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MADRAS RECORD OFFICE

Government of Madras

Public Works DEPARTMENT

G.O. No. 2806 Press Original
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Dated 14-9-1874 195—.

Not to be folded or roughly handled

Read the following papers:—

No. 600.

No. 277. *Note by the Chief Engineer for Irrigation.*

In the order of the 18th April 1871, No. 1,077, paragraph 3, a grant of Rupees 5,000 was made for the purpose of experiments to ascertain how concrete blocks, as a substitute for randum rubble masonry, might best be manufactured. The first thing to be done was to experiment upon the lime-stone available, so as to determine what mixtures of this and clay would be most suitable as a cementing material. Concurrently also it was of importance that the necessary admixture of clay with the several descriptions of lime-stone commonly found to render them highly and moderately hydraulic and suitable therefore for foundations on the one, and superstructures of works on the canals on the other, hand should be ascertained.

2. It was noticed in the memorandum of inspection of the Godavery Delta Works, on which orders have recently been passed that, up to the end of last year, the investigations had not made that progress which was desirable, but the District Engineer has now transmitted tables showing the results of the experiments since made; and further when Colonel Brownlow, R.E., visited the delta at the end of 1873, he kindly interested himself in the matter, took with him samples of the lime-stones, and obtained an analysis of and a report upon them from the Officer who is in charge of cement experiments in Bengal.

Proceedings of the Madras Government, 15th July 1874, No. 1,906.

3. The District Engineer has not classified the samples examined by Mr. Dejoux under the more apparent descriptions, viz., crystalline, semi-crystalline and non-crystalline, by which they have been designated in the local experiments at Dowlaishweram; but it is to be hoped that he has the means of doing this, otherwise much of the value of Mr. Dejoux's investigations will be lost. If Colonel Brownlow has not returned the samples, which after their transmission to Mr. Dejoux were duly numbered, probably there will be no difficulty in obtaining them; but, as it is stated in the concluding paragraph of Major Beatty's letter that, of specimens Nos. 11 and 13, further quantities were not to be found, probably the samples are with the District Engineer, and the desired classification can be made.

4. The analysis of the lime-stones shows that their qualities vary greatly, and that consequently for particular purposes their treatment will require to differ materially. Thus to add to Nos. 2 and 11 the proportion of clay which would be suitable for Nos. 1, 5, 7, 8, 12, etc., which are very rich in carbonate of lime, would probably spoil them. If a lime-stone similar to No. 11, but with a smaller proportion of sand, can be found, there is every probability, with suitable burning, of its proving, without any admixture of other material, suitable for all work where hydraulic cement is required. A further search should therefore be made.

5. Turning now to the experiments it will be seen that the admixture of clay with the lime in most cases produced a very superior cementing material to the lime alone. The maximum strength of brickets of lime after twenty-one days was 40 lbs. on 2¼ square inches, while by admixture this maximum became 325 lbs., which was obtained with crystalline burnt lime mixed with burnt clay in the proportion of one of the former to one and three quarters of the latter. Looking to the small age of the bricket, this must be deemed, it appears to me, a very satisfactory result,

Table III.

while numerous other mixtures of all the three different descriptions of lime yielded cement but little inferior and of ample strength for most purposes connected with the Delta works.

6. It has not been so stated in these papers, but it is supposed that all brickets were treated as in the previous experiments alluded to in the memorandum of inspection, *i.e.*, that they had two days air drying, and were then immersed. A further matter which requires to be recorded is the number of brickets of each kind experimented upon from which the average given in the tables was deduced.

7. It must be noticed that for each sort of lime-stone the admixture of clay in increasing proportions should produce an addition of tensile strength continuously up to the maximum, and then show a decreasing strength after the useful limit had been passed, but this result is not always apparent. Thus in table II. for twenty-one days it will be seen that the results given are as follow:—

Raw lime and raw clay in powder, mixed and burnt.

	A.	B.	C.
1 L and ¼ C, breaking weight...	...	199	128
1 ,, and ½ ,, ,, ...	...	102	267
1 ,, and ¾ ,, ,, ...	147	74	250
1 ,, and 1 ,, ,, ...	...	159	231
1 ,, and 1¼ ,, ,, ...	...	156	269
1 ,, and 1½ ,, ,, ...	63	171	88
1 ,, and 1¾ ,, ,, ...	...	183	266
1 ,, and 2 ,, ,, ...	38	136	...

Taking into account too that the District Engineer mentions that where the tables show blanks the brickets failed to bear any strain, it would seem, first that many of the brickets must have been badly made, and secondly that the number experimented upon must have been too small. It is impossible on any other supposition to account for such variations of strength as are exhibited in this table.

Table III exhibits much more regular results.

8. As regards rapid setting, a quality which is necessary for certain purposes, no definite information has been afforded, and special experiments for the determination of this point should be instituted. If air drying before immersion was practised, the tensile strength of various compositions at seven days is only indirect and inconclusive evidence of the degree in which this characteristic was exhibited. Probably air drying for six hours and then immersion for eighteen hours would afford a fair criterion.

9. On the subject of the cost of burning the several descriptions of lime-stone, and of the several modes of preparing hydraulic cement, definite information should be obtained if this has not already been done. Of several mixtures of about the same value as regards strength, that which is capable of being manufactured the more cheaply and conveniently should be selected for general use.

