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MADRAS RECORD OFFICE

Government of Madras

Public Works

DEPARTMENT

G.O. No.	1157	Press
B.P. No.		Mis.
Dated	22 - 4 -	1955

Not to be folded or roughly handled

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*Proceedings of the Madras Government, Public Works Department,
22nd April 1875.*

Read the following papers :—

No. 609. From Lieutenant-Colonel J. GODDARD, R.E., District Engineer, Presidency, to Colonel G. W. WALKER, R.E., Secretary to Government, Public Works Department, dated Fort St. George, 3rd April 1875, No. 89.

IN obedience to G. O., No. 427, dated 21st February 1874, I have the honor to submit an interesting report by Mr. Grainger, together with five bricks for inspection.

1 Report, with its accompaniments.
5 Bricks.

2. Mr. Grainger gave his constant and laborious personal attention to the experiments daily for weeks, and was the sole experimentalist.

3. I have much pleasure in submitting his report, and trust that the Government will be well satisfied with the manner in which he has conducted the duties which devolved upon him.

From J. N. GRAINGER, Esq., General Superintendent of Public Works Stores and Workshops, to Lieutenant-Colonel J. GODDARD, R.E., District Engineer, Presidency, dated Chepauk, 1st April 1875, No. 1.

I HAVE the honor to submit the following results of experiments on hydraulic cements made from limes and clays found in or near Madras.

The materials experimented on were :—

Madras stone lime, a common kunkur which yielded on analysis carbonate of lime 59.8, iron, alumina, &c., 9.3, clay 15.4, sand 14.7, and a trace of silica.

Shell lime, a nearly pure carbonate of calcium containing only 1.7 per cent. of impurities (Dr. Nicholson's Report).

Veysarbady clay, an impure clay containing small quantities of carbonates and 13 per cent. of sand.

Canal clay, obtained from the East Coast Canal near the Madras lime kilns, contains small quantity of carbonates and 32 per cent. of sand.

With these materials a series of twenty-eight preliminary experiments were made to test the hydraulic properties of mixtures of each lime with each kind of clay.

The limes and clays after being burned separately were mixed in proportions by weight varying from 80 per cent. of lime and 20 of clay to 20 per cent. of lime and 80 of clay, and of these mixture the following were found to be hydraulic :—

TABLE I.

No. of Experiments.	Composition.	Remarks.
5	Shell lime 40 Veysarbady clay 60	Immersed $\frac{1}{2}$ hour after mixing, hardens quickly.
10	Stone lime 60 Veysarbady clay 40	Immersed 1 hour after mixing, hardens.
17	Shell lime 60 Canal clay 40	Immersed $\frac{1}{2}$ hour after mixing, sets very slowly and is friable.

Proceedings of the Madras Government, Public Works Department,
22nd April 1875.

No. of Experiments.	Composition.	Remarks.
23	Stone lime ... 70 Canal clay ... 30	Immersed 1 hour after mixing, softens at first, ultimately hardens slowly.
24	Stone lime ... 60 Canal clay ... 40	Immersed 1 hour after mixing, hardens slowly.

These mixtures were made by weight, the lime being slaked as obtained from the lime kilns, and the clay in powder after being burnt.

Other mixtures of these limes and clays were then made in which the proportions were 5 per cent. above and below those given in Table I., but the quality of the cements was not improved. From the appearance and strength of these cements after hardening No. 5 was considered the best, and was the one selected for making bricks for trial of tensile strength when mixed with sand in varying proportions.

The average tensile strength per square inch of the bricks is given in Table II., which also shows for comparison the average strength per square inch of the bricks made from Portland cement, having the same proportion (by measure) of sand. The averages are the results of five trials with each kind of brick made from No. 5 cement, and of three to five trials in the case of Portland cement.

The table shows a very marked increase in strength due to immersion, especially in the cases of one-fifth cement and four-fifths sand (column 6), where the bricks had so little strength that they could scarcely be handled; yet after 60 days' immersion they stood 37 lbs. per square inch tensile strain. This table also shows that the cement possesses fair adhesive properties, especially after immersion; for on comparing the results in column 5 with those in column 2 we find the strength greater in the former than in the latter, although there is only two-fifths of the quantity of cement used. In column 6 we find it compares very favorably with the Portland cement, possessing over 50 per cent. of its strength, but whether it would retain this proportionate strength after a number of years is very doubtful.

The salt water in the fort ditch containing as it does large quantities of carbonic acid gas has to some extent made the bricks weaker than they would have been if immersed in pure water or good salt water; for on breaking the bricks the margin of the fracture was found to be white for a depth of one-eighth or three-sixteenths of an inch, showing carbonate of lime in large quantities, whilst only the inner portions had the grey color of the silicate.

