

(1) Number of pages 22

(2) Date of repair August, 1986

(3) Initials of the Referencer Cons

TAMIL NADU ARCHIVES

GOVERNMENT OF TAMIL NADU

Public works DEPARTMENT

G.O. No.	3008 W.	Press.
B.P. No.		Mis.
Dated	26-7-1978	497.

S.G. 57

Not to be folded or roughly handled

358
1

GOVERNMENT OF MADRAS.
PUBLIC WORKS DEPARTMENT.

26th July 1878, No. 3,008 W.

Buildings and Roads.
Civil Works.

Read the following paper —

No 262 Circular from the Government of India, Public Works Department
(Civil Works—Irrigation), dated Simla, 20th June 1878, No. 53 P W

In continuation of Circular No 46 P W, dated the 4th instant, the undersigned
is directed to forward, for information, copy of a paper by Mr P Dejoux on limes,
cements, sand, soorkee and mortars

(Signed) G. T. SKIPWITH, Captain, R E,
Asst Secy to the Govt. of India

To the Secretary to the Government of Madras, Public Works Department, General Branch

From P DEJOUX, Esq, Executive Engineer, Cement Experiments Division to the Superin-
tending Engineer, South-Western Circle, dated the 18th May 1878, No 2,969

HAVING lately heard discussions on the question of the degree of burning required for
making good "soorkee," and Departmental Officers having made many inquiries on the subject
of hydraulic mortars, I have the honor to submit the accompanying paper in two parts on limes,
cements, sand, soorkee, and mortars, which I recommend for circulation in the Department,
although my previous reports are pretty fully treated on both the subjects

2 I need add that while Part I of the paper is, more or less, based on theory, Part II
contains practical remarks concluded from experience as well as theory.

PART I.

PAPER ON LIMES, CEMENTS, SAND, SOORKEE AND MORTARS

1st —Induration of fat lime

1. If pure lime is dissolved in water and left exposed to air, the carbonic acid combines
very speedily with the lime, and the carbonate of lime formed gets precipitated as pellicles,
which adhere strongly to the solid bodies coming in contact with them

2 If the lime instead of being dissolved in water is left exposed to air and gets dry quickly,
it absorbs the carbonic acid, but the grains of carbonate remain separated without adhering to
each other

2nd —Induration of a mortar of fat lime and sand

1 If such mortar is immersed or kept in a place always damp, the lime after a time
dissolves entirely and sand alone remains

2. If the mortar is allowed to dry quickly, the lime readily absorbs the carbonic acid, and the result remains in a mixture of sand and carbonic powder not adhering together.
 3. If otherwise, the mortar is kept in a proper state of moisture, the lime dissolving slowly will absorb the carbonic acid.
- The carbonate will not be washed away, but on the contrary get deposited as a kind of varnish on the grains of sand.
- The water then in presence of the excess of lime remaining will dissolve another small quantity of it, which, being transformed also into a carbonate, will adhere to the first coating strongly. The process will continue in the same manner until the entire calcination of the mass of mortar.

3d — Effect of sand on mortar

1. The effect of sand is purely mechanical, and no chemical composition between the sand and lime takes place.
2. It facilitates the passage of the carbonic acid through the mass.
3. If it has sharp angles, it gives a good hold to the carbonate formed by exposure to air, and increases the degree of cohesion of the mortar.
4. The strength of a mortar of fat lime increases proportionally from 1 to 2 parts of sand for 1 of lime.
5. The sand must be coarse and sharp. In fact the size of the grain of such sand ought to vary from $\frac{1}{16}$ to $\frac{1}{8}$ of an inch.

4th — Sunkies as a substitute for sand

1. In places where good sand is not obtainable, the best substitute for it is "sunkies," the powder of well-burnt bricks. In fact, the harder the bricks are the better will the sunkies be.
2. It will then set similarly to sand as an inert matter, not giving any hydraulicity to the mortar.
3. The size of the grains of such sunkies ought to vary from $\frac{1}{16}$ to $\frac{1}{8}$ of an inch.

5th — Induration of hydraulic lime

1. An ordinary hydraulic lime contains silica, alumina, carbonate of lime, and small proportions of oxide of iron, magnesia, manganese, and sulphate of lime, which generally cannot have an appreciable effect on the setting of the lime.
2. When calcined, silicates and aluminates of lime are formed and some hydrated lime remains with the other foreign matters. Upon being made into paste by the addition of water, the silicates and aluminates of lime get hydrated and crystallize afterwards, and therefore harden. Some of the hydrated lime gets transformed into carbonate of lime, and some dissolves in proportion varying according to the quantity of silica and alumina contained in the lime forming either smaller or larger proportions of silicates and aluminates of lime.

6th — Induration of hydraulic mortar made with fat lime and properly burnt clay

1. If a fat lime is mixed with a certain proportion of pure clay burnt to the proper degree, the same reaction as for hydraulic lime takes place in the setting of the mortar, with the difference that it is enough powder of burnt clay is mixed with the fat lime, a most the volume will be transformed into silicates and aluminates of lime, provided it is either immersed or kept in a place always damp.
2. A mortar of fat lime and pure clay of a certain proportion of lime will therefore have very little lime dissolved, and will be stronger than a mortar made with hydraulic lime and sand.
3. It may be said, however, that, on account of the great density of burnt clay or pure clay, a good hydraulic lime is preferable on the whole.
4. The proportions in which sunkies ought to be used for different sorts of lime will be found in Part II.