10. It may be noticed also that some of the entries in the tables appear to indicate that the right degree of heat was not employed. This deduction would seem to be fairly obtainable from an examination of table II., and I am disposed to think that the temperature attained when dealing with raw lime and raw clay burnt in contact was generally too low. On the other hand table III. appears to show that it is easier to obtain fairly even and reliable results by burning the lime and clay separately and mixing them afterwards. Table IV. indicates that no advantage is secured by burning the lime, mixing it with raw clay, and then burning the mixture, and it is probably more expensive than either of the other processes.

Proceedings of the Madras Government, Public Works Department,
14th September 1874.

11. It is desirable, in order that the in formation gained in the Godavery should form a guide to investigations elsewhere, that all papers relating to the experiments should show exactly the way in which they were conducted, what processes have been found to answer, and what have been proved by experience to be either injurious or unnecessary. Future reports should, therefore, be made as complete as possible.

12. It was originally contemplated that a mill for grinding materials should be set up, and indeed for the preparation of cement good grinding arrangements are essential. I think two mills may with advantage now be set up, one at Dowlaishweram, and the other at Chettepett, where the Western Delta lime kilns are situated, and where the head-quarters of the range will shortly be located. That at Dowlaishweram should be placed where the manufacture of concrete blocks will be undertaken permanently. The confined space near the dry dock was suited only to the preliminary experiments.

13. It is satisfactory to find that a commencement has been made with the use of cement on the Delta works. The only matter of regret is that this was not done three years ago.

OOTACAMUND,
20th August 1874.

(Signed) JOHN MULLINS, Lieut.-Colonel, R E.,
Chief Engineer for Irrigation.

From Major J. BEATTY, R.E., District Engineer, Godavery, to Lieut.-Colonel J. MULLINS, R.E., Chief Engineer for Irrigation, dated Dowlaishweram, 5th August 1874, No. 1,418.

I HAVE the honor to furnish, herewith, for your information, four tables of results obtained from experimenting on various mixtures of lime and clay, together with copy of letter from the Executive Engineer, No. 1 Range.

2. The letters A, B, and C are used to denote the three kinds of lime-stone, crystalline, semi-crystalline and non-crystalline.

3. Table No. I. shows the breaking weight of the three descriptions of lime (when taken separately and also when mixed) made into brickets without admixture. Where the columns are left blank, it is to be understood that the brickets bore no strain whatever.

4. With reference to the remark in your memorandum, No. 184 C, of 26th February 1874, that brickets made of a mixture of one and a half parts river mud with one part of burnt lime broke with a weight of 375 lbs., Captain Brockman mentioned to me that those brickets were two months and twelve days old when broken.

5. Captain Brockman has proposed to me, at the suggestion of Mr. Vanstavern, getting down two of the steam mortar mills now lying at Dumagudiem, one to be used here, and the other at Chettepett, in preparing a stock of cement for use, where much baling is found necessary and the lime is likely to be washed out of the concrete; also in such places as lock sills and weirs, and for concrete blocks.

6. Colonel Brownlow having visited this district a few months since kindly consented to have the lime-stones used in the Western Delta experimented on to test their hydraulic properties. I send herewith copy of the statement received showing the results of that analysis. Mr. Dejoux asked for a cubic foot of the stones marked Nos. 11 and 13, but unfortunately no more stone of the kinds wanted could be found.

From Captain R.R.E. BROCKMAN, R.E., Executive Engineer, to Major J. BEATTY, R.E., District Engineer, Godavery, dated Dowlaishweram, 13th July 1874, No. 184.

I HAVE the honor, in accordance with your memorandum, No. 2,388, dated 6th November 1873, to forward, herewith, statements showing the results which have been obtained upon experimenting upon various mixture of lime with clay, both in their raw and burnt conditions.

2. The lime-stone used at Dowlaishweram and obtained from the Cahair quarry, about seven miles up the river, was divided into the three qualities of crystalline, semi-crystalline, and non-crystalline, as demarcated by the Chief Engineer in his memorandum, dated 5th November 1873. When the raw lime-stones ground to powder were mixed with equal weights of dry, raw clay and burnt, the cement derived therefrom appeared to yield the best results in the case where the non-crystalline or non-hydraulic description of lime-stone (marked C) was used. When both ingredients, however, had been calcined, and subsequently mixed together, the purer lime-stone (marked A) showed the best results.

3. The experiments with burnt lime and raw clay in different proportions are now nearly completed, and on the whole show results hitherto similar to the cement derived as above. I have yet to experiment upon the lime composed of the three qualities of stone above noted in equal parts, with varying quantities of clay, raw and burnt. The results attained last July when a tensile strength of 382 lbs. on 2½ square inches was arrived at cannot be taken into comparison, as although the mixture consisted of one burnt lime to one burnt clay, yet the period allowed for setting was two months and twelve days as against seven, fourteen, and twenty-one days of the present series of experiments.

4. As the Upper Godavery works are now on the point of being handed over to this district, I would suggest that one or two of the steam mortar mills lying up at Dumagudiem may be transferred to this station, in order that the cement prepared here may be milled and kept in stock for use on the works when wanted.

5. The ordinary stone mills drawn by bullocks are quite wanting in power, where a large quantity of material has to be turned out. Mr. Vanstavern informs me that one of the steam mills can keep sixty bricklayers steadily at work. The mixture of burnt clay with mortar, where lime is to the burnt clay in the proportion of one to one, is now being used on the face work 2 feet deep of the walls of the Choppella lock with excellent results.

No. I.

CEMENT EXPERIMENTS.

Pure lime brickets.

