CHAPTER VII

LIMESTONE FOR LIME

In the previous chapter, the requirements of limestones for the cement industry have been discussed. Metallurgical and chemical industries requisition only the top quality limestone of Grades-Super, I and II ($CaCO_3$ above 85 or CaO above 48 percent), while the cement industry demands the next best limestone of Grade-III ($CaCO_3$ - 78 to 85 or CaO 44 to 48 percent). However, such high grade limestones form only a fraction of the bulk of the total area covered by limestones. As such, the limestone balance awaiting utilisation still remains quite large, a considerable portion of which can be readily utilised in the manufacture of lime. As a matter of fact, in its own way, lime obtained from limestones is a very important mineral raw material that find extensive use in various walks of life. It is rather paradoxical to note that, inspite of large resources of unutilised limestones in Gujarat State, lime is imported from neighbouring States like Rajasthan. This indicates that there is a good scope for developing lime industry. It is necessary that the use of high grade limestone be restricted to industries where, they are undispensable, and the rest of the lower grade varieties be utilised for other purposes including lime manufacture. Lime can very well replace Portland cement in certain types of construction works in which the latter is not indispensable. Undertakings on small scales, utilising limestones of lower grades should be encouraged to relieve the strain and dependence on the Portland cement industry, provide more employment and bring down the cost of construction works.

It is well known that even before the Portland cement was invented, limestone in the form of lime was used as cement. The use of lime as 'Cement' in construction works dates back to the beginning of the civilization. In fact, 'Lime' was the only cement in old days. It got a setback in this field on the invention of Portland cement. However, the use of lime is still preferred on a considerable scale in construction works, because of its (i) cheapness, (ii) easy availability, as it can be prepared locally in country kilns, (iii) less dependence on the supply of Portland cement, and (iv) its characteristic suitability in hydraulic structures.

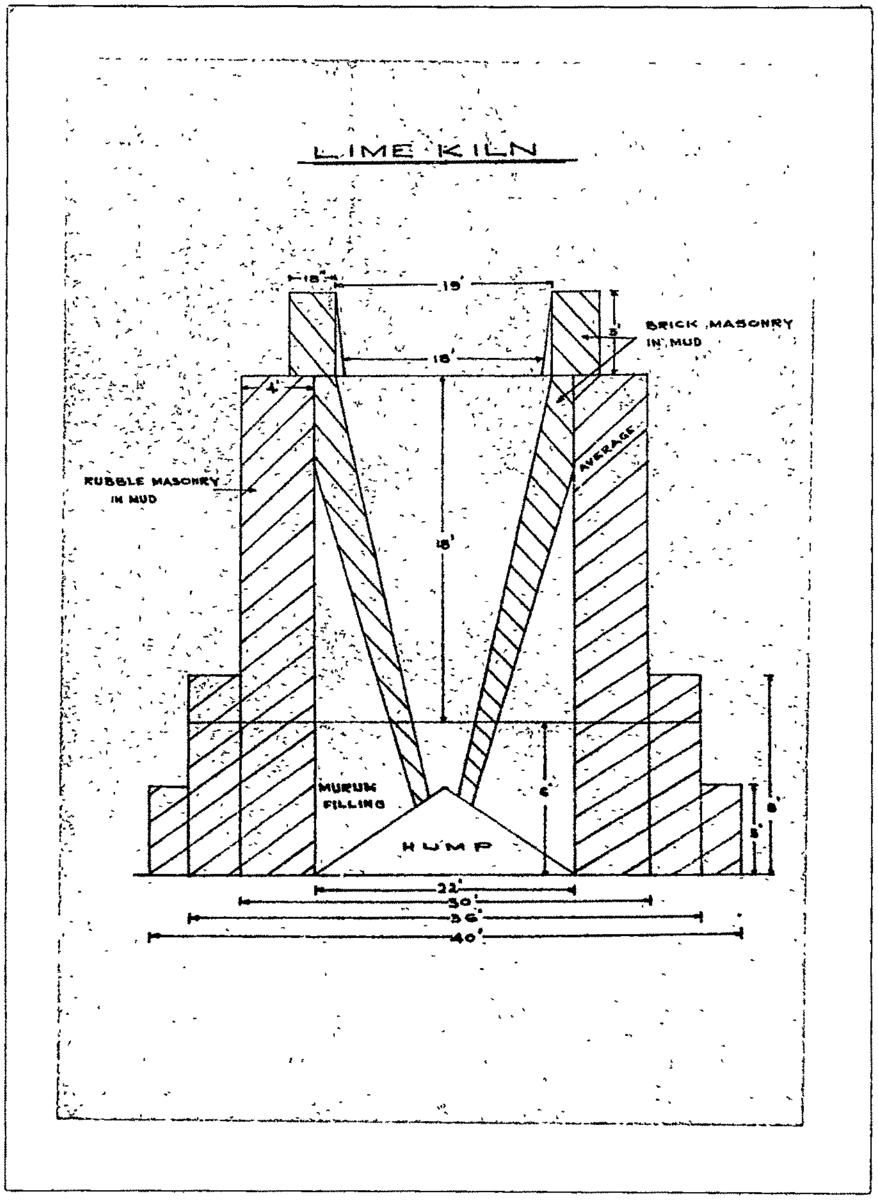
The lime in addition to its application as a cement, it also used for many other purposes. Finely pulverized white limestone, chalk, marble or lime, called as 'whiting' is required in many industries for the manufacture of paints and crayons, for fillers for textiles, paper, rubber, soap, and toilet powders, etc.