Another source of weakness is in the limes being imperfectly burned at the kilns. In England the limes after being burned is kept carefully in closed godowns, but in Madras it is kept under open sheds exposed to the action of the air for days, if not weeks, before being used, by which it becomes partly slaked and a large percentage of what should be hydrate of lime becomes carbonate of lime, and thus prevents the useful formation of carbonate of lime when used as mortar or silicate when used in cement. However, even taking every precaution, we cannot hope to make a cement with the materials obtainable in Madras that will be superior to the London Roman cements. With improved forms of furnaces and thorough burning of the cement balls we may be able to equal the London Roman cements, but at present we are far from it as shown by Tables III. and IV. Table III. shows the weight per bushel of the different cements and their tensile strength per square inch. The bricks were immersed about twenty-four hours after mixing.

Table IV. shows the strength of English Roman cements; their average weights were 80 lbs. per bushel, and are taken from Reid's "Treatise on Concrete," page 30. The cost of manufacturing these cements could not be ascertained from the small quantities made for these experiments.

Proceedings of the Madras Government, Public Works Department,
22nd April 1875.

TABLE II.

1 AGE AND TREATMENT OF Brickets.	2 PURE CEMENTS.		3 1 CEMENT. 1 SAND.		4 1 CEMENT. 1 SAND.		5 2 CEMENT. 3 SAND.		6 1 CEMENT. 1 SAND.	
	No. 5.	Port-land.	No. 5.	Port-land.	No. 5.	Port-land.	No. 5.	Port-land.	No. 5.	Port-land.
	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	No strength whatever	
15 days drying in air.	32.3	219.2	24.7	288.8	21.5	263.7	17.3	107.4	00.0	31.1
Afterwards immersed for 30 days.	46.4	303.1	53.9	309.8	50.8	311.5	49.6	174.4	27.5	48.0
(Age 45 days.)										
After 60 days' immersion.	61.3	308.4	94.2	332.0	86.2	322.7	83.6	232.8	37.7	63.3
(Age 75 days.)										
After 6 months in water.	100	315	..	..	..	..	..	..	..	..

TABLE III.

No. of Cement.	Composition.	Weight lbs. per bushel.	TIME OF IMMERSION.		
			1 Week.	1 Month.	5 Months.
5	Shell lime .. 40 Veysarbady clay .. 60	65	68	63	84
10	Stone lime .. 60 Veysarbady clay .. 40	69	78	72	44
17	Shell lime .. 60 Canal clay .. 40	53	19	58	90
23	Stone lime .. 70 Canal clay .. 30	66	10	40	
24	Stone lime .. 60 Canal clay .. 40	59	22	17	
36	Stone lime .. 80 Tough ball clay .. 20	39	27	66	108
37	Stone lime .. 70 Tough ball clay .. 30	55	43	47	

TABLE IV.

No.		BREAKING WEIGHT PER SQUARE INCH.			
		7 Days.	1 Month.	6 Months.	1 Year.
		lbs.	lbs.	lbs.	lbs.
1	Roman Cement made in London ..	89	108	167	144
2	Do. do. do. ..	89	116	209	286
3	Do. do. do. ..	54	160	112	120
4	Do. do. do. ..	60	96	194	212
5	Modina made in the Isle of Wight ..	41	136	183	212

Proceedings of the Madras Government, Public Works Department,
22nd April 1875.

No. 355-A.

No. 610.

Note by the Chief Engineer for Irrigation.

THE experiments carried out by Mr. Grainger on cements made by mixtures of lime and clay show that a considerable increase of strength and in all probability of durability also will result from the use of burnt clay, and the District Engineer, Presidency, should arrange for giving practical effect to these investigations by using cements of suitable mixtures on the works under his charge. Apparently 3 sand to 2 cement will form a suitable hydraulic mortar for ordinary constructive works.

FORT ST. GEORGE,
7th April 1875.

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

No. 611.

ORDER THEREON, 22nd April 1875, No. 1,151.

IRRIGATION, No. 69.

RECORDED, and communicated to all
Superintending and District Engineers
and to the Chief Engineer for Irrigation.

(True Extract.)

Colonel, R.E.,

Secretary to Government.

To all Superintending Engineers.

„ District Engineers.

To the Special Executive Engineer, Wynaad.

„ Chief Engineer for Irrigation.

„ „ and Manager, of the Madras Irrigation and Canal Company.

„ Principal of the Civil Engineering College.

„ Superintendent of the Government Central Museum.

„ Consulting Engineer for Railways.

Exd. W. J. Lewis.