Days old.	A.	B.	C.	
	All lime.			
14	24	13	...	In these experiments the lime-stone was selected before burning of the three qualities, but it was not mixed with any clay for the brickets.
21	40	18	...	
D.	Mixed lime.			
14	14	...	...	In these experiments the three kinds of lime-stone were left mixed as they came from the quarry.
21	32	...	...	

N.B.—A.—Crystalline.
B.—Semi-crystalline.
C.—Non-crystalline.

(Signed) J. BEATTY, Major, R.E.,
District Engineer, Godavery.

Proceedings of the Madras Government, Public Works Department,
14th September 1874.

No. II.

CEMENT EXPERIMENTS.

Raw Lime-stone in powder, mixed with raw clay in powder and burnt.

Days old.	A.	B.	C.
	1 raw lime-stone, ¼ raw clay.		
7	19	89	90
14	...	65	126
21	...	199	128
	...	117	114
	1 raw lime, ½ raw clay.		
D.			
7	....	...	141
14	...	...	224
21	...	102	267
	...	...	210
	1 raw lime, ¾ raw clay.		
D.			
7	39	...	139
14	82	...	184
21	147	74	250
	89	...	191
	1 raw lime, 1 raw clay.		
D.			
7	...	...	164
14	...	87	228
21	...	159	251
	...	...	214

Days old.	A.	B.	C.
	1 raw lime, 1¼ raw clay.		
7	...	90	155
14	...	119	227
21	...	166	269
	...	125	217
	1 raw lime, 1½ raw clay.		
D.			
7	25	83	58
14	55	114	106
21	63	171	88
	47	122	84
	1 raw lime, 1¾ raw clay.		
D.			
7	...	79	183
14	...	72	240
21	...	183	266
	...	111	239
	1 raw lime, 2 raw clay.		
D.			
7	...	41	...
14	19	94	...
21	38	136	...
	...	90	...

No. III.

CEMENT EXPERIMENTS.

Burnt Lime-stone mixed with burnt clay.

Days old.	A.	B.	C.
	1 burnt lime, ¼ burnt clay.		
7	17	14	36
14	87	72	46
21	89	87	103
	64	57	61
	1 burnt lime, ½ burnt clay.		
D.			
7	63	40	37
14	161	143	90
21	157	117	105
	127	100	77
	1 burnt lime, ¾ burnt clay.		
D.			
7	(12 days.) 215	105	76
14	141	176	138
21	215	225	197
	190	168	137
	1 burnt lime, 1 burnt clay.		
D.			
7	(10 days.) 164	140	124
14	193	207	194
21	213	257	200
	191	201	172

Days old.	A.	B.	C.
	1 burnt lime, 1¼ burnt clay.		
7	(9 days.) 139	158	160
14	197	234	235
21	282	283	252
	206	223	215
	1 burnt lime, 1½ burnt clay.		
D.			
7	167	135	169
14	244	218	256
21	265	290	253
	225	214	227
	1 burnt lime, 1¾ burnt clay.		
D.			
7	103	142	112
14	218	206	154
21	325	276	213
	215	208	159
	1 burnt lime, 2 burnt clay.		
D.			
7	174	185	128
14	238	204	226
21	320	294	251
	244	227	201

No. IV.

CEMENT EXPERIMENTS.

Burnt Lime-stone in powder, mixed with raw clay in powder and reburnt.

Days old.	A	B.	C.	Days old.	A.	B.	C.
	1 burnt lime, ½ raw clay.				1 burnt lime 1½ raw clay.		
7	75	27	63	7	187	150	169
14	103	73	.....	14	249	235	.....
21	181½	112	.....	21	209	..	.....
	119	70	.....		235	.....	.....
D.	1 burnt lime, ½ raw clay.			D.	1 burnt lime, 1½ raw clay.		
7	77	97	117	7	173	219	168
14	160	.....	.....	14	260	222	.....
21	194	.....	.....	21	275	.....	.....
	143	.....	.....		236	.....	.....
D.	1 burnt lime, ¾ raw clay.			D.	1 burnt lime, 1¾ raw clay.		
7	165	106	99	7	195	227	164
14	192	158	.....	14	231	257	.....
21	227	.....	.....	21	247	.....	.....
	194	.....	.....		211	.....	.....
D.	1 burnt lime, 1 raw clay.			D.	1 burnt lime, 2 raw clay.		
7	172	117	129½	7	140	189	172
14	218	202	.....	14	217	256	.....
21	261	.....	.....	21	240	.....	.....
	215	.....	.....		203	.....	.....

* NOTE.—The mixture of one of burnt lime-stone in powder, with one and a half of raw clay, reburnt yielded the best results, but comparing this with table No. III. it appears that reburning did little good.

(Signed) J. BEATTY, Major, R.E.,
District Engineer, Godavery.

Report on Lime-stones of the Western Delta obtained for Lieutenant-Colonel Fischer by Colonel Brownlow.

Lime-stone from quarries near Chettipett on Ellore Canal, Godavery District, not a hydraulic lime, slakes with considerable violence, will not set under water unless it can take the initial set in air for a fortnight or so, when it goes on hardening under water apparently. I shall be very much obliged if Mr. Dejoux will kindly analyse the stone and tell me what can be done to improve its hydraulic properties.

MORADABAD.

(Signed) H. A. BROWNLOW, Colonel, R.E.

From P. DEJOUX, Esq., Executive Engineer, Cement Experiments Division, to Colonel J. F. STODDARD, M.S.C., Superintending Engineer, South-Western Circle, (No. 417, dated Sealdah, Bulliaghatta Road, No. 138, the 18th March 1874).