LIME AS BUILDING MATERIAL:

Limestone is burnt in kilns to obtain lime, and which can be manufactured on any scale as per requirement, varying from 3 m^3 to 100 m^3 sized kilns. Plate V.

When heated in the kiln at 800^0 to 1000^0 C, limestone loses its carbon dioxide, leaving CaO as quick lime in hard white lumps, which has a great

PLATE V



Sketch of KILN for manufacturing lime.

affinity for water, taking as much as one quarter of its own weight. Roughly two tonnes of limestone gives one tonne of lime after a reject of underburnt or overburnt material.

The burnt product obtained from the kiln is mixed with sand and water in predecided proportion (worked out on the basis of laboratory trial results) to prepare the lime mortar. In rural areas this mixing is done by means of old fashioned 'GHANIES', operated by bullocks. But of late, mixers run on power or diesel, similar to those for cement, are available, and used on larger works.

Lime-mortar on exposure to air, sets by loss of water, and gradually hardens by absorbing CO_2 from the atmosphere. Hydraulic lime has unstable calcium silicates and aluminates along with sufficient uncombined lime present to permit slaking; this has a property of setting under water and becoming very hard in a few days.

Unlike Portland cement the composition of lime is quite variable within a wide range, and thus in the case of lime mortar, a strict check over the quality by frequent testing is necessary, particularly when used in important structures like dams.

Indian Standard Classification of Building Limes:

Various types of limes, derived from the lime burning, have been classified and standardised by the Indian Standard Institution as under:

Quick Lime: A calcined material, the major part of which is calcium oxide in natural association with a relatively smaller amount of magnesium oxide, capable of slaking with water.

Fat Lime: The lime which has high calcium oxide content and dependent for setting and hardening soley on the absorption of carbon dioxide from the atmosphere.

Hydraulic Lime: Lime containing small quantities of silica and alumina and/or iron oxide which are in chemical combination with some of the calcium oxide content; giving a putty or mortar which has the property of setting and hardening under water.

Hydrated lime: A dry powder resulting from treatment of quick lime with water enough to satisfy its chemical affinity for water under the conditions of its hydration.

Lump Lime: It is a quick lime as it comes from kilns. For building purpose, three classes of "LIME" are considered; those are as follows:

1. Class A - Eminently hydraulic lime used for structural purposes.
2. Class B - Semi-hydraulic lime used for masonry work.
3. Class C - Fat lime used mainly for finishing coat in plastering, whitewashing and with suitable admixture, such as surkhi, or any other pozzolanic material to produce artificial hydraulic lime.

