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Government of Madras

Public Works

DEPARTMENT

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27-11

195

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Read the following papers :—

No. 613. From Major J. BEATTY, R.E., Acting Superintending Engineer, Godavery District, to Lieutenant-Colonel J. MULLINS, R.E., Chief Engineer for Irrigation, dated Dowlaishweram, 29th October 1875, No. 2,240.

I HAVE the honor to send you, herewith, six statements showing the additional information collected up to date from cement* experiments at Dowlaishweram; also a letter from the Assistant Engineer in charge of the Western Delta bringing to notice his experience in the use of surki, and the difficulties in the way of its general use from the want of some good means of reducing the burnt cakes to a fine powder.

1 Report by Lieutenant Dorrard.
5 Statements marked A to F.
* *Vide* G.O., No. 174, of 21st January 1875.

2. The statement marked A was prepared with a view to showing the effect of burning the different limestones found in the Kátér quarries, from which the Dowlaishweram kilns are supplied separately and together; and, secondly, whether any advantage would be gained by breaking up the limestone to a smaller size than has been customary hitherto, *viz.*, the 2½ inch size. The same quantity of firewood and limestone was used in each case, and it will be observed that the crystalline limestone produces the largest quantity of hydrate of lime at the first burning. It is also best to break up the limestone into pieces, the size which will pass through a ring of 2½ inches diameter, in preference to breaking it smaller or leaving it unbroken in lumps as brought out of the quarry.

3. The statement marked B shows the cost of preparing burnt clay in cakes and grinding them by the two machines hitherto tried, and it is found that Wells' patent mill is of very little use. The explanation is, I suppose, that surki in Northern India is used instead of sand, and that the mill was intended to produce a powder resembling Godavery sand, and not to reduce the burnt cakes to the consistency of the finest flour. I wrote to Mr. Wells on the subject, but have had no reply. The Upper Godavery mortar-mixing machine is the best means of grinding yet tried. The clay now used is Godavery silt taken from a channel where there is no current and a great deposit. It is taken a few inches below the surface. Soil from a tank bed was also tried, but with much the same result.

4. Statement C† shows, first, the result of making bricks of common mortar; and, secondly, of making them with cement and different admixtures of fine and coarse sand.

† *Vide* postscript.

5. Statement D shows the cost of concrete blocks made of lime, sand, and small stone. This statement was framed by Mr. Chancellor from information on record in the range office, being the results of experiments made here some years ago, when the price of lime was considerably greater than at present. Within the last year the price has been reduced by the exertions of the Ancient Superintendent to 10 Rupees a garce of 60 parabs, and is now delivered at that rate at Dowlaishweram.

6. Statement E shows the probable cost of the best Dowlaishweram cement; composed of two parts of lime to three of fine surki, ground by our Upper Godavery mortar-mixing machine.

7. Statement F shows the probable cost of concrete blocks made of cement, sand, and small stone. Such blocks may hereafter be useful, but the quarries are

still yielding an abundant supply of stone, which must be better than any concrete; blocks might, however, be used for copings instead of cutstone, as was done in the Upper Godavery.

8. The experiments are still, I regret to find, incomplete, but I have thought it best to record at once the progress made and to state what I consider still wanting.

9. More experiments are wanted in the mixtures of the two kinds of cement with different proportions of sand before we can finally decide on the best mixture of each kind for different kinds of work; (2) as some additional strength is gained by making the cakes with lime and raw clay and then burning and grinding them, while this method will doubtless also be the cheapest, because the mixture of lime in the cakes will render pulverization easier, experiments are needed to ascertain the cost of the cement when ready for use by this method; (3) experiments should also be made on the strength of concrete blocks composed of cement, sand, and small stone; and (4) it will be well to ascertain whether surki deteriorates materially by keeping for a month or so.

10. I may mention that the difficulty pointed out by Lieutenant Dorrard, *viz.*, the want of a better means of grinding does not appear to have been felt by Colonel Haig on the Upper Godavery, where cement was always used, and the masonry is probably among the best of its kind to be found anywhere; the Inspector-General of Irrigation said he had not seen better in India.

11. The method adopted in the manufacture of cement on those works was as follows:—

I.—The limestone was broken into pieces small enough to pass through a ring 3 inches in diameter.

II.—It was then burnt slowly in a kiln.

III.—It was next slaked and sifted.

IV.—The lime after sifting was mixed with black clay in the proportion of one to one, and then well ground in a mill, *i.e.*, in one of the Upper Godavery mortar-mixing machines, driven by a portable steam engine. All the mortar-mixing machines at the Upper Godavery works were driven by steam-power.

V.—The mixture of lime and clay was then made into rough round cakes about 7 inches in diameter by $1\frac{1}{2}$ inches thick, and the cakes were spread out on the ground to dry. When well dried they were stored in a large shed until required for use. The cakes had of course to be burnt in order to make cement, but, as the cement deteriorated by keeping, the cakes were not burnt until the cement was required for use.

VI.—When the cement was required, the cakes were put into a kiln (a cylindrical kiln of the ordinary pattern) except that the interior diameter was 16 feet and the height 8 feet. The kiln was packed with cakes and firewood in alternate layers.* One layer of wood, small, to one layer of cakes of the same thickness.

VII.—The kiln was then lighted at bottom and allowed to burn itself out. If properly burnt the cement was of a reddish pink color; if half burnt, grey; if unburnt, dark, bordering on black. Only what was of the proper color was sent to the works.

VIII.—The cement, thus prepared and freshly burnt, was mixed with an equal quantity of clean sharp river sand, and the mixture well ground in the mortar-mixing machine; this machine was close to the site of the work on which the cement was to be used.

IX.—The masonry was kept constantly moist during the day, by frequent waterings, for about one month after it was built.

X.—The refuse of the siftings made excellent cement, but grinding it was found to be very destructive to the mills.

XI.—The weight of the cement thus made was—

1. Pure cement	...	...	106.66 lbs. per C. ft.
2. When mixed with sand (one to one)	...	...	117.33 lbs. per C. ft.
3. Cement in powder	...	...	54 lbs. per C. ft.

12. But it must be explained that there are no small works at Dumagudiem. The masonry works there are only four in number and of great size—(1) an ancient a mile long with long wings that rise 34 feet above the level of the ancient crest; (2) a set of fourteen scouring sluices in a body wall 224 feet long by 36 feet high, with wings each $143\frac{1}{2}$ feet long by 42 feet high; (3) a head lock 30 feet broad by 200 feet long with flood gates $38\frac{1}{2}$ feet high; and (4) a double lock having chambers of the same dimensions as the head lock and gates 20 feet high.

13. For our Delta works it will probably be found best to make surki, as well as the dried cakes of lime and raw clay, in large quantities at the head-quarters of the range, issuing surki for use on small works only, and grinding up the cakes on large works by a mixing machine as was done at Dumagudiem; at least until some better means of grinding is invented.

P.S.—Throughout the experiments shown in statement C, bricks of each mixture were tested in three different ways; first by sun-drying; secondly by air-drying in shade; thirdly by immediate immersion. Where no results are recorded, it is to be understood that the bricks cracked at their weakest part before being tested; this was the case with all the air-dried bricks.

From Lieutenant A. E. F. DORWARD, R.E., Assistant Engineer, in charge No. 3 Range, Godavery District, to Major J. BEATTY, R.E., Acting Superintending Engineer, Godavery District, dated Godavery, 4th September 1875, No. 259.