WITH reference to your memorandum, No. 194, dated 19th January last, forwarding fifteen specimens of lime-stone and a memorandum from Colonel Brownlow (both of which are herewith returned) I have now the honor to forward the results of analysis of those specimens.

2. The memorandum in question mentions simply "lime-stone from quarries near Chettipett on Ellore Canal;" but, as none of the fifteen specimens, which are quite different from each other not only in appearance but also in chemical composition were numbered, I conclude that they must have been found in the same quarries.

3. I have, however, numbered them consecutively, in order to show the result of analysis of each separately, *vide* statement over leaf.

Analysis.

Composition.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Clay	2·80	11·60	7·90	1·80	2·40	1·20	1·40	2·60	4·10	4·20	21·00	2·70	3·60	3·60	5·40
Sand (free)	Traces.	0·80	0·50	Traces.	Traces.	0·20	0·40	0·20	0·30	0·20	12·40	0·30	0·20	Traces.	Traces.
Oxide of Iron	2·40	1·00	1·20	1·30	0·40	1·80	1·80	0·50	1·20	1·20	0·80	0 80	0·50	0·40	0·60
Carbonate of Lime ...	93·00	85·60	88·60	72·50	95·30	70·50	95·00	95·80	93·50	92·60	65·00	94·60	65·30	94·60	92·60
Do. of Magnesia ...	1·80	1·00	1·80	24·40	1·90	26·30	1·40	0·90	0·90	1·80	0·80	1·60	30·40	1·40	1·40
Total...	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

NOTE.—Specimens Nos. 1, 6, and 7 contain traces of Manganese.

are

Remarks.

Specimens Nos. 5, 7, 8, 12, 13, and 14 are very rich in carbonate of lime and must yield fat lime of good quality.

Specimen No. 1, containing more impurities than those mentioned above, will yield fat lime of little inferior quality.

Specimens Nos. 9, 10, and 15 show the composition of stone yielding lime possessing feeble hydraulic properties.

Specimen No. 3 contains nearly 8 per cent. of clay, and is a very ordinary hydraulic lime-stone. The lime obtained from it ought to set in water after ten or twelve days.

Specimen No. 2 is an ordinary hydraulic lime-stone, and ought to be of good quality so as to answer for any ordinary hydraulic works. This lime ought to set under water after six or seven days.

Specimens Nos. 4, 6, and 13 are magnesian lime-stones. The proportion of clay contained in Nos. 4 and 6 is too small to admit of the production of magnesian hydraulic lime. Sample No. 13, however, by careful calcination, with slow fire so as to expel only a certain quantity of carbonic acid, may, perhaps, yield hydraulic lime.

Specimen No. 11. The proportion of clay and carbonate of lime contained in this specimen may bring it within the category of natural cement stones, but the rather large proportion of sand prevents cement of very good quality being obtained from it.

However I think that by calcining this stone with slow fire, causing the carbonic acid to be expelled entirely, and then pulverizing it finely, it may advantageously be used with other fat and magnesian limes. If a quantity of about a cubic foot of each of the stones, Nos. 11 and 13, was sent, I could then make proper experiments and give a more definite opinion, especially as regards improving their hydraulic properties, as required by Colonel Brownlow.

2. In conclusion, I may state that, as far as I can judge from analysis only, limes from stones Nos. 2 and 3 may be used as ordinary hydraulic lime, but that all the other limes save No. 11 may only be used for hydraulic mortar with puzzolannah made either with pure or marly clays (free from sand) and ground very fine, or with calcined red ochre earth if any can be found near the works.

No. 405-I.

COPY of the foregoing, together with the Lox of samples, forwarded to Colonel H. A. Brownlow, R.E., for information.

(By order of the Lieutenant-Governor of Bengal.)

10*th April* 1874. (Signed) H. W. GULLIVIN, Lieut.-Colonel, R.E.,
Offg. Joint Secy. to the Govt. of Bengal,
P.W.D., Irrigation Branch.

No. 278. ORDER THEREON, 14th September 1874, No. 2,606.

IRRIGATION, No. 37.

THE Government are glad to find that since the end of 1873 considerable progress has been made with the experiments for ascertaining the best way of turning the properties of the lime-stones available for use on the Delta works to account. It is hoped that the investigations will shortly be completed, and that then the manufacture of cement and concrete blocks will be carried on successfully, and at a cost which will make their use economical as well as highly advantageous. It is observed with satisfaction that the result of the experiments is likely to be the determination of a mixture yielding cements of very considerable strength, and possessing the qualities necessary to render them suitable to the Delta works.

2. The observations of the Chief Engineer for Irrigation in the foregoing note should receive careful consideration and attention.

3. The Government are gratified to learn that Colonel Brownlow interested himself in the subject when he visited the Godavery, and that he has obtained for the District Engineer information which must be of very considerable value.

(True Extract.)

(Signed) J. MULLINS, Lieut.-Colonel, R.E.,
Joint Secretary to Government.

To the District Engineer, Godavery.
" Chief Engineer for Irrigation,
" other District Engineers.
" Exd. E. C. Shunker.

Exd. E. C. Shunker.
Spare Copies

are

District Engr. Office, Godavery.

No. 1418 Dowlaishweram 5th Augt. 1874

From

Major J. Beatty R.E.

District Engineer Godavery.

To,

Lieutenant Colonel J. Mullins R.E.

Chief Engineer for Irrigation

Madras.