The Class A lime is supplied as hydrated lime only; Class B and Class C limes are supplied both as quick lime and hydrated lime. The chemical composition of the three classes of limes is shown below:

TABLE NO.63

Percent

Sr. No.	Constituent	Requirements for Class A	Class B Quick	Class B Hydrated	Class C Quick	Class C Hydrated
1.	CaO & MgO					
	(a) Minimum	60	70	70	85	85
	(b) Maximum	70	--	--	--	--
2.	SiO_2, Al_2O_3 and Fe_2O_3					
	Minimum	25	15	15	--	--
3.	Insoluble residue in HCl, less silica, Maximum	2	3	2	--	--
4.	Loss Ignition Maximum	-	(a) 5(for lump lime)	-	(a) 5(lump lime)	-
		-	(b) 7(for ground lime)	-	(b) 7(Ground lime)	--
5.	Carbon dioxide Maximum	5	5	5	5	5

Magnesium should not exceed 5.0 percent in any class of lime; if in excess, it requires greater care in slaking.

The cementation value of class A and Class B limes as calculated by the formula below should not be less than 0.6 for Class A limes, and between 0.3 and 0.6 for Class B limes.

$$\text{Cementation value: } \frac{2.8A + 1.1B + 0.7C}{1.0D + 1.4E}$$

where, $A = SiO_2$, $B = Al_2O_3$, $C = Fe_2O_3$ D=CaO and E = MgO.

(the constituents are expressed as percentage by weight)

The strengths specified for the three classes of building limes are as follows:

TABLE NO.64.

Period	Compressive strength (Minimum) Class A	Class B	Transverse strength Class A	Class B
	(In kg / cm^2)			
14 days	17.5	12.5		
28 days	28.0	17.5	10.5	7.0

LIME MANUFACTURE IN GUJARAT:

It will not be an exaggeration to state that the limestone resources suitable for manufacturing lime in Gujarat are boundless and almost inexhaustible. In fact, this aspect of the utilisation of not-very-rich limestones in Gujarat, has received little attention till now. However, of late, at several places, experiments of manufacturing lime by burning limestones have been conducted, and the results are very encouraging and interesting. A brief account of a few important projects are discussed below:

1. Recently, an attempt of large scale utilisation of lime was made in the colony construction for the Narmada Project, near Rajpipla (Broach district). Limestones belonging to Bagh Beds were used in the manufacture of lime. Two kilns, one of 30 m^3 and another of 100 m^3 capacities were constructed. The cost of lime worked out to be Rs.30/- per m^3 (Rs.90.00 per 100 cft.). **Plate VI**.

2. Lime kilns have also been set up at Amirgarh (Banaskantha district), a railway station on Ahmedabad-Delhi Metre Gauge of Western Railway, where crystalline

PLATE VI

Lime kiln near Rajpipla.

limestone from Diwania hill (Delhi System) is burnt.

3. Crystalline limestone from Atal-Mahudi area (Banaskantha) was burnt, and the fat lime obtained was made hydraulic by the addition of artificial pozzolana (surkhi). This was used in the construction of masonry dam across the Banas river at Dantiwada near Palanpur (Banaskantha). The use of lime-pozzolana-mortar gave adequate strength to **satisfy** the design criteria.

4. Another deposit of crystalline limestones of Delhi System near Jitpur has now been investigated for the construction of the proposed dam across the Sabarmati river near Dharoi (Sabarkantha district) on the similar lines. The test results are as follows:

TABLE NO.64

	Compressive strength (kg/cm^2) (28 days)
Fat lime mortar	
$1:1\frac{1}{2}$	6.0
1:2	4.25
$1:2\frac{1}{2}$	3.51
1:3	4.18

Contd..

	Compressive strength (kg/cm^2) (28 days)
<u>Lime Pozzolana mortar</u>	
1:1:2	31.86
1:1½:2	40.13
1:1:3	36.84
1:1½:3	42.98

It can thus be seen that the addition of pozzolana contributes towards the appreciable increase in strength of the mortar.