7th — Remarks on the use of burnt lime of commercial kinds

1. As it has been stated in chapter 6 that half-burnt clay combines chemically with fat lime, it is necessary to explain now why the clay must be so burnt.
 2. Let us, however, first define pure clay.
- Pure clay — It is a clay which contains no free silica and carbonate of lime, or, if it does contain both, it should not be more than 5 per cent.

"Clays are hydrated combinations of silica and alumina."

The degrees of calcination which give them the maximum of hydraulic properties have been found, by experience, to be the same as the degree of calcination required for expelling entirely the water contained in the clay. Therefore to transform clay into a kind of puzzolana, the theoretical calcination must be regulated so as to expel the last particle of water without exceeding 1,100° to 1,300° Fahrenheit. This is what Vicat calls "cuisson normale" (normal burning).

3. *Impure clays containing sand, carbonate of lime, &c., and brick-earth* — A calcination lasting a longer time than for pure clay, to a temperature varying from 1,300° to 1,500° Fahrenheit, is required for expelling the carbonic acid, &c., from such clays. The fact of requiring a higher temperature is the cause of the inferiority of the sunkies made with common bricks.

4. From the above it is to be considered that sunkies made with pure clay or common brick-earth requires only a slight calcination.

5. However, the practical hints for burning clay to the proper degree will be found in Part II.

8th — Induration of cements, either natural or artificial.

1. Cements set quicker than any hydraulic lime, and their hardening increases much more rapidly.
2. This is due to the fact that in cements very nearly the whole of the clay and lime is transformed into silicate and aluminate of lime, either on account of the large proportion of clay contained in cements of the quality of Roman cement, or on account of the high temperature to which cements like Portland are burnt.
3. The silicates and aluminates get hydrated very quickly, and then crystallize in a very short time, in comparison with hydraulic lime which always contains an excess of lime not combined.

9th — Lime-cements.

1. Great many kunkurs or glooting stones in India can be considered as containing a mixture of hydraulic lime-cement, more or less quick setting, and a certain quantity of fine sand and clay, which act when burnt as inert matters.
2. The kunkurs generally slake very little, and require always to be ground fine either before or after slaking.
3. These kinds of lime-cements ought to be used only with sand or extra burnt sunkies, but the admixture of half-burnt sunkies would be very prejudicial to the strength of mortar after a certain time.

10th — Hydraulic limes or cements containing sulphate of lime

1. According to Vicat, Rivet, and other authors on treatise of limes, any hydraulic lime or cement containing a rather large proportion of sulphate of lime cannot be considered of good quality.
2. Rivet mentions that, from the experiments made up to 1876 it has been impossible to fix exactly what is the largest proportion of sulphate of lime which can exist in a lime without injuring its hydraulic properties and the solidity of the mortar immersed.
3. Vicat says that any limestone not containing more than 2 per cent of sulphate of lime can be very safely used for any hydraulic work.
4. It is easy to understand the reaction which takes place with the sulphate of lime contained in an hydraulic lime. The sulphate when strongly calcined gets hydrated very slowly, and its crystallization takes place after the setting of the mortar. The increase of volume may therefore disturb the mass of the mortar, especially if it has been immersed immediately after being prepared.
5. I should say, however, from personal experience, that in mortars made with hydraulic limes not containing more than 10 per cent of sulphate, which have been allowed to set slowly for a certain time in air, and then put in contact with water, the solidity will not be disturbed. The only effect will be its becoming more porous when the sulphate of lime gets slowly dissolved in water.

PART II

PRACTICAL REMARKS

1st — Mortar of fat lime and sand

1. Such mortar ought to be used only for buildings not exposed to great dampness.
2. If the lime is very rich the best proportion should be—
2 parts of sand and
1 part of lime.

3 If the lime is magre (containing notable proportions of clay, sand, and magnesia) the quantity of sand must be reduced proportionally

2nd — *Mortar of fat lime and soorkee (half burnt)*

1 *Works immersed* — For works constantly under water half burnt soorkee only must be used, and the following proportion is the best for a rich fat lime. —

2 parts of fine (half burnt) soorkee, and
1 part of lime

2 *Works exposed to the inclemency of the weather* — For buildings exposed to heavy rain and the damp climate of Bengal as also to the heat of the sun, it will be advisable to use a portion only of half burnt soorkee and a portion of extra coarse sand, or coarse soorkee extra burnt, but the proportion which secures the best result for a rich fat lime is —

1 part of fine (half burnt) soorkee;
1 part of coarse (extra burnt) do., and
1 part of lime

3rd — *Made of preparation of soorkee possessing hydraulic properties*

1 *Soorkee made with pure clay* — For works in which a very hydraulic mortar is required, it is preferable to make soorkee from pure clay cut in small pieces of about the size of an egg (as found in its natural state), and then burnt either in clamps or in a kiln. When lime kilns are at work at the same place where the soorkee is manufactured, the best way to burn it to a proper degree is to load the top part of the kiln with the raw clay and the bottom with lime-stone. The hydraulic soorkee called half burnt above may be considered to be burnt to the proper degree when it has been submitted to a red heat and cannot dissolve in water; it must, in fact, be a kind of very soft brick which will, after a certain time, be affected by exposure to air, but which must have lost the plastic power of raw clay when mixed with water.