Spare Copies

No. 1

Presidency Workshops D. P.M.
Chepauk 1st April 1875

From

The General Superintendent
P.M. Workshops and Stores

To

The District Engineer
Presidency
Fort Saint George

Sir,

I have the honor to
submit the following results of
experiments on Hydraulic cements
made from Limes and Clays found
in or near Madras.

The materials experimented on
were:-

Madras Stone Lime a common
kind which yielded on analysis
Carbonate of Lime 89.8 Iron, alumina
&c. 0.3, Clay 13.4 Sand 11.7 and a trace
of Silica.

Shell Lime a nearly pure carbonate
of Calcium containing only 1.7 per
cent. of impurities. (Dr. Nicholson's Report)
Very good clay an impure clay
containing

containing small quantities of carbonates and 13 per cent of sand.

Canal Clay, obtained from the East Coast Canal near the Madras Lime Kilns. Contains small quantity

of carbonates and 32 per cent of sand.

With these materials a series of 28 preliminary experiments were made to test the hydraulic properties of mixtures of each lime with each kind of clay.

The limes and clays after being burned separately were mixed in proportions, by weight, varying from 80 per cent of lime and 20 of clay to 20 per cent of lime and 80 of clay and of these mixtures the following were found to be hydraulic.

Table I

Table I

No. of Experiments	Composition	Remarks
5	Shell Lime - 40 Vejasarbady clay - 60	Immersed $\frac{1}{2}$ hour after mixing. Hardens quickly.
10	Stone lime - 60 Vejasarbady clay - 40	Immersed 1 hour after mixing - hardens.
17	Shell Lime - 60 Canal Clay - 40	Immersed $\frac{1}{2}$ hour after mixing. Sets very slowly and is friable.
23	Stone Lime - 70 Canal Clay - 30	Immersed 1 hour after mixing. Softens at first. Ultimately hardens slowly.
24	Stone Lime - 60 Canal Clay - 40	Immersed 1 hour after mixing. Hardens slowly.

These mixtures were made by weight the lime being slaked, as obtained from the Lime Kilns, and the clay in powder after being burnt.

Other mixtures of these limes and clays were then made in which the proportions were 5 per cent above and below those given in Table I but the quality of the cements was not improved. From the appearance and strength of these cements after hardening

Hardening No 5 was considered the best and was the one selected for making bricks for trial of tensile strength when mixed with sand in varying proportions.

The average tensile strength per square inch of the bricks is given in Table II which also shows, for comparison, the average strength per square inch of the bricks made from Portland Cement, having the same proportion (by measure) of sand. The averages are the results of five trials with each kind of brick made from No 5 cement and of three to five trials in the case of Portland Cement.

The table shows a very marked increase in strength due to immersion especially in the cases of No 5 cement and No 5 sand (column 6) where the bricks had so little strength that they could scarcely be handled yet after 60 days immersion they stood

924
37 lbs. per square inch tensile strain. This table also shows that the cement possesses fair adhesive properties especially after immersion for, on comparing the results in column 5 with those in column 2 we find the strength greater in the former than in the latter although there is only $\frac{2}{3}$ of the quantity of cement used. In column 6 we find it compares very favorably with the Portland Cement possessing over 50 percent of its strength ^{but} whether it would retain this proportionate strength after a number of years is very doubtful.

The salt water in the Flort Ditch containing as it does, large quantities of carbonic acid gas, has to some extent made the bricks weaker than they would have been if immersed in pure water or good salt water for on breaking

breaking the bricks the margin
of the fracture was found to be
white for a depth of $\frac{1}{8}$ " or $\frac{3}{16}$ " of
an inch showing carbonate of
lime in large quantities whilst
only the inner portions had the
grey colour of the Silicate.

Another source of weakness is
in the limes being imperfectly
burned at the kiln. In England
the limes after being burned is
kept carefully in closed godowns
but in India it is kept under
open sheds exposed to the action
of the air for days if not weeks
before being used by which it
becomes partly slaked and a
large per centage of what should
be hydrate of lime becomes carbo-
nate of lime and thus prevents
the useful formation of carbonate
of lime when used as mortar or

112
Silicate when used in cement.
However even taking every precaution
we cannot hope to make a cement
with the materials obtainable in
India that will be superior to
the London Roman Cement.
With improved forms of furnaces
and thorough burning of the cement
balls we may be able to equal the
London Roman Cement but at
present we are far from it as
shown by Tables III and IV. Table
III shows the weight per bushel
of the different cements and their
tensile strength per square inch.

The bricks were immersed about
24 hours after mixing.

Table IV shows the strength of
English Roman Cements their average
weights were 80 lbs per bushel and
are taken from Reid's "Treatise on
Concrete" page 30.

The cost of manufacturing these
cements could not be ascertained
from the small quantities
made for these experiments.