I have the honor to bring to your notice the subject of using surki in mortar for masonry works. The cost in this range for surki is generally—

Coarsely ground surki	...	...	Rupees 15 per garco.
Very finely	...	...	25 " "

Even coarsely ground surki is therefore more expensive than lime. When lately in Dowlish-waram Captain Brockman informed me that he could not by any means known to him produce surki at a cheaper rate than Rupees 15 per garco. He also told me that for this rate he could only produce coarsely ground surki; so the rates in the two ranges are similar.

2. There are two great drawbacks to the extensive use of surki,—first its cost; second the great length of time which it takes to turn it out in any quantity.

The coarsely ground surki is much inferior to the finely ground, and adds very little to the strength of the mortar; I have, therefore, quite given up using it. The very finely ground surki, however, is used extensively. I have tried various mixtures and lately have used a mortar of 1 lime, $1\frac{1}{2}$ surki and 6 sand for small brickwork, and am well satisfied with it. The cost of this

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27th November 1875.

mortar, as compared with that previously used in the range, viz., 1 lime to 2 sand, is as 5 to 6; owing, however, to the slowness of the manufacture of surki, the cost of supervision is increased. In Koder lock walls a mortar of 1 lime, 1½ surki and 3 sand has been used, and with excellent results as far as strength of work goes. It is more expensive, however, than the ordinary lime mortar, and its use has delayed the work; in fact, the progress of a work is now regulated by the supply of surki.

3. To cheapen the mortar I have in some cases reduced the quantity of surki, but found that while a cement of 1 lime and 1 surki was nearly as strong as 1 of 1 lime and 1½ surki, the former was weakened much more than the latter by admixture with sand. I have only the roughest means of testing strength; but I believe, if tried with the machine at Dowlaishweram, this will be found to be the case, and if so it will show that sand is not a mere diluent. I am also nearly certain that a mortar of 1 lime and 1 sand is stronger than one of pure lime; a few experiments at Dowlaishweram would settle this point, and, if this be found to be the case, I do not think that it can be accounted for by mere mechanical action.

4. I believe surki is extensively used in upper India, and I should be obliged if you could get me a description of their method of preparing it, with the cost. I think a cheap way to manufacture it would be by a water wheel working hammers; it would be a very convenient power to work at Chettipett, where there is a considerable head of water available. I have not sufficient time to work out the details of such a machine, as having no practical experience of water motors, I could only gain knowledge by failure. I think the difficulties that stand in the way of the general use of surki should be brought to the notice of the Chief Engineer for Irrigation. I propose using a mortar of 1 lime, 1½ surki, and 4 sand for the concrete in foundations of the works at Palkolo. Such a mortar sets fairly fast and is amply strong.

5. As surki deteriorates by keeping I cannot make it long beforehand, and shall probably lose the advantage of decrease in cost of buling caused by its use, through delay in getting in the concrete.

6. I am anxiously awaiting the result of the Dowlaishweram experiments as to the best mortars to use for various descriptions of masonry work, and hope that you will soon be able to give me some positive information on the subject.

A.

Statement showing the Results of Experiments on burning different sorts of Limestone at Dowlaishweram Lime Kiln—11,664 Parahs equal 1 Cubic Yard.

	Limestone in Parahs.	Fuel in Cubic Yards.	Lime in Parahs.	Unburnt Limestone in Cubic Yards.	Remarks.
Stone, large, without breaking...	35	6	*39	$\frac{5}{8}$	* These are the quantities found after slaking. † The sizes here given are those which will pass through rings of 1½" and 2½" diameter.
Stone, crystalline, 2½" size† ...	35	6	52½	$\frac{1}{2}$	
Do., do., 1½" size ...	35	6	42	1	After repeated burnings the Kater limestone leaves no residuum, the second burning usually turns what was left at the first burning into lime.
Do., semi-crystalline, 2½" size...	35	6	45	$\frac{1}{2}$	
Do., do., 1½" " ...	35	6	39½	$\frac{1}{2}$	
Stone, non-crystalline, 2½" " ...	35	6	42	1	
Do., do., 1½" " ...	35	6	38	$1\frac{1}{8}$	

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27th November 1875.

B.

Statement showing the rates for making Surki by different methods—11,664 parahs make 1 Cubic Yard.

Description.	Rate.	Amount.	Remarks.
Quarry Channel Clay.*	RS. A. P.	RS. A. P.	* The clay is Godavery silt taken about 9 to 12 inches below the surface; the upper 9 inches being rejected as too sandy.
For digging and carrying 1 cubic yard of clay to experiment shed, about ¼ mile.	0 2 0		
For ½ parah of chunam† to mix with the clay.	0 1 4		† About 2 per cent. of lime is added to reduce the cost of disintegration. In these experiments quick lime was used which would be about twice the price of the hydrate of lime.
For tempering and making cakes.	0 2 6		
Firewood	0 8 0		
Filling and emptying kiln ...	0 1 9		
Cost of 1 cubic yard of burnt clay in cakes.	...	0 15 7	
Grinding by Wells' patent mill...	...	‡3 1 6	‡ This rate includes six or seven siftings.
Total cost of 9 parahs well ground surki.¶	...	4 1 1	Or 7½ Annas per parah. ¶ The kind of surki here meant is equal to the finest hand-made and may be blown into a cloud off the palm of one's hand, or like the finest flour.
Cost of 1 cubic yard of burnt clay in cakes.	...	0 15 7	
Grinding by the Upper Godavery mortar-mixing machine§ worked by six men.	...	§1 15 6	§ It is hoped that by applying steam power to this machine the cost may be reduced to 1½ or 2 Annas per parah. § This rate includes about three siftings.
Total cost of 9 parahs well ground surki.	...	2 15 1	Or 5½ Annas per parah.

(Signed) J. BEATTY, Major, R.E.

Acting Superintending Engineer, Godavery District.

C.

EXPERIMENTS ON GODAVARI LIME AND CEMENTS.

N.B.—In this statement where it is noted that the blocks were immersed "in water" it is to be understood that they were put in water immediately after they were manufactured, and tested immediately after removal from the water. The columns headed "number of experiments" show the number from which an average was taken. The numbers on the line marked "maximum" show the maximum strength obtained from any sample of that kind of brickwork.

I.—Four Sets of Experiments on the strength of Common Mortar.

	Days old.	Number of Experiments.	1 Lime and 1 1/2 fine Sand.	Days old.	Number of Experiments.	1 Lime and 1 1/2 coarse Sand.	Days old.	Number of Experiments.	1 Lime and 2 coarse Sand.	Remarks.
Averages	In water. 45	2	8	45	4	16	46	3	272	All the air-dried and sun-dried bricks of these mixtures were failures.
Maximum	Do. 45	..	10	45	..	20	46	..	29	

II.—Seven Sets of Experiments on the strength of Cement made of Lime and Surki mixed, and the Cement so formed afterwards mixed with fine Sand.

	Days old.	Number of Experiments.	1 Cement and 1 1/2 fine Sand.	Days old.	Number of Experiments.	1 Cement and 1 1/2 coarse Sand.	Days old.	Number of Experiments.	1 Cement and 2 coarse Sand.	Remarks.
Averages	Sun-dried In water. 25	8	118	25	4	100	25	4	128	
Maximum	Do. 25	..	150	..	..	130	..	..	136	
	Do. 25	..	154	..	..	137	..	..	138	

REMARKS.—The cement here referred to was simply a mixture of two parts slaked lime with three parts surki, which the previous experiments had shown to be the best proportion.