Sir,

I have the honor to furnish herewith for your information four tables of results obtained from experimenting on various mixtures of lime and clay, together with copy of letter from the Executive Engineer No. 1 Range.

2. The letters A. B. & C. are used to denote the three kinds of limestone; crystalline, semi-Crystalline and non crystalline.

3. Table No. I shows the breaking weight of the three descriptions of lime, [when taking separately, and also when mixed] made into brickets without admixture. Where the columns are

are left blank it is to be understood that the brickets bore no strain whatever.

4 With reference to the remark in your Memorandum No 184 C of 26th February 1874 that brickets made of a mixture of 4 parts river mud with one part of burnt lime broke with a weight of 375 lbs, Captain Brockman mentioned to me that those brickets were 2 months and 12 days old when broken.

5. Captain Brockman has proposed to me, at the suggestion of Mr Tanstavern, getting down two of the steam mortar mills now lying at Dumagudiem; one to be used here and the other at Chettypett, in preparing a stock of cement for use where much baling is found necessary, and the lime is likely to be washed out of the concrete; also in such places as lock sills and weirs; and for concrete blocks.

6 Colonel Brownlow having visited this District a few months since kindly consented to have the limestones used in the Western Delta experimented on to test their hydraulic properties; I send herewith copy of the Statement received showing the results of that analysis. Mr Dejoux asked for a Cubic foot of the Stones marked Nos 11, 12, 13, but unfortunately no more stone of the kinds wanted could be found.

I have the honor to be,
Sir,
Your Most obedient Servt
T. Peatty. Major R.E.
District Engineer Godavery.

Copy of a printed report on
Experiments on Cements
by Lieut. Colonel Orlebar
Executive Engineer, Godavery.

Circular from Chief Engineer
Public Works Branch, Madras
No 1418 dated 5th August 1874
= To Executive Engineers
= Sir
= I am directed to forward for your information
= and guidance, a copy of a Report
= on Experiments with Cements
= recently submitted to Government
= by Lieut. Colonel Orlebar
= Executive Engineer, Godavery
= and to request that you will favour
= this office with your opinion
= as to the value of the results
= recorded in the Report
= I have the honor to be
= Sir
= Your most obedient Servant
= (Signed) W. H. Bowdon
= Secretary
= North Western Provinces

From Lieut. Colonel Orlebar
Executive Engineer, 1st Division, Godavery
To The Secretary to Government
P. W. Department Madras
Enquiry, South. Western Circle, - No 417
Dated Sealdah, Bulliaghatta Road, No 138
the 18th March 1874.

From C.E. No 1452
Ref
The District Engineer
Godavery.

To The Chief Engineer
for Irrigation
Madras.

Dated 5th Aug. 1874
Recd 11th Aug. 1874

No 1418

Reporting the results of experiments on Cements

P.W. D 14 Sept. 74
In 13 No 277.

P.W. 54 1874
7/74.

Analysis

Composition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Clay	2.80	11.60	7.90	1.80	2.40	1.20	1.40	2.60	4.10	4.20	21.00	2.70	3.60	3.60	5.40
Sand (free)	Traces	0.80	0.50	Traces	Traces	0.20	0.40	0.20	0.30	0.20	12.40	0.30	0.20	Traces	Traces
Oxide of Iron	2.40	1.00	1.20	1.30	0.40	1.80	1.80	0.50	1.20	1.20	0.80	0.80	0.50	0.40	0.60
Carbonate of Lime	93.00	85.60	88.60	72.50	95.30	70.50	95.00	95.80	93.50	92.60	63.00	94.60	65.30	94.60	92.60
Do of Magnesia	1.80	1.00	1.80	24.40	1.90	26.30	1.40	0.90	0.90	1.80	0.80	1.60	30.40	1.40	1.40
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Note. Specimens Nos 1. 6. and 7 contain traces of Manganese.

Remarks

Specimens Nos 5, 7, 8, 12, 13, and 14, are very rich in carbonate of lime and would yield fat lime of good quality.

Specimen No 1, containing more impurities than those mentioned above, will yield fat lime of little inferior quality.

Specimens Nos 9, 10, and 15 show the composition of stone yielding lime possessing feeble hydraulic properties.

Specimen No 3 contains nearly 8 per cent of clay, and is a very ordinary hydraulic limestone. The lime obtained from it ought to set in water after 10 or 12 days.

Specimen No 2 is an ordinary hydraulic limestone, and ought to be of good quality, so as to answer for ordinary hydraulic works.

This lime ought to set under water after 6 or 7 days.

Specimens Nos 1, 6, and 13 are magnesian limestones.

limestones. The proportion of clay contained in Nos 4 and 6 is too small to admit of the production of magnesian hydraulic lime. Sample No 6 however, by careful calcination with slow fire, so as to expel only a certain quantity of carbonic acid, may, perhaps, yield hydraulic lime.

Specimen No 11. The proportion of clay and carbonate of lime contained in this specimen may bring it within the category of natural Cement Stones, but the rather large proportion of sand prevents Cement of very good quality being obtained from it. However, I think that by calcining this stone with slow fire, causing the carbonic acid to be expelled entirely, and then pulverizing it finely, it may advantageously be used with other fat and magnesian limes.

If a quantity of Cleats as enlarged sketch of each of the stones Nos 11 and 13 was sent, I could then make proper experiments and give a more definite opinion, especially as regards improving their hydraulic properties, as required by Colonel Brownlow.