Soorkee made with common brick-clay — This soorkee must be burnt for a longer time until the carbonate of lime it contains gets extinguished, however the burnt bricks must be only a little harder than those made with pure clay.

Sifting — These two soorkes made either with pure clay or common bricks require to be ground so fine as to give the fat lime all their hydraulic properties. They ought to be sifted through a sieve of 40 meshes to the lineal inch.

The chemical combination between the lime and the burnt clay cannot take place if the powder is coarse, and the mortar will be injured by the introduction of a soft inert body.

4th — *Made of preparation of soorkee as a substitute for sand*

1 *Running* — The soorkee which is to be used either with fat or hydraulic lime and cement when sand is not obtainable, acting the same as an inert matter, must be made either with clay or bricks perfectly well burnt, very hard, and in fact a little vitrified, if possible.

2 *Grinding and Sifting* — This soorkee must not be ground fine; and the grains ought to be of such a size as to pass through a sieve of 8 meshes, and not to pass through one of 16.

5th — *Remarks on the mode of treating various kinds of hydraulic lime-stones, kunkurs, or ghootings*

1 Every hydraulic lime stone, kunkur or ghooting, containing less than 25 per cent. of either clay or sand, should be burnt, slaked, sifted, and the refuse rejected. If the lime is properly burnt, the refuse of it ought not to be much.

If the refuse, however, is ground and mixed with the lime, it may impart to it portions of a kind of cement, but it also generally contains a good deal of inert matter, and thus the lime will bear a less proportion of sand than if only the slaked lime was used, and hence no savings in the final cost of the mortar will be effected by such a process.

This rule is applicable to the generality of ghooting stones found in Lower Bengal.

2 Now supposing that the kunkur or ghooting lime contains more than 25 and less than 33 per cent of clay and sand, and that the proportion of free sand (not in the state of impalpable powder) exceeds 5 per cent, it will be better to act with it as above shown, but if the stone is in her free of sand, the lime may be slaked when burnt, and the whole pulverized by a soorkee-mill before screening.

Such lime will in every case bear less sand than that described above.

3 If the kunkur contains more than 33 per cent of clay and sand, the last process will be found more advantageous than ordinary slaking.

Some of these burnt limes do not slake when water is poured over them. For these, however, it is evident that grinding is necessary, but there are others which seem to slake, or, at any rate, turn into coarse powder.

In many cases apparent slaking results only from partial disintegration of the mass. The parts containing enough clay to become a kind of cement are then in too coarse a state to have any binding properties, and very often sand is the principal constituent of the finer portion.

Such lime may be considered as composed of a mixture of sand, hydraulic lime in very small proportion, cement of very variable quality and some kind of puzzolana; consequently a very satisfactory result can only be obtained by grinding the whole of the burnt stone.

However the powder thus obtained will never bear a large proportion of sand in the mortar.

It may even happen that the lime must be used alone as mortar without any admixture, when the chemical composition of the stone shows that it already contains a large proportion of free sand.

This kind of kunkur is very common in the Punjab and the North-Western Provinces.

Remarks about sifting — All these limes and lime-cements ought to be sifted through a sieve not coarser than 20 meshes to the lineal inch, but when very quick setting is required a sieve of 40 meshes ought to be used.

It may seem strange to use for fine half burnt soorkee a sieve of 40 meshes, and for lime one of 20 only. The reason is, that lime tolerably burnt could, if properly dried, pass through a sieve of 40 meshes quite as well as one of 20, by leaving very little residue, but, as the particles of fine lime adhere always, more or less, together, the sieve of 20 meshes is quite sufficient, but it will not answer for soorkee which is made with very dry bricks.

6th — *Use of soorkee and sand with hydraulic lime*

1 *Limes very hydraulic* — All the hydraulic limes which slake well and set under water in less than five days can be safely used without the addition of fine half burnt soorkee for any hydraulic works.

They ought to be used with either sharp sand or coarse soorkee (extra burnt).

2 *Limes moderately hydraulic* — Limes taking more than five and less than ten days to set under water do not require any admixture of half burnt soorkee for works not requiring a great degree of hydraulicity.

For works immersed and requiring to be very hydraulic, the following proportions can be used —

1 or 1½ parts of sand or coarse extra burnt soorkee;
½ part of sand or half burnt fine soorkee, and
1 " of lime

3 *Limes feebly hydraulic* — They can be considered as impure fat lime, and treated in the same way.

4 *Lime-cements* — Such lime-cements as slake very little and require grinding do not, as a rule, require admixture with half burnt soorkee.