III.—Seven Sets of Experiments on the strength of Cement made of Lime and Surki mixed, and the Cement so formed afterwards mixed with coarse Sand.

	Days old.	Number of Experiments.	1 Cement and 1 1/2 coarse Sand.	Days old.	Number of Experiments.	1 Cement and 1 1/2 coarse Sand.	Days old.	Number of Experiments.	1 Cement and 2 coarse Sand.	Remarks.
Averages	Sun-dried In water. 25	4	155	25	4	171	25	4	186	
Maximum	Do. 25	..	200	..	..	186	..	..	197	
	Do. 25	..	200	..	..	186	..	..	197	

REMARKS.—Same remarks as in the preceding series.

IV.—Five Sets of Experiments on the strength of Cement made by mixing Lime with raw Clay and then burning the mixture, afterwards mixing one part of this Cement with fine Sand.

	Days old.	Number of Experiments.	1 Cement and 1 1/2 fine Sand.	Days old.	Number of Experiments.	1 Cement and 1 1/2 coarse Sand.	Days old.	Number of Experiments.	1 Cement and 2 coarse Sand.	Remarks.
Averages	Sun-dried In water. 8	3	100	8	2	134	8	4	174	
Maximum	Do. 8	..	134	..	..	138	..	..	160	
	Do. 8	..	134	..	..	138	..	..	160	

REMARKS.—In these experiments the method adopted in making the cement was as follows:—The lime was not merely slaked, but it was made into a paste, which was exposed for 24 hours, then mixed with twice its quantity of raw clay; this mixture was then made into balls, which were dried in the sun, then burnt in a kiln, afterwards ground, made into bricks, and lastly put into the water to set.

V.—Five Sets of Experiments on the strength of Cement made by mixing Lime with raw Clay and then burning the mixture, afterwards mixing one part of this Cement with coarse Sand.

	Days old.	Number of Experiments.	1 Cement and 1 1/2 coarse Sand.	Days old.	Number of Experiments.	1 Cement and 1 1/2 coarse Sand.	Days old.	Number of Experiments.	1 Cement and 2 coarse Sand.	Remarks.
Averages	In water. 8	3	115	8	2	134	8	4	174	
Maximum	Do. 8	..	134	..	..	138	..	..	160	
	Do. 8	..	134	..	..	138	..	..	160	

REMARKS.—Same remarks as in preceding series.

DOWLAISHWARAM,
29th October 1875.

(Signed) J. BEATTY, Major, R.E.,
Acting Superintending Engr., Godavery District.

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27th November 1875.

D.

Cost of Manufacture of Concrete Blocks

RS. A. P.	Materials.	Form.
0 4 0	At 0-8-0 $\frac{1}{2}$ Cubic yard small stone.	11 Concrete blocks of dimensions, 18" x 9" x 9" or $\frac{1}{2}$ cubic yards, and
0 5 0 $\frac{1}{2}$	At 0-5-0 $\frac{1}{2}$ 1 Parah lime ...	11 Concrete blocks of dimensions, 18" x 9" x 6" or $\frac{1}{4}$ cubic yards.
0 0 2 $\frac{1}{2}$	At 0-0-1 2 $\frac{1}{2}$ Do. sand ...	
	22 $\frac{1}{2}$ Gallons water ...	
0 9 3 $\frac{1}{2}$	Total cost of materials for $\frac{3}{4}$ cubic yards of concrete block.	
0 7 6	At 0-1-6 5 days coolies (pounding).	
0 4 6	At 0-3-0 1 $\frac{1}{2}$ days do. (mixing and manufacturing) for do. do.	
1 5 3 $\frac{1}{2}$	Total cost of $\frac{3}{4}$ cubic yards, or concrete blocks cost Rupees 2-5-1 per cubic yard.	

DOWLAISHWERAM,
6th October 1875.

(Signed) A. J. CHANCELLOR,
Asst. Engr. in charge, No. 1 Range, Godavery.

E.

Estimate of the Cost of Dowlaishweram Cement per Parah.

No.	Particulars.	Rate.	Per	Amount.
$\frac{3}{4}$	Parah lime, at ...	RS. A. P. 0 2 8	Parah.	RS. A. P. 0 1 1
$\frac{1}{2}$	" surki, at ...	0 5 3	"	0 3 2
	Add for mixing ...	...	"	0 0 3
	Cost of one parah of cement ...	...	...	0 4 6

F.

Estimate of the probable Cost of Manufacturing Concrete Blocks at Dowlaishweram with Cement, Sand, and small Stones.

No.	Particulars.	Rate.	Per	Amount.
...	One parah cement, at ...	RS. A. P. 0 4 6	Parah.	RS. A. P. 0 4 6
2 $\frac{1}{2}$	Parahs sand, at ...	0 0 1	"	0 0 2 $\frac{1}{2}$
5832	Parahs = $\frac{1}{2}$ cubic yard of small stone ...	0 9 0	Cubic yard.	0 4 6
1	Cooly for pounding, mixing, &c. ...	...	...	0 3 0
3	Women ...	...	...	0 6 0
	Rate for $\frac{3}{4}$ * of a cubic yard ...	...	...	1 2 2 $\frac{1}{2}$
	Hence, rate per cubic yard ...	...	...	1 15 6

(Signed) J. BEATTY, Major, R.E.,
Acting Suptg. Engr., Godavery District.

No. 1,368.

Note by the Chief Engineer for Irrigation.

No. 613-A.

The information contained in the papers submitted with the letter, No. 2,240, of the 29th ultimo, from the Superintending Engineer, Godavery, is of considerable value and interest.

* See results obtained from experiments on blocks made with lime, statement marked D.

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1st.—It is shown, statement A, that the best size of limestone for charging the kilns is to break it into pieces which will just pass through a 2 $\frac{1}{2}$ inch ring. Larger and smaller pieces yield less burnt lime and more refuse, owing no doubt in the former case to the pieces not being burnt through, and in the latter probably to the draught of the fire being checked by the smallness of the interstices.

2nd.—Statement B shows that the cost of burnt clay in fine powder is 7 $\frac{1}{2}$ Annas when ground by Wells' surki mill, and 5 $\frac{1}{2}$ when a mortar mill was used. It is explained that the former machine is not adapted for grinding to an impalpable powder, but nevertheless it may be very useful for grinding to the size of coarse sand, further reduction being otherwise accomplished.

3rd.—Statement C shows:—

(a.) The inferiority of sand mortar to cement mixtures for hydraulic work, and it has to be remembered that the Godavery limestone yields a lime much less fat than the descriptions elsewhere found and used.

(b.) That with lime burnt and mixed with burnt clay, the subsequent dilution with coarse sand gives much better results than with fine sand.

(c.) That on the other hand with a cement prepared by making burnt lime into paste, mixing it with raw clay and burning the mixture, dilution with fine sand yielded the best results.

4th.—With lime at 5 $\frac{1}{2}$ Annas a parah and stone at 1 Rupee a cubic yard, concrete blocks made with lime and sand mortar—

18 inches by 9 inches by 9 inches and

18 " by 9 " by 6 " cost formerly Rs. 2-5-1 a cubic yard.