Recently experiments were carried out for making good hydraulic lime of controlled quality and composition under the name '<u>Masonry Sagol</u>'. The process of manufacture of this is more or less on the identical lines of Portland cement, (on a very small scale), utilising Grades-Super, III and V limestones as raw material with slack coal as the principal fuel. The experiments were conducted by the Research Hobby Club of the Faculty of Technology and Engineering, M.S. University of Baroda. The findings published by Khadilkar (1967) are summarised below. Limestones from various sources as indicated in the table No.65, along with their chemical composition were utilised.

TABLE NO.65

Percent

Sr No.	Locality	Dist.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Insl.	Loss Ign.	Total	Remarks
1	Ranoli	Baroda	36.12	2.94	2.55	31.1	31.34	-	27.02	101.10	Kankar
2	Chhota Udepur	"	4.70	-	-	53.50	-	-	42.05	100.25	Calcite
3	Godhra	Panch-mahals	29.70	1.15	1.15	36.47	0.90	-	29.80	99.17	
4	Dohad	"	16.70	1.10	0.40	44.70	1.40	-	35.70	100.00	
5	Kim	Surat	9.38	2.82	4.83	44.38	0.50	-	38.06	99.97	
6	Rajpipla (Gora)	Broach	5.60	0.40	0.20	47.10	7.00	2.0	37.70	100.00	Calc-tufa

The raw mix was prepared from limestones of the above localities in the proportion mentioned in the table No.66.

TABLE NO.66

Locality	Percent	Raw material composition	Percent	Masonry Sagol composition - percent
Kim	40	SiO_2	13.65	22.7
Ranoli	25	Al_2O_3	4.96	7.1
Chhota Udepur	15	Fe_2O_3	2.58	7.1
Rajpipla	15	CaO	41.86	59.2
Bauxite	5	MgO	1.53	1.2
				Loss ign.2.3% Gypsum 2-3% added while grinding lime

A vertical kiln of the capacity of 5 tonnes was used to calcine the above raw mix. The fuel consisted of 1 part charcoal, 1 part of slack coal, and one part of by-product hard coke. The charcoal was ignited with the help of oil burners; at 350°C, slack coal started burning, and the temperature rose to 850°C. At this stage coke started burning, and burners were shut off. The temperature was raised to 900° to 1000°C and burning was continued at this temperature for 10-12 hours.

After this it was raised to 1400°C.

The strength of this 'masonry sagol' is reported to be 60 percent of the cement. A plant of a 10-tonne a day capacity is estimated to cost Rs.5.0 lakhs capital investment. With the selling price of Rs.7/- per bag of 50 kg, the profit is estimated at Rs.2/- per bag.

This masonry sagol can be satisfactorily used for ordinary construction works, such as buildings, being as good as mortar of class A hydraulic lime or even better than that.

This experiment is worthwhile in view of the need of manufacturing cement on a small scale with a unit of 10-tonne capacity a day.

The Portland cement costs Rs.210/- per tonne in the market against the manufacturing cost, deprecciation and profits. This unit expects the likely ex-factory selling price to be not more than Rs.180/- per tonne; this includes the cost of production, depreciation of the plant and machinery, normal profits and excise duties, etc.

The chemical composition and other test results of this cement as reported by Khadilkar (1967) are as follows:

TABLE NO.67

Percent

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Loss Ign.	Total
22.7	7.4	4.8	62.5	0.7	3.3	101.4

(a)	Fineness of grinding:		
	Residue on mesh No.170		4.5 percent
(b)	Setting time - Initial		53 minutes
	Final		175 minutes
(c)	Tensile strength	7 days	27.07 kg/cm^2
(d)	Compression strength	7 "	210.0 kg/cm^2

GUJARAT'S POTENTIALITIES:

The author has given below an account of the present utilisation of limestones for lime manufacture and recommendations for further development of lime industries in Gujarat:

Mainland Gujarat.

Banaskantha district:

Delhi Limestones in Khunia and Atal-Mahudi area (Grades-II and IV respectively) whose reserves are small, viz. 0.2 each, are ideally suited and recommended for lime burning for local use.

