times 62.5$$

$$G_1S = a - \tfrac{1}{2}(a-b) = \tfrac{1}{2}(a+b)$$

$$\therefore M = \frac{x}{2}(a+b)(a-b) \times 62.5$$

$$x = \frac{M}{\frac{1}{2}(a+b)(a-b) \times 62.5}$$

62.5 lbs is taken as the weight of 1 cft of water

Calculation for Height of Pivots

The total depth required to pass over the shutter before it overturns is made of (1) Head required to produce equilibrium on the pivot (2) Head required to overturn the shutter. 1869

Suppose the pivot to be 18½ Inches high.

Then (the formulae)

$a = 22\frac{1}{2}$, $b = 13\frac{1}{2}$

$h = 20.5$ Head for equilibrium 6 Inches.

Again Head for overturning

$H = \frac{M}{1\frac{1}{2} \times 62.5 + \frac{9}{12}} \left(\frac{80 \times 12 \times 12}{1\frac{1}{2} \times 62.5} \times \frac{1}{9} \right)$ Inches.

$= \frac{122.88}{9} = 13.65$ Inches

Head for overturning = 13.65.

Total head = 19.65 Inches.

Similarly with pivot at 13 Inches.

$a = 23$ $b = 13$

$h = 26.6$ Head for equilibrium = 3.6

Head for overturning $= \frac{122.88}{10} = 12.288$ Inches.

Total Head = 15.88 Inches

and when pivot is at 12½ Inches

$a = 23\frac{1}{2}$ $b = 12\frac{1}{2}$

$h = 25.1$ Head for equilibrium = 1.6

Head for overturning $= \frac{122.88}{11} = 11.17$ Inches.

Total head = 12.77 Inches.

Wm. Ellis
Captain R.E.
Executive Engineer

20/7/97

Drow 2

SUPERINTENDIND ENGINEER'S OFFICE,
SECOND CIRCLE, Bezwada

No. 1320 K.N. Dated 5 August 1897

From, Major W. L. C. Baddeley R.E.
SUPERINTENDING ENGINEER,
II CIRCLE.

To,
The Chief Engineer,
For Irrigation,
Madras.

Enclos: 11

Sir,

In reference to G. O. No. 75 I. dy 20th January '97 I have the honour to forward complete proposals for fitting falling shutters to the crest of the Krishna Anicut. The estimate is Rs 47,200.

The following papers are forwarded,

i. Note by Captain Ellis R.E. dy 4th July 1897 on various points raised in demi-official correspondence about the shutters.

ii. Letter No. 295 S.E. of 23rd July '97 from the same Officer forwarding

forwarding

4 plans.
1 D & A. Estimate.
1 Data Sheet.
1 Report.

iii. Letter No. 314 S.E. of 31st July '97 from the same officer giving the results of his enquiries regarding the rates at which the shutters could be made.

2. Captain Ellis has worked out his proposals with much care, and in great detail, and the conclusions he arrives at regarding the advisability of procuring 237 Shutters from Messrs. Burn & Co and the balance, viz, 50 from the Bezwada workshops, have my strongest support.

3. The height of the Kistna Anicut is at the present time insufficient for the large acreage of the System, and it is most essential that the Shutters should all be fixed by next irrigation season.

4. If we rely on the Government Workshops, I am certain that the Shutters will not be ready in time, and I trust that I may receive very early orders to put the work in hand according to Captain Ellis' proposals.

5. I should be glad if orders could be sent to me by wire as soon as the estimate is approved, for every week's delay is of importance.

I have the honour to be,
Sir,
Your most Obt Servt.

Lee Baddeley
Major R.E.

Supg Engr. 1st Circle.

3/8/97

DUPLICATES
FOR INFORMATION.
7-JAN-1997
No. 269 KS