On the other hand similar blocks made with cement, the cost of lime having been lately reduced from 5 $\frac{1}{2}$ to 2 $\frac{1}{2}$ Annas a parah, are estimated to cost Rupees 1-15-6 a cubic yard. Since the stone quarries have been turned to so much better account, the importance of concrete blocks has much diminished; but, as mentioned by Major Beatty, their use for heavy coping in lieu of cut stone may be advantageous.

5th.—Cement of two parts of lime to three of burnt clay is estimated to cost 4 $\frac{1}{2}$ Annas a parah, or 1-7-3 Annas a cubic foot, a very moderate price. With lime so much cheaper than it used to be, masonry in cement will probably not cost more than the former rate for masonry in sand mortar.

2. The letter from Lieutenant A. R. F. Dorward in charge of the Western

Delta shows that his experience is that the use of burnt clay gives good results, but that, owing to the difficulty of obtaining it promptly in sufficient quantities, the cost of masonry has been somewhat, though not very much, greater than with sand mortar. The use of water-power for grinding clay is worthy of attention, and at Chettipett, where the head-quarters of the range will shortly be, plenty of such power is available. Stamping mills might easily be constructed, but probably rollers as in mortar mills would give the finest powder most readily. There is some plant at

Bezwađa originally obtained for a rice-hulling mill which would, it is thought, be useful, though the grit stones would perhaps not do for rollers. At present the best plan will be for Dowlaishweram to supply clay powder as far as possible, and with steam-power applied to the mills it may be practicable to produce as much of this material as is needed.

3. Major Beatty in paragraph 9 mentions the points on which further information is required, and in paragraph 11 he gives a full and clear description of the mode of preparation and use of the cement used by Colonel Haig on the Upper Godavery works; the masonry there is believed to be almost unequalled in this Presidency for strength and durability.

CAMP AT ROYACHOTY,
18th November 1875.

(Signed) JOHN MULLINS, Lt.-Col., R.E.,
Chief Engineer for Irrigation.

No. 614.

ORDER THEREON, 27th November 1875. No. 3,390.

IRRIGATION, No. 59.

THESE papers will be communicated to all Superintending and District Engineers in continuation of G.O., 21st January 1875, No. 174.

2. The Government notice with satisfaction the steady progress made with the investigation of the preparation of cements, and with the practical application of the information obtained for the benefit of the works in progress in the Godavery Delta.

(True Extract.)

Major General, R.E.,
Secretary to Government.

To all Superintending and District Engineers.
To the Chief Engineer for Irrigation.

Exd. E. C. Shunker.

Spurs Copies

No. 2240 Supr Engineer's Office Godavery
Dowlaishweram 29 October 1875.

From,

Major J. Beatty R.E.

Mr Supr Engineer Godavery D.

To,

Lieutenant Colonel J. Mullins R.E.

Chief Engineer for Irrigation.

Sir,

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2. The statement marked A was prepared with a view to showing the effect of burning the different limestones found in the Kati's quarries, from which the Dowlaishweram kilns are

are supplied, separately, and together; and secondly, whether any advantage would be gained by breaking up the limestone to a smaller size than has been customary hitherto, viz, the 2½" size. The same quantity of firewood and limestone was used in each case, and it will be observed that the crystalline limestone produces the largest quantity of hydrate of lime at the first burning. It is also best to break up the limestone into pieces the size which will pass through a ring of 2½ inches diameter, in preference to breaking it smaller or leaving it unbroken in lumps as brought out of the Quarry.

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the subject, but have had no reply. The Upper Godavery Mortar mixing machine is the best means of grinding yet tried. The clay now used is Godavery silt taken from a channel where there is no current and a great deposit. It is taken a few inches below the surface. Soil from a tank bed was also tried but with much the same result.

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rate at Dowlaishweram.

6. Statement I shows the probable cost of the best Dowlaishweram cement, composed of two parts lime to three of fine turki ground by our Upper Godavery mortar mixing machine.

7. Statement II shows the probable cost of concrete blocks, made of cement, sand, and small stone. Such blocks may hereafter be useful, but the quarries are still yielding an abundant supply of stone, which must be better than any concrete blocks might however be used for copings instead of cut stone, as was done in the Upper Godavery.

8. The experiments are still I regret to find incomplete, but I have thought it best to record at once the progress made, and to state what I consider still wanting.

9. More experiments are wanted in the mixtures of the two kinds of cement with different proportions of sand before we can finally decide on the best mixture of each

15
each kind for different kinds of work; (2) as some additional strength is gained by making the cakes with lime and raw clay, and then burning and grinding them; while this method will doubtless also be the cheapest because the mixture of lime in the cakes will render pulverization easier, experiments are needed to ascertain the cost of the cement when ready for use by this method; (3) experiments should also be made on the strength of concrete blocks composed of cement, sand, and small stone; and (4) it will be well to ascertain whether turki deteriorates materially by keeping for a month.

10. I may mention that the difficulty pointed out by Lieutenant Dornward, viz, the want of a better means of grinding does not appear to have been felt by Colonel Haig on the Upper Godavery where cement was always used, and the masonry is probably among the best of its kind to be found anywhere; the Inspector General of Irrigation said he had not seen better in India.

11. The method adopted in the manufacture of

of cement on those works was as follows:-

- I. The limestone was broken into pieces small enough to pass through a ring 3 inches in diameter.
- II. It was then burnt slowly in a kiln.
- III. It was next slaked and sifted.
- IV. The lime after sifting was mixed with black clay in the proportion of one to one, and then well ground in a mill; i.e. in one of the Upper Godavery Mortar mixing machines driven by a portable steam engine. All the mortar mixing machines at the Upper Godavery works were driven by steam power.
- V. The mixture of lime and clay was then made into rough round cakes about 7 inches in diameter by $\frac{1}{2}$ inches thick, and the cakes were spread out on the ground to dry. When well dried they were stored in a large shed until required for use. The cakes had of course to be burnt in order to make cement, but as the cement deteriorated by keeping the cakes were not burnt until the cement was required for use.

VI. When the cement was required, the cakes

were

^x each ten
inches
thick

- were put into a kiln (a cylindrical kiln of the ordinary pattern) except that the interior diameter was 16 feet, and the height 8 feet. The kiln was packed with cakes and firewood in alternate layers^x. One layer of wood, small, to one layer of cakes of the same thickness.
- VII. The kiln was then lighted at bottom and allowed to burn itself out. If properly burnt the cement was of a reddish pink colour, if half burnt grey; if unburnt dark, bordering on black. Only what was of the proper colour was sent to the works.
 - VIII. The cement, thus prepared and freshly burnt, was mixed with an equal quantity of clean sharp river sand, and the mixture well ground in the mortar mixing machine; this machine was close to the site of the work on which the cement was to be used.
 - IX. The masonry was kept constantly moist during the day, by frequent waterings, for about one month after it was built.
 - X. The refuse of the siftings made excellent cement, but grinding it was found to be very destructive to the mills.

XI The weight of the cement thus made was-

I 1. Pure cement 106.66 lbs per Cft.

2. When mixed with sand

(1 to 1) 157.33 lbs per Cft.

II 3. Cement in powder 50 lbs per Cft.