In conclusion, I may state that, as far as I can judge from analysis only, lines from stones Nos 2 and 3 may be used as ordinary hydraulic lime, but that all the other lines save No 11, may only be used for hydraulic Mortar with pozzolannah made either with pure or marly clays (free from sand) and ground very fine, or with calcined red Ochre earth, if any can be found near the works.

No 405 B

Copy of the foregoing together with the box of samples forwarded to Colonel H. A Brownlow R.E for information.

By

51

By order of the Lieut Governor of Bengal

(Signed) H. D Gallwey Lieut RE

Offg Joint Secy to the Govt of Bengal

P.W.D. Irrigation Branch

P.W.D. No 3
Dt 10 April 74

True Extract

H. Beatty Major RE

District Engineer Godavery

Camp Dowlaishweruma
Executive Engr's Office,
13th July 1874.

No. 184.

From,

The officer in charge No. 1 or Eastern
Delta Range, Godavery Dt.

To

The District Engineer
Godavery District,
Dowlaishweruma.

Sir,

I have the honor in accordance with your Memo No. 2388 dated 6th November 1873, to forward herewith statements showing the results which have been obtained upon experimenting upon various mixtures of lime with clay, both in their raw & burnt conditions-

2. The limestone used at Dowlaishweruma and obtained from the Catair Quarry, about 7 miles up the river, was divided into the three qualities of crystalline, semi-crystalline, and non-crystalline, as

Recd 15/7/74.
Assistant
Exd. Engr's Office
Dowlaishweruma
by
Overseer Delta Limestone

as demarcated by the Chief Engineer in his Memo No.— dated 5th Novem-ber 1873. When the raw limestones ground to powder were mixed with equal weights of dry raw clay, and burnt, the Cement derived therefrom appeared to yield the best results in the case where the non-crystalline or non-hydraulic description of lime stone, [marked C] was used. When both ingredients however had been calcined, and subsequently mixed together, the purer limestone [marked A] showed the best results.

3. The experiments with burnt lime and raw clay in different pro-portions are now nearly completed, and on the whole show results, hitherto, similar to the Cement derived as above. I have yet to experiment upon the lime composed of the three qualities of stone above noted in equal parts, with varying quanti-ties of clay raw and burnt.

The results attained last July when a tensile strength of 382 lbs on 2½ Sq^re inches was arrived at cannot be taken into comparison, as although the mixture consisted of 1 burnt lime to 1 burnt clay, yet the period allowed for setting was 2 months and 12 days as against 7, 14, & 21 days of the present series of experiments.

4. As the Upper Godavery works are now on the point of being handed over to this District, I would suggest that one or two of the steam mortar mills lying up at Dumagudium may be transferred to this Station, in order that the Cement prepared here may be milled and kept in stock for use on the works when wanted.

5. The ordinary stone mills drawn by bullocks are quite wanting in power, where a large quantity of material has to be turned out. Mr Vanstavern informs me that one of the steam mills can keep 60 bricklayers steadily at work. The mixture of burnt clay with mortar where lime is to the burnt clay

proportion of 1 to 1 is now being used on the face work 2 feet deep, of the walls of the Choppella Lock with excellent results.

I have the honor to be, &c &c

[Sd/] R. R. E. Brockman Capt. R.E.
Executive Engineer.

[True Copy]

P. Beatty Major R.E.
District Engineer Godavery.

No. 500.

Note by the Chief Engineer for Irrigation

In the order of the 18th April 1871, No 1077, para: 3, a grant of Rupees 5000 was made for the purpose of experiments to ascertain how concrete blocks, as a substitute for random rubble masonry, might best be manufactured. The first thing to be done was to experiment upon the lime stone available, so as to determine what mixtures of this and clay would be most suitable as a cementing material. Concurrently also it was of importance that the necessary admixture of clay with the several descriptions of lime stone commonly found, to render them highly and moderately hydraulic and suitable therefore for foundations on the one, and superstructures of works on the canals on the other, hand should be ascertained

2. It was noticed in the memorandum of inspection of the

P.W. G 15 July 1874 - 12 1906.

God avery Delta works, on which orders have recently been passed, that up to the end of last year the investigations had not made that progress which was desirable, but the District Engineer has now transmitted tables showing the results of the experiments since made; and further, when Colonel Browne R. E. visited the Delta at the end of 1873, he kindly interested himself in the matter, took with him samples of the lime stones, and obtained an analysis of and a report upon them from the officer who is in charge of Cement experiments in Bengal.

Dmls 15 July 1874 No 1906.

3. The District Engineer has not classified the samples examined by Mr Dejonx under the more apparent descriptions viz crystalline, semi-crystalline and non-crystalline, by which they have been quoted in the local experiments at Dowlaishwaram, but it is to be hoped that he has the means of doing this, otherwise much of the value of Mr Dejonx's investigations will be lost. If Colonel Brownlow has not returned the samples, which after their transmission to Mr Dejonx were duly numbered, probably there will be no difficulty in obtaining them; but, as it is stated in the concluding para: of Major Beatty's letter that of specimens Nos 11 & 13 further quantities were not to be found, probably the samples are with the District Engineer, and the desired classification can be made

4. The analysis of the lime stones shows that their qualities vary greatly, and that consequently for particular purposes their treatment will require to differ materially. Thus

to add to numbers 2 & 11 the proportion of clay which would be suitable for Nos 1, 5, 7, 8, 12 &c, which are very rich in carbonate of lime, would probably spoil them. If a limestone similar to No 11, but with a smaller proportion of sand can be found, there is every probability, with suitable burning, of its proving without any admixture of other material, suitable for all work where hydraulic cement is required. A further search should therefore be made

5. Turning now to the experiments it will be seen that the admixture of clay with the lime in most cases produced a very superior cementing material to the lime alone. The maximum strength of briskets of lime after 21 days was 40 lbs or 2¼ square inches, while by admixture this maximum became 325 lbs, which was obtained with crystalline burnt lime

Table III

mixed with burnt clay in the proportion of 1 of the former to 1¾ of the latter. Looking to the small age of the bricket this must be deemed, it appears to me, a very satisfactory result, while numerous other mixtures of all the 3 different descriptions of lime yielded cement but little inferior, and of ample strength for most purposes connected with the Delta works.