In fact they give better results when simply mixed with either sand or extra burnt soorkee, and the proportion for these cements ought never to exceed —

1½ parts of sand or extra burnt soorkee, and
1 part of lime

7th — *Cement-mortars*

1 *Quick-setting cement* — For a quick-setting cement of the kind of Roman cement, the proportion of sand ought not to exceed —

1 part of sand, and
1 " of cement

2 *Slow-setting cement* — For Portland and magnesian cement the best proportion is —

2 parts of sand, and
1 part of cement

For Portland cement, the quantity of sand could be increased very much with careful workmen, but with native masons it will not be safe to exceed —

4 parts of sand, and
1 part of cement

3 *Remarks* — Cement must always be used with less water than hydraulic lime, and hydraulic lime with less water than fat lime.

4 *Substitute for sand* — If sand is not obtainable, extra burnt coarse soorkee can be used instead, but the strength of such mortar will be always below that of sand mortar.

Calcutta,
The 18th May 1878

(Signed) P. DEJOUX,
Lie. Engr, Cement Experiments Dur

3008
4

6 PUBLIC WORKS DEPARTMENT, 26TH JULY 1878, No 3,008 W.

No 263 ORDER THEREON, 26th July 1878, No. 3,008 W.

COMMUNICATED to the undermentioned officers.

(True Extract)

(Signed) E. A. FOORD, Colonel, R.E.,
Secretary to Govt, P.W.D.

(True Copy.)

Major, R.E.,
Under Secy. to Govt, P.W.D.

To District Engineers
To the Chief Engineer for Irrigation
" Consulting Engineer for Railways.
" Chief Engineer and Manager of the Madras Irrigation and Canal Company
" Superintendent, Madras Harbour Works

Edw T D Ryan
& true Copies

3008/5
Circular No 53 P W

GOVERNMENT OF INDIA
PUBLIC WORKS DEPARTMENT.

CIVIL WORKS

Irrigation

To

THE GOVERNMENTS OF MADRAS AND BOMBAY, IN THE PUBLIC WORKS DEPARTMENT,
GENERAL, IRRIGATION AND RAILWAY BRANCHES
THE GOVERNMENT OF BENGAL, IN THE PUBLIC WORKS DEPARTMENT, GENERAL BRANCH
THE GOVERNMENTS OF THE NORTH-WESTERN PROVINCES AND OUDH AND PUNJAB, IN THE
PUBLIC WORKS DEPARTMENT, GENERAL AND IRRIGATION BRANCHES
THE CHIEF COMMISSIONERS, CENTRAL PROVINCES, BALUCHISTAN, MYSORE AND COORG
AND ASSAM
THE RESIDENT, HYDERABAD
THE AGENTS OF THE GOVERNOR GENERAL FOR CENTRAL INDIA AND RAJPOOTANA
THE SUPERINTENDENT OF PORT BLAIR, AND CHIEF COMMISSIONER, ANDAMAN AND
NICOBAR ISLANDS
THE INSPECTOR GENERAL OF MILITARY WORKS
THE DIRECTORS OF STATE RAILWAYS, CENTRAL, WESTERN AND NORTH-EASTERN SYSTEMS
THE DIRECTOR OF STATE RAILWAY STORES
THE CONSULTING ENGINEERS TO THE GOVERNMENT OF INDIA FOR GUARANTEED RAILWAYS,
CALCUTTA, LAHORE AND LUCKNOW
THE SUPERINTENDING ENGINEER, SIMLA IMPERIAL CIRCLE

Simla, June 20th 1878

In continuation of Circular No 46 P.W., dated the 4th instant, the
undersigned is directed to forward, for information, copy of a paper by Mr.
P. Dejeux on limes, cements, sand, soorkee and mortars.

Frederick Smith

Captain, R. E.,
Asst. Secy to the Govt of India.

*To The Secretary to the Govt of Madras.
P.W. Dept. Railway Branch.*

40 ho 2590 w 21 June 78

GOVERNMENT OF INDIA.
PUBLIC WORKS DEPARTMENT.
CIVIL WORKS.
Irrigation

To *e 1. 5311*

Circular No 53 P. W.

Dated SIMLA June 20th 1878.

Received *3. 11. 78*

E.I.
No 3008 W 21 July 78
Comm.
the subcommittee
Office.
20.7.78

Mr. P. Depoux
Mr. E. P. J. S.
Mr. E. P. J. S.
Mr. E. P. J. S.
Forwards, for information, copy of a paper by
Mr P. Depoux, on limes, cements, sand, soorkee
and mortar.

Staff 9-8-78

GOVT. OF INDIA, PUBLIC WORKS DEPARTMENT, CIVIL WORKS, IRRIGATION

Locality 25-7-78. Date 29-7-78

3008
h.
Copy of the following forwarded to the
for information
D. B. HORN,
The June 1878. *Asst. Secretary to the Govt. of Bengal*
in the P. W. Dept., Irrig. Branch.