III 12. But it must be explained that there are
IV no small works at Dummagudem. The masonry
works there are only four in number, and of
great size; an annicut a mile long with long
wings that rise 34 feet above the level of the annic-
ut crest; a set of 14 scouring sluices in a body
wall 224 feet long by 36 feet high, with wings
each 140 1/2 feet long by 42 feet high; a head
lock 30 feet broad by 200 feet long with floor
gates 38 1/2 feet high; and a double lock ha-
ving chambers of the same dimensions as the
head lock and gates 20 feet high.

13. For our Delta works it will probably be
found best to make Surki, as well as the dried
cakes of lime and raw clay, in large quanti-
ties at the head quarters of the Range, issuing
Surki for use on small works only, and grind-
ing up the cakes on large works by a mixing
machine as was done at Dummagudem; at

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at least until some better means of grind-
ing is invented.

I have the honor to be,
Sir,

Your Most obedient Servant,

L. Reatty, Major R.E.

As Supr Engineer Godavery.

P. S. Throughout the experiments shown in
statement bricks of each mixture were
tested in three different ways, first by sun drying,
secondly by air drying in shade; thirdly, by
immediate immersion. Where no results
are recorded, it is to be understood that the
bricks cracked at their weakest part before
being tested; this was the case with all the
air dried bricks.

No 259

No 3 or Western Delta Range
Godanery District & Lepny

From,

The Officer in charge

To,

No 3 or Western Delta Range G.D.

The Superintending Engineer.

Godanery District

Sir,

I have the honor to bring to your notice
the subject of using Surki in Mortar for Masonry
works. The cost in this Range for Surki is
generally:-

Coarsely ground Surki — Rs 15 per garea

Very finely ground Surki — " 25 per garea

Even coarsely ground Surki is therefore more
expensive than lime. When lately in Dowlaish-
waran Captain Brockman informed me that
he could not by any means know to him
produce Surki at a cheaper rate than Rs 15.
per garea. He also told me that for this
rate he could only produce coarsely ground
Surki; So the rates in the two Ranges are
similar.

There are too great drawbacks to the extensive
use

To the Officer in charge
No 3 or Western Delta Range

From

The Officer in charge
No 3 or Western Delta Range

The Superintending Engineer

Godanery District

No 259

Enclosure.

Reporting further
progress with the
current experiments

with reference to
S.O. No 174 of 21st
January, 1895.

M. 15057
2/95

9027 K. M. S. S. S.
No 3890

use of Surki.

1) Its cost

2) The great length of time which it takes to turn it out in any quantity.

The coarsely ground Surki is much inferior to the finely ground, and adds very little to the strength of the mortar. I have therefore quite given up using it. The very finely ground Surki however is used extensively. I have tried various mixtures and lately have used a Mortar of 1 lime, $\frac{1}{2}$ Surki & 6 sand for small brickwork and am well satisfied with it. The cost of this Mortar as compared with that previously used in the Range. Viz, 1 lime to 2 sand is as 5 to 6; owing however to the slowness of the manufacture of Surki the cost of supervision is increased. In Roder Rock walls a Mortar of 1 lime, $\frac{1}{2}$ Surki and 3 sand has been used, and with excellent results as far as strength of work goes. It is more expensive however than the ordinary lime Mortar and its use has delayed the work; in fact the progress of a work is now regulated

regulated by the supply of Surki.

To cheapen the mortar I have in some cases reduced the quantity of Surki, but found that while a cement of 1 lime and 1 Surki was nearly as strong as one of 1 lime & $\frac{1}{2}$ Surki, the former was weakened much more than the latter by admixture with sand. I have only the roughest means of testing strength, but I believe if tried with the machine at Dowlaishweram this will be found to be the case, and if so, it will show that sand is not a mere diluent. I am also nearly certain that a Mortar of 1 lime and 1 sand is stronger than one of pure lime; a few experiments at Dowlaishweram would settle this point, and if this be found to be the case I do not think that it can be accounted for by mere Mechanical action.

I believe Surki is extensively used in upper India and I should be obliged if you could get me a description of their method of preparing it, with the cost. I think a cheap way to manufacture it would be by a water

wheel working hammers, it would be a
very convenient power to work at Chittipet
where there is a considerable head of water
available. I have not sufficient time to
work out the details of such a machine,
as having no practical experience of water
motors, I could only gain knowledge by fair-
-ture. I think the difficulties that stand
in the way of the general use of Surki should
be brought to the notice of the Chief Engineer
for Irrigation. I propose using a mortar
of 1 lime, $1\frac{1}{2}$ Surki, and 4 sand for the
concrete in foundations of the works at Pal-
-Rolu. Such a mortar sets fairly fast &
is amply strong.

As Surki deteriorates by keeping I can
not make it long before hand, and shall
probably lose the advantage of decrease in
cost of hauling caused by its use, through
delay in getting in the concrete.

I am anxiously awaiting the result of the
Dowlaiswaram experiments as to the best mor-
-tars to use for various descriptions of masonry
work

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work, and hope that you will soon
be able to give me some positive information
on the subject.

I have &c &c

/s/ J. R. F. Dorrard Esq. R.E.
Asst Engineer in ch. Ho. B. R. C. P.

(True copy)

W. H. M. Major R.E.
Asst Supr Engineer Godavery D.

Statement showing the results of experiments on burning different sorts of Lime Stone at 1800° = limestone limestone limestone 11.664 pounds = 1 cubic yard.

	Limestone		Limestone		Limestone	
	in	Parale	in	Parale	in	Parale
Stone, large, without breaking	35	6	39	6	42	6
Stone crystalline 2 1/2" dia	35	6	39 1/2	6	42 1/2	6
Do. Do. 1 1/2" dia	35	6	42	6	45	6
Stone semi crystalline 2 1/2" dia	35	6	39 1/2	6	42 1/2	6
Do. Do. 1 1/2" dia	35	6	42	6	45	6
Stone more crystalline 2 1/2" dia	35	6	38	6	42	6
Do. Do. 1 1/2" dia	35	6	38	6	42	6

Remarks.

These are the quantities found after slaking. The above have given are those which will pass through sieves of 1 1/2" and 2 1/2" inches diameter.

After repeated burnings the water lime stone leaves no residue, the second burning usually turns what was left at the first burning into lime.

Proctor. Major R.E.

As. Superintendent Engineering Corps, A.C.

8th of January 1870

Ch 2/20/75

Statement showing
the results of experiments
on burning different
sorts of lime stone at
Dowlaiswhram Lime
Works -

$\frac{179506 \text{ lb}}{2}$

Ch 2/20/75

$\frac{179506 \text{ lb}}{3/75}$

Ch 2/20/75

B

Statement showing
the rates for making
lime by different means -
= made at Dowlaiswhram -
= same -

Ch 2/20/75

Statement showing the rates for making Surki by different Methods 11.00 Rs. parabs make one cubic yard.