6. It has not been so stated in these papers, but it is supposed that all brickets were treated as in the previous experiments alluded to in the memorandum of inspection. i.e. that they had 2 days air drying, and were then immersed. A further matter which requires to be recorded is the number of brickets of each kind experimented upon from which the average given in the tables was deduced.

7. It must be noticed that for each sort of limestone the admixture of clay in increasing proportions should produce an addition of tensile strength continuously up to the maximum, and then show a

a decreasing strength after the useful limit had been passed, but this result is not always apparent. This in table II for 21 days it will be seen: that the results given are as follows

Raw lime & raw clay in powder, mixed & burnt

1 & ¼ & breaking weight	A.	B.	C.
1 – & ½ –	lbs.	—	199. 128
1 – & ¾ –	lbs	—	102. 267
1 – & 1 –	lbs	147	74. 250
1 – & 1¼ –	lbs	—	159. 251
1 – & 1½ –	lbs	—	166. 269
1 – & 1¾ –	lbs	63	171 – 88
1 . & 2 – . –	lbs	—	153. 266
	lbs	38	136 —

Taking into account too that the District Engineer mentions that where the tables show blanks the bricks to failed to bear any strain, it would seem, first that many of the bricks must have been badly made, and secondly that the number experimented upon must have been too small. It is impossible to any other supposition to account for such variations of strength as are exhibited in this table.

Table III exhibits much more regular results

8. As regards rapid setting, an quality which is necessary for certain purposes, no definite information has been afforded, and special experiments for the determination of this point should be instituted. If air drying before immersion was practised, the tensile strength of various compositions at 7 days is only indirect and inconclusive evidence of the degree in which this characteristic was exhibited. Probably air drying for 6 hours & then immersion for 18 hours would afford a fair criterion.

9. On the subject of the cost of burning the several descriptions of limestone, and of the several modes of preparing hydraulic cement definite information should be obtained if this has not already been done. Of several mixtures of about the same value as regards strength, that which is capable of being manufactured the more cheaply, and conveniently, should be selected for general use

10. It may be noticed also that some of the entries in the tables appear to indicate that the right degree of heat was not employed This deduction would seem to be fairly obtainable from an examination of table II, and I am disposed to think that the temperature attained when dealing with raw lime and raw clay burnt in contact was generally too low - On the other hand table III appears to show that it is easier to obtain fairly even and reliable results by burning the lime and clay separately and mixing them afterwards. Table IV indicates that no advantage is secured by burning the lime, mixing it with raw clay, and then burning the mixture; and it is probably more expensive than either of the other processes.

11. It is desirable, in order that the information gained in the Godavery should form a guide to investigations elsewhere, that all papers relating to the experiments should show exactly the way in which they were conducted, what processes have been found to answer, and what have been proved by experience to be either injurious or unnecessary. Future reports should therefore be made as complete as possible.

12. It was originally contemplated that a mill for grinding materials should be set up, and indeed for the preparation of cement good grinding arrangements are essential. I think two mills may with advantage now be set up, one at Dowlaishweram and the other at Chettipett where the Western Delta lime kilns are situated, and where the head quarters of the Range will shortly be located - That at Dowlaishweram should be placed where

where the manufacture of concrete blocks will be undertaken permanently. The confined space near the dry dock was suited only to the preliminary experiments.

13. It is satisfactory to find that a commencement has been made with the use of cement on the Delta works. The only matter of regret is that this was not done 3 years ago.

Dated Simla the 20th August 1874

I have the honor to be
Sir
Your most obedient servant
Chief Engineer for Irrigation

To
The Secretary to Govt N.W.P. &c.

P. W. 1874 Dept.
Registered
No: 5467

From

The Chief Engr
for Irrigation

Dated 20 Augt. } 1874.
Recd 31st —"— }

C. 7.

E.C. No: 2606. 14-9-74.

Note on a report of the results of Cement experiments in the Godavery District.

No 277

4

Burnt limestone in powder, mixed with raw clay in powder, and reburnt.

Sand	A.	B.	C.	Sand	A	B.	C.
	1 B.L. ¼ R.C.				1 B.L ¼ R.C.		
7	75	27	62	7	187	190	165
14	103	73	"	14	249	235	
21	187½	112		21	269		
0	1 B.L. ½ R.C.			0	1 B.L. 1½ R.C.		
7	77	97	117	7	173	212	166
14	160			14	260	225	
21	194			21	275		
0	1 B.L. ¾ R.C.			0	1 B.L. 1¾ R.C.		
7	165	106	99	7	155	227	164
14	192	158		14	231	287	
21	227			21	247	"	
0	1 B.L. 1 R.C.			0.	1 B.L. 2. R.C.		
7	172	117	129½	7	140	188	172
14	212	202	"	14	217	256	
21	261	"	"	21	250		

H. Beatty. Major R.E.
District Engineer Godavery

Cso 8/1452/34
PWD 8467/34
3
pls. 7/14 Sept/34
Le Bas 277.