From P. Depoux, Esq., Executive Engineer, Cement Experiments Division, to the Superin-
tending Engineer, South-Western Circle, (No 2069, dated the 15th May 1878)
SIR,

Having lately heard discussions on the question of the degree of burning
required for making good "soorkee," and Departmental Officers having made many enquiries
on the subject of hydraulic mortars, I have the honor to submit the accompanying paper in
two parts on limes, cements, sand, soorkee and mortars, which I recommend for circula-
tion in the Department, although my previous reports frequently treated on both the subjects.
2. I need add that while Part I of the paper is, more or less, based on theory, Part II
contains practical remarks concluded from experience as well as theory.

PART I.

PAPER ON LIMES, CEMENTS, SAND, SOORKEE AND MORTARS.

1st —Induration of fat lime

1. If pure lime is dissolved in water and left exposed to air, the carbonic acid combines
very speedily with the lime, and the carbonate of lime formed gets precipitated as pellicles,
which adhere strongly to the solid bodies coming in contact with them.
2. If the lime instead of being dissolved in water is left exposed to air and gets dry
quickly, it absorbs the carbonic acid, but the grains of carbonate remain separated without
adhering to each other.

2nd —Induration of a mortar of fat lime and sand

1. If such mortar is immersed or kept in a place always damp, the lime after a time
dissolves entirely and sand alone remains.
2. If the mortar is allowed to dry quickly, the lime rapidly absorbs the carbonic acid,
and the result remains in a mixture of sand and calcareous powder not adhering together.
3. If otherwise, the mortar is kept in a proper state of moisture, the lime dissolving
slowly will absorb the carbonic acid.
The carbonate will not be washed away, but on the contrary get deposited as a kind of
varnish on the grains of sand.
The water then in presence of the excess of lime remaining will dissolve another
small quantity of it, which, being transformed also into a carbonate, will adhere to the first
coating strongly. The process will continue in the same manner until the entire induration
of the mass of mortar.

3rd —Effect of sand on mortars

1. The effect of sand is purely mechanical, and no chemical composition between the
sand and lime takes place.
2. It facilitates the passage of the carbonic acid through the mass.
3. If it has sharp angles, it gives a good hold to the carbonate formed by exposure to
air, and increases the degree of cohesion of the mortar.
4. The strength of a mortar of fat lime increases proportionally from $\frac{1}{2}$ to 2 parts of
sand for 1 of lime.
5. The sand must be coarse and sharp. In fact, the size of the grain of such sand
ought to vary from $\frac{12}{100}$ to $\frac{6}{100}$ of an inch.

4th —Soorkee as a substitute for sand

1. In places where good sand is not obtainable, the best substitute for it is "soorkee,"
the powder of well burnt bricks. Indeed, the harder the bricks are the better will the
soorkee be.
2. It will then act similarly to sand as an inert matter, not giving any hydraulicity to
the mortar.
3. The size of the grains of such soorkee ought to vary from $\frac{12}{100}$ to $\frac{6}{100}$ of an inch.

5th—*Induration of hydraulic lime*

1 An ordinary hydraulic limestone contains silica, alumina, carbonate of lime, and small proportions of oxide of iron, magnesia, manganese and sulphate of lime, which generally cannot have an appreciable effect on the setting of the lime

2 When calcined, silicates and aluminates of lime are formed and some hydrated lime remains with the other foreign matters. Upon being made into paste by the addition of water, the silicates and aluminates of lime get hydrated and crystallize afterwards, and therefore harden. Some of the hydrated lime gets transformed into carbonate of lime, and some dissolves in proportions varying according to the quantity of silica and alumina contained in the lime, forming either smaller or larger proportions of silicates and aluminates of lime

6th—*Induration of hydraulic mortars made with fat lime and properly burnt clay or puzzolanna.*

1 If a fat lime is mixed with a certain proportion of pure clay burnt to the proper degree, the same reaction as for hydraulic lime takes place in the setting of the mortar, with the difference that, if enough powder of burnt clay is mixed with the fat lime, almost the whole will be transformed into silicates and aluminates of lime, provided it is either immersed or kept in a place always damp.

2 A mortar of first rate puzzolanna and a suitable proportion of lime will therefore have very little lime dissolved, and will be less porous than a mortar made with hydraulic lime and sand

3 It may be said, however, that, on account of the great difficulty of burning clay or puzzolanna to the exact degree required for the maximum power of combining chemically with the lime, a good hydraulic lime is preferable on the whole

4 The proportions in which soorkee ought to be used for different sorts of lime will be found in Part II

7th—*Remarks on soorkee made of burnt clay or of common bricks.*

1 As it has been stated in chapter 6 that half burnt clay combines chemically with fat lime, it is necessary to explain now why the clay must be so burnt.