Description -	Rate	Amount	Remarks
Quarry Channel Clay			
For digging and carrying one cubic yard of clay to experiment shed, about $\frac{1}{4}$ mile	2		* The clay is Godavery still taken about 9 to 12 inches below the surface, the upper 9 inches being rejected as too sandy
For $\frac{1}{4}$ Parabs of Chumato mixed with the clay	1 4		† About 2 per cent of lime is added to reduce the cost of disintegration. In these experiments quicklime was used which would be about twice the price of the hydrate of lime
For tempering and making cakes	2 6		* The kind of Surki here meant is equal to the finest hand made and may be blown into a cloud off the palm of ones hand, or like the finest blow
Firing and emptying kiln	8		size or seven siftings
Each 4 are cubic yard of burnt clay in cakes	1 9	15 7	* The kind of Surki here meant is equal to the finest hand made and may be blown into a cloud off the palm of ones hand, or like the finest blow
Grinding by Wells Pottery Mill		3 1 6	size or seven siftings
Total cost of 4 parabs well ground Surki		1 1 1	* The kind of Surki here meant is equal to the finest hand made and may be blown into a cloud off the palm of ones hand, or like the finest blow
Cost of one cubic yard of burnt clay in cakes grinding by the Wells Godavery mortar mixing Machine worked by 6 men		15 7	* It is hoped that by applying steam power to this machine the cost may be reduced to $\frac{1}{2}$ or 2 annas per parab
Total cost of 9 parabs well ground Surki	2	15 1	* This rate includes about three siftings

W. Beatty - Major R.C.

A. J. Superintending Engineer Godavery District

Experiments on Godavery Lime and Cements

123

In this statement where it is noted that the blocks were immersed "in water" it is to be understood that they were put in water immediately after they were manufactured immediately after removal from the water. The columns headed "number of experiments" show the number from which an average was taken. The line marked "Maximum" show the maximum strength obtained from any sample of that kind of brick -

I. 4 Sets of Experiments on the strength of common mortar -

I. 4 Sets of Experiments on the strength of													
	Days old	Number of Experiments	1 Lime and 1/2 fine sand	Days old	Number of Experiments	1 Lime and 2/3 fine sand	Days old	Number of Experiments	1 Lime and 1/2 coarse sand	Days old	Number of Experiments	1 Lime and 2 coarse sand	
Averages	In water	45	2	8	15	4	16	46	3	17	46	3	27 3/4
Maximum	do	do	10	do	do	20	do	do	22	do	do	29	All the above were,

All the above were,

II 7 Sets of experiments on the strength of cement made of lime and Surki mixed, and the cement so formed afterwards mixed with fine sand -

II 7 Sets of experiments on the strength of cement in beds of lime and sand.																	
	Days old	Number of Experiments	1 Cement and 1/2 fine sand old	Days old	Number of Experiments	1 Cement and 1/4 fine sand old	Days old	Number of Experiments	1 Cement and 1/2 fine sand old	Days old	Number of Experiments	1 Cement and 1/4 fine sand old	Days old	Number of Experiments	1 Cement and 1/2 fine sand old	Days old	Number of Experiments
Averages	In water	23	4	150	25	4	100	24	122 3/4	24	4	123 3/4	35	4	46	34	4
	do.	"	"	"	"	"	"	"	"	"	"	"	72	2	125	72	8
	do.	"	"	"	"	"	"	"	"	"	"	"	"	"	130	"	"
Maximum		"	"	154	"	"	130	"	127	"	"	136	"	"	"	"	"

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III. 7 Sets of experiments on the strength of cement made of lime and Surki mixed, and the cement so formed afterwards mixed with coarse sand -

III. 7 Sets of experiments on the strength of cement made of lime and Surinam sand, and																			
Days old		Number of Experiments	1 Cement and $\frac{1}{2}$ coarse sand old	Days	Number of Experiments	1 Cement and $\frac{3}{4}$ coarse sand old	Days	Number of Experiments	1 Cement and 1 coarse sand old	Days	Number of Experiments	1 Cement and $1\frac{1}{2}$ coarse sand old	Days	Number of Experiments	1 Cement and 2 coarse sand old				
Sundried	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"				
In water	28	4	185	28	4	171	26	4	150 $\frac{1}{2}$	26	4	156 $\frac{1}{4}$	34	3	53 $\frac{1}{4}$				
Averages	do	"	"	"	"	"	"	"	"	"	"	"	"	"	"				
do	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"				
do	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"				
Maximum	"	"	200	"	"	186	"	"	180	"	"	197	"	"	105				

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185 28 4 171 26 4 150 $\frac{1}{2}$ 26 4

IV. 5 Sets of experiments on the strength of cement made by mixing lime with raw clay and then burning the mixture, afterwards mixing 1 part this cement with

IV. 5 Sets of experiments on the strength of cement made by mixing lime with sand																		
	Days old	Number of Experiments	1 Cement and 1/2 fine sand	Days old	Number of Experiments	1 Cement and 1/4 fine sand	Days old	Number of Experiments	1 Cement and 1/2 fine sand	Days old	Number of Experiments	1 Cement and 1/4 fine sand	Days old	Number of Experiments	1 Cement and 2 fine sand			
Averages	8	3	100 1/2	8	2	134	8	117 1/2	8	10	80	8	10	95	8	10	60 1/2	
Sm dried	8	3	100 1/2	8	2	134	8	117 1/2	8	10	80	8	10	95	8	10	60 1/2	
In water	8	10	138 1/2	8	10	110 3/4	8	10	80	8	10	95	8	10	95	8	10	60 1/2
do	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
do	"	"	160	"	"	138	"	"	150	"	"	104	"	"	"	"	69	

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V. 5 Sets of experiments on the strength of cement made by mixing lime with raw clay and then burning the mixture, afterwards mixing 1 part of this cement with

Days old	Number of Experiments	1 Cement and 1 Coarse sand	Days old	Number of Experiments	1 Cement and 1 1/4 Coarse sand	Days old	Number of Experiments	1 Cement and 1 1/2 Coarse sand	Days old	Number of Experiments	1 Cement and 1 3/4 Coarse sand	Days old	Number of Experiments	1 Cement and 2 Coarse sand
80	8			8			8			8		8		
100 1/2	2			134			117 1/2			150		104		104
160	1			138			104			104		69		69

Experiments on Godavery Lime and Cements

that the blocks were immersed "in water" it is to be understood that they were put in water immediately after they were manufactured, and from the water. The columns headed "number of experiments" show the number from which an average was taken. The numbers show how the maximum strength obtained from any sample of that kind of brick.

I. 4 Sets of Experiments on the strength of common mortar -

Time and Days	Number of Experiments	1 Lime and 2 Fine sand	Days Old	Number of Experiments	1 Lime and 1/2 Coarse sand	Days Old	Number of Experiments	1 Lime and 2 Coarse sand
8	15	14	16	46	3	17	46	3
10	do	"	20	do	"	22	do	"

Remarks.

All the air dried and sundried bricks of these mixtures were failures.

Strength of cement made of lime and Surki mixed, and the cement so formed afterwards mixed with fine sand.

1 Cement and 3/4 fine sand	Days Old	Number of Experiments	1 Cement and 1/2 fine sand	Days Old	Number of Experiments	1 Cement and 1/4 fine sand	Days Old	Number of Experiments	1 Cement and 1/8 fine sand	Days Old	Number of Experiments
100	24	"	122 3/4	24	14	123 3/4	35	14	49 1/4	35	14
							72	2	125	72	8
130			127			136			130		

Remarks.

The cement here referred to, was simply a mixture of two parts slaked lime with three parts surki; which the previous experiments had shown to be the best proportion.

Strength of cement made of lime and Surki mixed, and the cement so formed afterwards mixed with coarse sand.