S

1	2	3	4	5	6	
Age and kind: ment of	Port. Cement	4 1/2 - Cement	4 1/2 - Cement	4 1/2 - Cement	4 1/2 - Cement	
Bricksets	1 1/2 - Cement	2 1/2 - Cement	2 1/2 - Cement	2 1/2 - Cement	2 1/2 - Cement	
18 days	100	100	100	100	100	
changing in air	32.3	219.2	24.7	288.8	21.5	263.7
after 6 months	110.4	303.1	53.9	309.8	57.8	311.5
after 60 days	61.3	308.4	91.2	332.0	86.2	322.7
in water	100	315	"	"	"	"

Dr. 2194/45

I have the honor to be
Sir
Your most Obedt Servant

J. H. Wanger
Genl Sup of Workshops & Store

Table III

No. of Element	Composition	Weight the per bushel			Time of immersion	
		1 week	1 month	3 months	8 months	1 year
5	Shell Lime. 110 Hydrated clay. 60	65	68	68	84	
10	Stone Lime. 60 Hydrated clay. 110	69	78	72	44	
17	Shell Lime. 60 Canal clay. 110	53	19	58	90	
23	Stone Lime. 70 Canal clay. 30	66	10	40	"	
24	Stone Lime. 60 Canal Clay. 40	59	22	17	"	
26	Stone Lime. 80 Chicago ball clay. 20	39	13	66	108	
34	Stone Lime. 70 Chicago ball clay. 30	55	24	47	"	

$\frac{2196}{2} = 1098$
 1098

		Breeding weight per day, week			
		1 day	1 month	6 months	1 year
1	Person Enant made in London	89	108	167	144
2	Do	89	116	209	286
3	Do	54	160	112	120
4	Do	60	96	194	212
5	Bred in the Isle of Wight.	41	136	183	219

Q. 7 2194/5

Q. R. 2196 / 45

From
The Genl. Superintendent
P.M. Workshops & Store

To
The District Engineer
Presidency
Fort Saint George.

Dated 1st April 1875
No 1

Submits results of
experiments on Hydran-
lic Cements made
from Limes and
Clays found in
or near Nagrae

M. 2502/75
2

P. N. 2196/55
41

[Faint, mostly illegible handwritten notes on the left page, possibly related to the experiments mentioned in the right page.]

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 N. 355 A
 21/5

Note by the Chief Engineer for Irrigation

The experiments carried out by Mr. Kranger on cements made by mixtures of lime and clay show that a considerable increase of strength and in all probability of durability also will result from the use of burnt clay, and the District Engineer, Presidency, should arrange for giving practical effect to these investigations by using cements of suitable mixtures on the works under his charge. Apparently 3 sand to 2 cement will form a suitable hydraulic mortar for ordinary constructive works.

Substantive }
 7th April 1875 }
 Wm. Mullins Lt. Col. R.E.
 Chief Engineer for Irrigation

To
 The Secretary to Government
 P. W. D.

No. 89.
Form,

236

The District Engineer
Presidency

30.
The Chief Engineer, and
Secretary to Government S.P.N.

Sir,
In obedience to G.O. No. 427 of 21 Feb'y 1874
I have the honor to submit an interesting
report by Mr. Brainger, together with five
bricks for inspection.
2. Mr. Brainger gave his constant and la-
borious personal attention to the experiments
daily for weeks, and was the sole experimental
ist.
3. I have much pleasure in submitting
his report, and trust ^{that} the Government will be
well satisfied with the manner in which
he has conducted the duties which devolved
upon him.

I have the honor to be
Sir,

Your most obedient servant

[Signature]
District Engineer
Presidency

Fort St. George
31 April 1875

Geo. L.
25

4. 6. 214 344 174 408 4410
" 10. 800 174 194 4196
" 30. 845 174 585 4586
" 18. 845 174 356 4357
" 17. 845 173 308 4309
" 14. 845 173 183 4181
" 13. 845 174 128 4129
" 5. 845 173 53 4064

Mr. 1845 4410
No. 355 4-12. 2502.

The Chief Engineer for
the Government of
P.W.D.

October 1875
March 1875

See Volume 2

Note on report by Mr.
Brainger C.E. on results
of experiments on Hydrants
- his comments -
G.O. No. 1151-22-4-75

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Govt. of 1875; Madras.
PUBLIC WORKS.

To

Mr. Engr. W. S. S. S.

by Rep.
Dated

Recd.

Encl.

G. O. 22nd April 1875, No. 1151

No. 609-611

Experiments on Hydraulic
Cements - Mr. Grainger's Report
on results of ———, and the
Chief Engineer's Note thereon,
recorded and communicated to
the Superintending and District
Engineers and to the Chief Engineer
of Irrigation