2 Let us, however, first define pure clay

Pure clay—It is a clay which should be free from sand and carbonate of lime, or, if it does contain both, it should not be more than 5 per cent

Clays are hydrated combinations of silica and alumina

The degrees of calcination which give them the maximum of hydraulic properties have been found, by experience, to be the same as the degree of calcination required for expelling entirely the water contained in the clay. Therefore to transform clay into a kind of puzzolanna, the theoretical calcination must be regulated so as to expel the last particle of water without exceeding 1,100° to 1,300° Fahrenheit. This is what Vicat calls "cuisson normale" (normal burning)

3 *Impure clays containing sand, carbonate of lime, &c., and brick-earth*—A calcination lasting a longer time than for pure clay, to a temperature varying from 1,300° to 1,500° Fahrenheit, is required for expelling the carbonic acid, &c., from such clays. The fact of requiring a higher temperature is the cause of the inferiority of the soorkee made with common bricks

4 From the above, it is to be considered that soorkee made with pure clay or common brick-earth requires only a slight calcination

5 However, the practical hints for burning clay to the proper degree will be found in Part II

8th—*Induration of cements, either natural or artificial.*

1 Cements set quicker than any hydraulic lime, and their hardening increases much more rapidly

2 This is due to the fact that in cements very nearly the whole of the clay and lime is transformed into silicate and aluminate of lime, either on account of the large proportion of clay contained in cements of the quality of Roman cement, or on account of the high temperature to which cements like Portland are burnt.

3 The silicates and aluminates get hydrated very quickly, and then crystallize in a very short time, in comparison with hydraulic lime which always contains an excess of lime not combined

9th—*Lime-cements.*

1 Great many lunkurs or ghooting stones in India can be considered as containing a mixture of hydraulic lime-cement, more or less quick setting, and a certain quantity of free sand and clay, which act when burnt as inert matters.

2 The lunkurs generally slake very little, and require always to be ground fine either before or after slaking

3 These kinds of lime cements ought to be used only with sand or extra burnt soorkee, but the admixture of half burnt soorkees would be very prejudicial to the strength of mortar after a certain time

10th—*Hydraulic limes or cements containing sulphate of lime*

1 According to Vicat, Rivet, and other authors on treatise of limes, any hydraulic lime or cement containing a rather large proportion of sulphate of lime cannot be considered of good quality

2 Rivet mentions that, from the experiments made up to 1876, it has been impossible to fix exactly what is the largest proportion of sulphate of lime which can exist in a lime without injuring its hydraulic properties and the stability of the mortar immersed

3 Vicat says that any limestone not containing more than 2 per cent of sulphate of lime can be very safely used for any hydraulic work

4 It is easy to understand the reaction which takes place with the sulphate of lime contained in an hydraulic lime. The sulphate when strongly calcined gets hydrated very slowly, and its crystallisation takes place after the setting of the mortar. The increase of volume may therefore disturb the mass of the mortar, especially if it has been immersed immediately after being prepared

5 I should say, however, from personal experience, that for mortars made with hydraulic limes not containing more than 10 per cent of sulphate, which have been allowed to set slowly for a certain time in air, and then put in contact with water, the stability will not be disturbed. The only effect will be its becoming more porous when the sulphate of lime gets slowly dissolved in water.

PART II.

PRACTICAL REMARKS

1st—*Mortar of fat lime and sand*

- 1 Such mortar ought to be used only for buildings not exposed to great dampness
- 2 If the lime is very rich the best proportion should be—

2 parts of sand, and
1 part of lime

- 3 If the lime is meagre (containing notable proportions of clay, sand and magnesia) the quantity of sand must be reduced proportionally

2nd—*Mortar of fat lime and soorkee (half burnt)*

- 1 *Works immersed*—For works constantly under water half burnt soorkee only must be used, and the following proportion is the best for a rich fat lime—

2 parts of fine (half burnt) soorkee, and
1 part of lime.

- 2 *Works exposed to the inclemency of the weather*—For buildings exposed to heavy rain and the damp climate of Bengal, as also to the heat of the sun, it will be advisable to use a portion only of half burnt soorkee and a portion of sharp coarse sand, or coarse soorkee extra burnt, but the proportion which seems the best for a rich fat lime is—

1 part of fine (half burnt) soorkee,
1 part of coarse (extra burnt) duto, and
1 part of lime

3rd—*Mode of preparation of soorkee possessing hydraulic properties.*

1 *Soorkee made with pure clay*—For works in which a very hydraulic mortar is required, it is preferable to make soorkee from pure clay cut in small pieces of about the size of an egg (as found in its natural state), and then burnt either in clumps or in a kiln. When lime kilns are at work at the same place where the soorkee is manufactured, the best way to burn it to a proper degree is to load the top part of the kiln with the raw clay and the bottom with lime-stone. The hydraulic soorkee called half burnt above, may be considered to be burnt to the proper degree when it has been submitted to a red dark heat and cannot dissolve in water, it must, in fact, be a kind of very soft brick which will, after a certain time, be affected by exposure to air, but which must have lost the plastic power of raw clay when mixed with water.

Soorkee made with common brick-earth—This soorkee must be burnt for a longer time until the carbonate of lime it contains gets extinguished, however the burnt bricks must be only a little harder than those made with pure clay.

Sifting—These two soorkees made either with pure clay or common bricks require to be ground so fine as to give the fat lime all their hydraulic properties. They ought to be sifted through a sieve of 40 meshes to the lineal inch.

The chemical combination between the lime and the burnt clay cannot take place if the powder is coarse, and the mortar will be injured by the introduction of a soft inert body.