1 Cement and 3/4 coarse sand	Days Old	Number of Experiments	1 Cement and 1/2 coarse sand	Days Old	Number of Experiments	1 Cement and 1/4 coarse sand	Days Old	Number of Experiments	1 Cement and 1/8 coarse sand	Days Old	Number of Experiments
71	26	4	150 1/2	26	14	156 1/2	34	3	55 1/4	33	14
							71	4	84 3/4	70	4
16			180			197			105		

Remarks.

Same Remarks as in the preceding series

Strength of cement made by mixing lime with raw clay and then burning the mixture, afterwards mixing 1 part this cement with fine sand.

1 Cement and 3/4 fine sand	Days Old	Number of Experiments	1 Cement and 1/2 fine sand	Days Old	Number of Experiments	1 Cement and 1/4 fine sand	Days Old	Number of Experiments
8	2	134	8	14	117 1/2	8	10	95
8	10	110 1/2	8	10	80	8	10	60 1/2
		138			150			104

Remarks.

In these experiments the method adopted in making the cement was as follows: The lime was not merely slaked, but it was made into a paste, which was then mixed with twice its quantity of raw clay, then burnt in a kiln, afterwards ground, made into bricks, and lastly put into the water to set.

Strength of cement made by mixing lime with raw clay and then burning the mixture, afterwards mixing 1 part of this cement with coarse sand.

1 Cement and 3/4 coarse sand	Days Old	Number of Experiments	1 Cement and 1/2 coarse sand	Days Old	Number of Experiments	1 Cement and 1/4 coarse sand	Days Old	Number of Experiments

Remarks.

II. 7 Sets of experiments on the strength of cement made of lime and Surki mixed, and the cement so formed afterwards mixed with fine sand.

1 Cement and Days 2 fine sand old				1 Cement and Days 2 fine sand old				1 Cement and Days 2 fine sand old				1 Cement and Days 2 fine sand old				1 Cement and Days 2 fine sand old				
Number of Experiments				Number of Experiments				Number of Experiments				Number of Experiments				Number of Experiments				
Smudged	8	2	118	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
In water	28	4	150	25	4	100	24	"	122 ³ / ₄	24	4	128 ³ / ₄	"	"	"	"	"	"	"	
"	"	"	"	"	"	"	"	"	"	"	"	85	4	42 ¹ / ₂	35	4	46	34	4	37
"	"	"	"	"	"	"	"	"	"	"	"	72	2	125	72	8	50 ³ / ₄	71	7	51
"	"	"	"	"	"	"	"	"	"	"	"	136	"	130	"	"	80	"	"	59
Averages	"	"	154	"	"	130	"	"	127	"	"	136	"	"	"	"	80	"	"	59

III. 7 Sets of experiments on the strength of cement made of lime and Surki mixed, and the cement so formed afterwards mixed with coarse sand.

Days old	Number of Experiments	1 Cement and 1/2 coarse sand old	Days	Number of Experiments	1 Cement and 1/2 coarse sand old	Days	Number of Experiments	1 Cement and 1/2 coarse sand old	Days	Number of Experiments	1 Cement and 1/2 coarse sand old	Days	Number of Experiments	1 Cement and 1/2 coarse sand old	Days	Number of Experiments	1 Cement and 1/2 coarse sand old	Days	Number of Experiments	1 Cement and 1/2 coarse sand old
Smudged	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
In water	28	4	185	28	4	171	26	4	150 1/2	26	4	156 1/4	"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"	"	"	"	"	34	3	55 1/4	33	4	44 3/4	33	4	48
"	"	"	"	"	"	"	"	"	"	"	"	42	3	74	"	"	"	"	"	"
"	"	"	"	"	"	"	"	"	"	"	"	71	4	84 3/4	70	4	95	70	"	109 3/4
Averages	"	"	200	"	"	186	"	"	180	"	"	197	"	"	105	"	120	"	"	150

IV. 5 Sets of experiments on the strength of cement made by mixing lime with raw clay and then burning the mixture, afterwards mixing 1 part this cement with fine sand.

Days old	Number of Experiments	1 Cement and 1/2 fine sand old	Days	Number of Experiments	1 Cement and 1/2 fine sand old	Days	Number of Experiments	1 Cement and 1/2 fine sand old	Days	Number of Experiments	1 Cement and 1/2 fine sand old	Days	Number of Experiments	1 Cement and 1/2 fine sand old	Days	Number of Experiments	1 Cement and 1/2 fine sand old	Days	Number of Experiments	1 Cement and 1/2 fine sand old
Averages	Smudged	8	3	100 1/2	8	2	134	8	4	117 1/2	"	"	"	"	"	"	"	"	"	"
	In water	8	10	133 1/2	8	10	110 3/4	8	10	80	8	10	95	8	10	60 1/2	"	"	"	"
Maximum	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
	"	"	160	"	"	138	"	"	150	"	"	104	"	"	69	"	"	"	"	"

In these experiments the mortar was not merely slaked, exposed for 24 hours, then this mixture was then made then burnt in a kiln, after-
lastly put into the water to

V. 5 Sets of experiments on the strength of cement made by mixing lime with raw clay and then burning the mixture, afterwards mixing 1 part of this cement with coarse sand.

Days old	Number of Experiments	1 Cement and 1/2 coarse sand old	Days	Number of Experiments	1 Cement and 1/2 coarse sand old	Days	Number of Experiments	1 Cement and 1/2 coarse sand old	Days	Number of Experiments	1 Cement and 1/2 coarse sand old	Days	Number of Experiments	1 Cement and 1/2 coarse sand old	Days	Number of Experiments	1 Cement and 1/2 coarse sand old	Days	Number of Experiments	1 Cement and 1/2 coarse sand old
Averages	In water	8	8	115	8	10	77 1/2	8	7	43 1/4	8	7	40	8	2	38	"	"	"	"
Maximum	"	"	"	"	"	"	90	"	"	54	"	"	46	"	"	40	"	"	"	"

Same Remarks as in

Dowlaishevaram
29th October 1875

L. Pearty. Major R.E.
Superintending Engineer Coimbatore District

15 10 4.6 3 17 4.6 3 27 3/4
do 20 do " 22 do 29

All the air dried and summer
were failures

Cement made of lime and Surki mixed, and the cement so formed afterwards mixed with fine sand.

Cement and Days and old	Number of Specimens	1 Cement and Days 1 1/2 fine sand old	Number of Specimens	1 Cement and Days 1 1/2 fine sand old	Number of Specimens	1 Cement and Days 1 3/4 fine sand old	Number of Specimens	1 Cement and 2 fine sand	Number of Specimens
100	24	129 3/4	4	123 3/4	1	42 1/2	35	46	34
				88	1	125	79	50 3/4	71
				72	2	130		80	
130		127		136					59

Remarks.
The cement here referred to, was simply a mixture of two parts slaked lime with three parts Surki, which the previous specimens had shown to be the best proportion.

1/2 lb of cement made of lime and Surki mixed, and the cement so formed afterwards mixed with coarse sand.

Cement and Days coarse sand old	Number of Specimens	1 Cement and Days 1 1/2 coarse sand old	Number of Specimens	1 Cement and Days 1 1/2 coarse sand old	Number of Specimens	1 Cement and Days 1 3/4 coarse sand old	Number of Specimens	1 Cement and 2 coarse sand	Number of Specimens
171	26	150 1/2	26	156 1/4	34	55 1/4	33	44 3/4	33
				42	3	74			
				71	4	81 3/4	70	95	70
186		180		197		105		120	

Same Remarks as in the preceding series

1/2 lb of cement made by mixing lime with raw clay and then burning the mixture, afterwards mixing 1 part this cement with fine sand.