As already mentioned, limestones from Atal-Mahudi area were used for the manufacture of lime for the construction of a major dam on Banas river nearby, a few years back. It is now contemplated to use it in the construction of another dam on Sipu river, a tributory of Banas.

Delhi limestones of Karamundi of Grade-IV are extensive, viz. 15 m.tonnes. These can be utilised for the manufacture of 'Building Limes' of the best quality, suitable even for major hydraulic structures like dams.

The Directorate of Geology and Mining has recorded 100 m.tonnes of limestones other than marble in the Ambaji area. These too can be made use of for various purposes. The detailed investigation is necessary to classify the same for further use.

Sabarkantha district:

(1) Delhi limestones of Vadali area mostly of Grade-IV and V, are suited for the manufacture of 'building limes'. However, the quantity of limestone is very limited and only selective quarrying will help in its exploitation, and utilising for local use.

(2) Lameta limestones near Gabat (Grades-IV to VI; reserves about 4 m.tonnes) can be successfully utilised in the manufacture of 'building limes'.

Mehsana district:

Though the crystalline limestones (Delhi) of Grade-III at Jitpur occuring on the western bank of Sabarmati are of cement grade, because of their small reserves (2 m.tonnes) can best be utilised in the manufacture of 'building limes'. The author has recommended to use the lime obtained from these limestones, in the construction of a proposed dam across the Sabarmati river nearby, as well as in construction works of buildings of Capital Project at Gandhinagar.

Kaira district:

Lameta limestones of this district at Balasinor, Parbia, etc., are mainly of Grades-IV to VI, the reserves of which are of the order of 800 m.tonnes, and a very small portion of this is of Grade-II & III.

There is a good scope of utilising these limestones for the manufacture of 'building limes' on a large scale. Improved type of kilns, with standard methods of burning by keeping controlled and proper temperature can provide still better quality lime.

Panchmahals district:

Areas in Dohad and Devgad-baria talukas provide Lameta limestones of Grades-II to VI. Limestones of Grades-II and III are in lenses, and in limited quantities; limestones of remaining grades are in abundance.

Already, a number of crude and old type kilns are working in these areas, and are well known for supplying good quality lime. Methods of manufacturing of lime can be improved as discussed earlier so as to bring down the cost.

Broach district:

Bagh limestones of Gora-Limdi area and in the vicinity (Mokhadi, Vandri, Vanji, etc.) fall under the Grade-IV. Those can be utilised for the manufacture of 'building limes'. Their use as hydraulic lime is already described in the construction works of Narmada Project colony near Rajpipla. These limestones are available in large quantities, and their utilisation as 'building limes' need be encouraged.

Calc-tufa deposits of Grade-Super occur in this district at several places. As their extent is very limited, these can be utilised only for lime burning to get 'fat lime'.

Broach and Surat districts:

Tertiary limestones from these districts at Kanerao, Dinod, Kandh, Tarkeshwar, etc., of Grades-III (Fe) to V(Fe) are unsuitable for the manufacture of

Portland cement.

However, these provide a vast resource to yield 'building limes' of good quality. There is wide scope for such undertakings; a detailed study in these districts is required.

Saurashtra

Limestones from districts of Amreli, Bhavnagar, Jamnagar and Junagadh, mostly of Grades-Super to Grade-III are useful for such industrial uses where large quantities are required. But the total reserves are so enormous, that even after meeting the needs of chemical and cement industries there is ample scope for developing 'building lime' industries also.

Kutch

Similar to Saurashtra, limestones of this region are of higher grade and plentiful; thus part of it can be utilised for the manufacture of building limes.

The mention of 'Kankar' is very important before concluding this chapter. It is interesting to note that the kankar production in India forms 17 percent of total production of limestones, kankar and dolomite (Coggin Brown, 1955).

Kankar is scattered more or less all over the State, except that quantitatively it differs from place to place. Burning of kankar for the manufacture of hydraulic lime is common, and is undertaken on a large scale near Baroda, under the trade name of 'Sagol'.