4th—Mode of preparation of soorkee as a substitute for sand

1 *Burning*—The soorkee which is to be used either with fat or hydraulic lime and cements when sand is not obtainable, acting then as an inert matter, must be made either with clay or bricks perfectly well burnt, very hard, and in fact a little vitrified, if possible.

2. *Grinding and Sifting*—This soorkee must not be ground fine, and the grains ought to be of such a size as to pass through a sieve of 8 meshes, and not to pass through one of 16.

5th—Remarks on the mode of treating various kinds of hydraulic limestones, kunkurs or ghootings

1 Every hydraulic limestone, kunkur or ghooting, containing less than 25 per cent of either clay or sand, should be burnt, slaked, sifted, and the refuse rejected. If the lime is properly burnt, the refuse of it ought not to be much.

If the refuse, however, is ground and mixed with the lime, it may impart to it portions of a kind of cement, but it also generally contains a good deal of inert matter, and thus the lime will bear a less proportion of sand than if only the slaked lime was used, and hence no savings in the final cost of the mortar will be effected by such a process.

This rule is applicable to the general ty of ghooting stones found in Lower Bengal.

2 Now supposing that the kunkur or ghooting lime contains more than 25 and less than 33 per cent of clay and sand, and that the proportion of free sand (not in the state of impalpable powder) exceeds 5 per cent, it will be better to act with it as above shown, but if the stone is rather free of sand, the lime may be slaked when burnt, and the whole pulverized by a soorkee-mill before screening.

Such lime will in every case bear less sand than that described above.

3. If the kunkur contains more than 33 per cent of clay and sand, the last process will be found more advantageous than ordinary slaking.

Some of these burnt limes do not slake when water is poured over them. For these, however, it is evident that grinding is necessary, but there are others which seem to slake, or, at any rate, turn into coarse powder.

In many cases apparent slaking results only from partial disintegration of the mass. The parts containing enough clay to become a kind of cement are then in too coarse a state to have any binding properties, and very often sand is the principal constituent of the finer portion.

Such lime may be considered as composed of a mixture of sand, hydraulic lime in very small proportion, cement of very variable quality and some kind of puzzolanna; consequently a very satisfactory result can only be obtained by grinding the whole of the burnt stone.

However the powder thus obtained will never bear a large proportion of sand in the mortar.

It may even happen that the lime must be used alone as mortar without any admixture, when the chemical composition of the stone shows that it already contains a large proportion of free sand.

This kind of kunkur is very common in the Punjab and the North-Western Provinces.

Remarks about sifting—All these limes and lime-cements ought to be sifted through a sieve not coarser than 20 meshes to the lineal inch, but when very quick setting is required a sieve of 40 meshes ought to be used.

It may seem strange to use for fine half burnt soorkee a sieve of 40 meshes, and for lime one of 20 only. The reason is, that lime tolerably burnt could, if properly dried, pass through a sieve of 40 meshes quite as well as one of 20, by leaving very little residue, but as the particles of fine lime adhere always, more or less, together, the sieve of 20 meshes is quite sufficient, but it will not answer for soorkee which is made with very dry bricks.

6th—Use of soorkee and sand with hydraulic lime.

1. *Limes very hydraulic*—All the hydraulic limes which slake well and set under water in less than five days can be safely used without the addition of fine half burnt soorkee for any hydraulic works.

They ought to be used with either sharp sand or coarse soorkee (extra burnt).

2 *Limes moderately hydraulic*—Limes taking more than five and less than ten days to set under water do not require any admixture of half burnt soorkee for works not requiring a great degree of hydraulicity.

For works immersed and requiring to be very hydraulic, the following proportions can be used—

1 or 1½ parts of sand or coarse extra burnt soorkee,
½ part of sand or half burnt fine soorkee, and
1 „ of lime

3 *Limes feebly hydraulic*—They can be considered as impure fat lime, and treated in the same way.

4 *Lime-cements*—Such lime-cements as slake very little and require grinding do not, as a rule, require admixture with half burnt soorkee.

In fact they give better results when simply mixed with either sand or extra burnt soorkee and the proportion for these cements ought never to exceed—

1½ parts of sand or extra burnt soorkee, and
1 part of lime

7th—Cement-mortars

1 *Quick setting cement*—For a quick setting cement of the kind of Roman cement, the proportion of sand ought not to exceed—

1 part of sand, and
1 „ cement

2 *Slow setting cement*—For Portland and magnesium cement the best proportion is—

2 parts of sand, and
1 part of cement

For Portland cement, the quantity of sand could be increased very much with careful workmen, but with native masons it will not be safe to exceed—

4 parts of sand, and
1 part of cement

3 *Remarks*—Cement must always be used with less water than hydraulic lime, and hydraulic lime with less water than fat lime.

4 *Substitute for sand*—If sand is not obtainable, extra burnt coarse soorkee can be used instead, but the strength of such mortar will be always below that of sand mortar.