Cement and Days old	Number of Specimens	1 Cement and Days 1 1/2 fine sand old	Number of Specimens	1 Cement and Days 1 1/2 fine sand old	Number of Specimens	1 Cement and Days 1 3/4 fine sand old	Number of Specimens	1 Cement and 2 fine sand	Number of Specimens
8	2	134	8	117 1/2					
8	10	110 3/4	8	80	8	95	8	60 1/2	
		138		150		104		69	

Remarks.
In these experiments the method adopted in making the cement was as follows: The lime was not merely slaked, but it was made into a paste, which was exposed for 24 hours, then mixed with twice its quantity of raw clay, this mixture was then made into balls, which were dried in the sun, then burnt in a kiln, afterwards ground, made into bricks, and lastly put into the water to set.

1/2 lb of cement made by mixing lime with raw clay and then burning the mixture, afterwards mixing 1 part of this cement with coarse sand

Cement and Days and old	Number of Specimens	1 Cement and Days 1 1/2 coarse sand old	Number of Specimens	1 Cement and Days 1 1/2 coarse sand old	Number of Specimens	1 Cement and Days 1 3/4 coarse sand old	Number of Specimens	1 Cement and 2 coarse sand	Number of Specimens
8	10	77 1/2	8	143 1/4	8	40	8	38	
		90		54		46		40	

Same Remarks as in preceding series

L. Beatty. Major R.E.
As Superintending Engineer Cuddalore District

From C. 1/2207/75
The Officer in Charge
No 3 Range
Godavery

To The Sup^y Engineer
Gody. Dist.

Dated 4th 3 Sept/75
Recd. 3 Sept/75
No 259
Encls.

Worki. Draw.
backs to the exten-
-sive use of the-
Brings to notice
the - in his Range
& the high rates at
which it is manu-
-factured.

17/9505/75

Cost of manufacture of concrete blocks.

39

Rs. A. P.

Materials

" 4 . At 0-8-0 $\frac{1}{2}$ Cubic yard Small Stone

" 50 $\frac{3}{4}$ At 0-5-0 $\frac{3}{4}$ 1 Barah lime

" 2 $\frac{1}{2}$ At 0-0-1 2 $\frac{1}{2}$ — Do. — Sand

22 $\frac{1}{2}$ Gallons water

Form

11 Concrete blocks of dimensions

18" x 9" x 9" — or — $\frac{11}{32}$ Cyp.

and

11 Concrete blocks of dimensions

18" x 9" x 8" — or — $\frac{11}{48}$ Cyp.

" 9 $\frac{3}{4}$ Total Cost of materials for $\frac{55}{96}$ Cubic yards of Concrete block.

Labor

" 70 At 0-1-0 5 days Coolies / pounding /

" 40 — " — 0-3-0 1 $\frac{1}{2}$ days — Do. / mixing and Manufacturing / for — Do. — Do. —

" 5 $\frac{3}{4}$ Total Cost of $\frac{55}{96}$ Cubic yards

or

Concrete Blocks Cost Rupees 2-5-1 per Cubic yard.

Doc Laishner am

No 1 or 8 D Range Office

6th October 1875

/ True Copy /

Hearty Major R.C.

Superintending Engineer Godanry District

/ s/ A. J. Chancellor

Assistant Engineer in charge

No 1 Range Godanry

Estimate of the cost of Dowlaishweram
cement per parakh _____

No	Particulars	Rate Per	Amount
$\frac{2}{5}$	Parakh lime at _____	" 2-8 parakh "	" 1-1
$\frac{3}{5}$	Parakh Surki at _____	" 5-3 parakh "	" 3-2
	Add for mixing _____	" "	" 3

Cost of one parakh of Cement _____ " 4-6

L. Beatty Major R.E.
As Superintending Engineer Gody Dist.

Statement showing
the cost of manufacturing
concrete blocks at
Dowlaishweram
with lime, sand,
and small stones

Chesposh's

G.O. of Government
No 3390

11/10/95
5/95

43

Estimate of the probable cost of manufacturing
concrete blocks at Dowlaishwaram with ce-
ment, sand, and small stones

Particulars	Rate Per	Amount
One parakh cement at — 4 — 6 Parakh — 4 — 6		
2 1/2 parakhs sand at — — — 1 Parakh — — — 2 1/2		
5882 parakhs = 1/2 Cubic yard		
of small stone — — — 9 "Cubic yard" — 4 — 6		
1 Cooly for pounding		
mixing fee — — —		" — 3 — "
3 Women — — —		" — 6 — "

Rate for ^{*} 55/96 of a Cubic yard — — — 1 — 2 — 2 1/2

hence, Rate per Cubic yard — — — 1 — 15 — 0

* See results obtained from experiments
on blocks made with lime, statement
marked D

P. Peatty. Major R.E.

As Superintending Engineer Cdy. Dist.

Estimate of the cost
of Dowlaishwaram
Cement for Parakhs

Rs 6/2203/35

Rs 2000/35

No. 1368

Note by the Chief Engineer for Irrigation.

Encls 8.

The information contained in the papers submitted with the letter No. 2240 of the 29th Ultimo from the Superintending Engineer, Godavery, is of considerable value and interest.

Best size of lumps of limestone for burning.

1st It is shown, Statement A, that the best size of limestone for charging the kilns is to break it into pieces which will just pass through a 2½ inch ring. Larger and smaller pieces yield less burnt lime and more refuse, owing no doubt in the former case to the pieces not being burnt through, and in the latter probably to the draught of the fire being checked by the smallness of the interstices.

Cost of burnt clay in fine powder.

2nd Statement B shows that the cost of burnt clay in fine powder is 7½ Annas when ground by Wells' Surki mill, and 5½ when a mortar mill was used. It is

explained

Ch. 1/202/15

Estimate of the probable cost of manufacturing concrete blocks at Nos. 1 and 2 with cement sand and small stones.

1/1/95

14. Sept 74 No 277-278.
21st Jan 75. 358-360.

G. W. 1895 Dept

No: 4505

From

The Chief Engr.
for Irrigation

Dated 18th Nov. 3
Recd 24th. in 31895.

G. S. No: 1368

Note on letter of the
Supr. Engr. Gadavay,
reporting further pro-
gress with the Cement
Experiments.

G.O. No 3390. 27. 11/75.

No 3390 Public Works Dept

Proceedings of the Madras Government
Under date the 27th Nov. 1895
Read the following

From,

The Chief Engineer
for Irrigation

G.O. No 1368 of the 18/11/95

These papers will be
communicated to all Su-
perintending and District
Engineers in continuation of
G.O. 21st January 1895 No 194.
2. The Government notice
with satisfaction the
steady progress made with
the investigation of the pre-
paration of cements, and
with the practical appli-
cation of the information
obtained for the benefit
of the works in progress in
the

Godavery Delta

Jan. 1911

1911

To all Supply & Dist. Engineers
at Chicago for Inspection

Sept - 11 - 12 - 78

613,644

Godavery Delta

Aug. 19/14

2503

Govt. of India
PUBLIC WORKS.

Supg. & Dist. Engrs

30/11/7

27/1000

3370

Report of the
Commissioner of the
District of the
Godavery Delta
District of the
Godavery Delta
District of the
Godavery Delta

12613, 64