Results. Major Cement

Results of tests of Portland cement mixed with burnt clay

Results of tests of Portland cement mixed with burnt clay-stone

Results of tests of Portland cement mixed with burnt clay-stone mixed with lime-stone

Sample	Age	1:3	C.	Sample	Age	1:3	C.	Age	1:3	C.
	1 Cl. to ¼ B.C.				1 Cl. to ½ B.C.			1 Cl. to 1½ B.C.		
7	17	14	36	7	139	105	154	183	142	112
14	87	72	46	14	197	176	213	234	205	154
21	80	87	103	21	282	225	257	282	276	213
	1 Cl. to ½ B.C.				1 Cl. to ¾ B.C.			1 Cl. to 2 B.C.		
7	63	43	37	7	157	105	76	102	72	46
14	161	143	90	14	244	198	139	218	205	154
21	157	117	105	21	266	213	197	325	290	213
	1 Cl. to ¼ B.C.				1 Cl. to 1¼ B.C.			1 Cl. to 2½ B.C.		
7	215	105	76	7	102	72	46	174	185	128
14	141	176	139	14	218	205	154	238	254	226
21	215	225	197	21	325	276	213	320	294	257
	1 Cl. to 1 B.C.				1 Cl. to 2 B.C.					
7	162	143	124	7	124	72	46	174	185	128
14	198	237	194	14	194	205	154	238	254	226
21	213	287	200	21	200	276	213	320	294	257

Cement Experiments

"Raw lime-stone, in powder, mixed with raw clay in powder, and burnt.

Days old	A.	B.	C.
	1 R.L. 1 – ¼ R.C.		
7	19	89	90
14		65	126
21		199	128
D.	1 R.L. – ½ R.C.		
7		102	141
14			224
21			267
D	1 R.L. ¾ R.C.		
7	39	74	139
14	82		184
21	147		250
D	1 R.L. 1 R.C.		
7		87	164
14		159	228
21			257

Days old	A	B.	C.
	1 R.L. 1½ R.C.		
7		90	155
14		119	227
21		166	269
D.	1 R.L 1½ R.C.		
7	25	83	58
14	56	114	106
21	63	171	88
D	1 R.L. 1¾ R.C.		
7		79	182
14		72	240
21		183	266
D.	1 R.L. 2 R.C.		
7		41	
14	19	94	
21	38	136	

G. Beatty. Major R.E.
District Engineer 6th C.

Mr. Smith
Mr. Smith
Mr. Ellis

Cement Experiments.

23

Pure lime brickets.

Days old.	A.	B.	C.	
	All lime.			
14	24	13	"	In these experiments the limestone was selected before burning of the three qualities; but it was not mixed with any clay for the brickets.
21	40	18	"	
D	Mixed lime.			
14	14	"	"	In these experiments the three kinds of limestone were left mixed as they come from the quarry.
21	32	"	"	

L. Beatty - Major R.E.
District Engineer Godavery

NB A - Cryptalline
B. - Semicryptalline
C - Non cryptalline

Corrosive Sublimate 2.7.71
Mix. 3rd Sept. 71.
Put in 5th Sept. 71.

Proceedings of the Naval Court of Inquiry held on board H.M.S. Assistance at Queenstown on the 6th August 1874 and following days, to investigate the circumstances attending the loss of the Screw Collier Captain Boadicea on the Coast of Ireland on the 4th August 1874.

Letter from the Secretary to the Admiralty dated 30th July 1874, forwarding Report of Proceedings of Court of Inquiry assembled on board H.M.S. Assistance at Queenstown on the 4th August 1874 to investigate the circumstances attending the loss of the Screw Collier Captain Boadicea on the Coast of Ireland on the 4th August 1874.

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Note to the Admiralty dated 30th August 1874, forwarding Depositions taken at Queenstown.

2 Vols.

Note to the Admiralty dated 30th August 1874, forwarding Depositions taken at Queenstown.

1st Vol.

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Depositions taken at Queenstown.

2nd Vol.

M.N. 5467/74.
6/74.

P.G. 14 Sept. 74
In B.N. 277.

them the manufacture of cement & concrete blocks will be carried on successfully, and at a cost which will make their use economical as well as highly advantageous. It is observed with satisfaction, that the results of the experiments is likely to lead the determination of a mixture yielding cements of very considerable strength, and possessing the qualities necessary to render them suitable to the Delta works.

2. The observations of the Chief Engineer for Irrigation in the foregoing Note should receive careful consideration and attention.

3. The Government are gratified to learn that Colonel Bourdillon interested himself in the subject, when he visited the Godavery, and that he has obtained for the District Engineer information which must be of very considerable value.

W. 22/9/74

Genl

To The D.C. Godavery
-.- Chf Engr for Irrn
-.- other Dist Engrs
Spl Ex Engineer Mysore
Secl. Copies, dated 22/9/74.

5467

Govt. of H.S.H. Nizam's

PUBLIC WORKS.

The Asst. Engineer
Godavery
by order of Superintendent

Dated

Rect.

Entd.

G. O. 16 Sept. 74. No. 2660

K.J.A.

Nos. 277-278.

Cement experiments

To Pressing orders on
the table by the Chief-
Engineer for Irrigation
with report of the
results of the ce
ments in the
Godavery District