CALCUTTA,

The 18th May 1878

P. DELJOUX,

Lac Engr, Cement Experiments Divn

3008
9

Circular No 53 P. W.
GOVERNMENT OF INDIA
PUBLIC WORKS DEPARTMENT.
CIVIL WORKS
Irrigation

To

THE GOVERNMENTS OF MADRAS AND BOMBAY, IN THE PUBLIC WORKS DEPARTMENT,
GENERAL, IRRIGATION AND RAILWAY BRANCHES
THE GOVERNMENT OF BENGAL, IN THE PUBLIC WORKS DEPARTMENT, GENERAL BRANCH
THE GOVERNMENTS OF THE NORTH-WESTER, PROVINCES AND OUDH AND PUNJAB, IN THE
PUBLIC WORKS DEPARTMENT, GENERAL AND IRRIGATION BRANCHES
THE CHIEF COMMISSIONERS, CENTRAL PROVINCES, BRITISH BURMAH, MYSORE AND COORG
AND ASSAM
THE RESIDENT, HYDERABAD.
THE AGENTS OF THE GOVERNOR GENERAL FOR CENTRAL INDIA AND RAJPOOTANA
THE SUPERINTENDENT OF PORT BLAIR, AND CHIEF COMMISSIONER, ANDAMAN AND
NICOBAR ISLANDS
THE INSPECTOR GENERAL OF MILITARY WORKS
THE DIRECTORS OF STATE RAILWAYS, CENTRAL, WESTERN AND NORTH-EASTERN SYSTEMS.
THE DIRECTOR OF STATE RAILWAY STORES
THE CONSULTING ENGINEERS TO THE GOVERNMENT OF INDIA FOR GUARANTEED RAILWAYS,
CALCUTTA, LAHORE AND LUCKNOW
THE SUPERINTENDING ENGINEER, SIMLA (IMPERIAL CIRCLE)

Simla, June 20th 1878

In continuation of Circular No. 46 P W, dated the 4th instant, the
undersigned is directed to forward, for information, copy of a paper by Mr.
P. Dejeux on limes, cements, sand, soil and mortars.

Frederick Smith

Captain, R. E.,
Asst Secy to the Govt of India.

*To The Secretary to the Govt of Madras
Public Works Dept. General Branch.*

GOVERNMENT OF INDIA.
PUBLIC WORKS DEPARTMENT
CIVIL WORKS
Irrigation

Circular No 53 P. W.

Dated Simla, June 20th 1878

Received

Forwards, for information, copy of a paper by
Mr P Dejoux, on limes, cements, sand, sorkhee
and mortars.

3008
10.
Circular No 53 P. W.

GOVERNMENT OF INDIA
PUBLIC WORKS DEPARTMENT.

CIVIL WORKS
Irrigation

To

THE GOVERNMENTS OF MADRAS AND BOMBAY, IN THE PUBLIC WORKS DEPARTMENT,
GENERAL, IRRIGATION AND RAILWAY BRANCHES
THE GOVERNMENT OF BENGAL, IN THE PUBLIC WORKS DEPARTMENT, GENERAL BRANCH
THE GOVERNMENTS OF THE NORTH-WESTERN PROVINCES AND OUDH AND PUNJAB, IN THE
PUBLIC WORKS DEPARTMENT, GENERAL AND IRRIGATION BRANCHES
THE CHIEF COMMISSIONERS, CENTRAL PROVINCES, BRITISH BURMAH, MYSORE AND COORG
AND ASSAM
THE RESIDENT, HYDERABAD
THE AGENTS OF THE GOVERNOR GENERAL FOR CENTRAL INDIA AND RAJPOOTANA
THE SUPERINTENDENT OF PORT BLAIR, AND CHIEF COMMISSIONER, ANDAMAN AND
NICOBAR ISLANDS
THE INSPECTOR GENERAL OF MILITARY WORKS
THE DIRECTORS OF STATE RAILWAYS, CENICAL, WESTERN AND NORTH-EASTERN SYSTEMS.
THE DIRECTOR OF STATE RAILWAY STOWES
THE CONSULTING ENGINEERS TO THE GOVERNMENT OF INDIA FOR GUARANTEED RAILWAYS,
CALCUTTA, LAHORE AND LUCKNOW
THE SUPERINTENDING ENGINEER, SIMLA IMPERIAL CIRCLE

Simla, June 20th 1878

In continuation of Circular No 46 P.W., dated the 4th instant, the
undersigned is directed to forward, for information, copy of a paper by Mr.
P Dejoux on limes, cements, sand, sorkhee and mortars

Leg. E. R. P. W.

Captain, R. E.,
Asst. Secy to the Govt of India

*To, The Joint Secy to the Govt of Madras.
P.W.D. Irrigation Branch.*

GOVERNMENT OF INDIA
PUBLIC WORKS DEPARTMENT.

CIVIL WORKS,

Irrigation

To

Circular No 53 P W

Dated Siwa June 20th 1878.

Received

Forwards, for information, copy of a paper by
Mr P. Dejou, on limes, cements, sand, scories
and mortars.

3008
11

8311

Vol. 21 (1876) E. 10000

PUBLIC WORKS.

To

Dated

Issue

Recd.

Encl

26th July 1878, No. 3008 W

Recd. 26th July 1878

Report by Mr. P. Dejeux
on lime, cement, sand,
rook & mortars.

Communicating to
certain officers the
forwarded
by the Govt. of Ind.

Intro. Rpt.