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Reprinted from KHADIGRAMODYOG
(January 1983 : Pp. 181 to 186)

DIRECTORATE OF PUBLICITY
KHADI AND VILLAGE INDUSTRIES COMMISSION
Gramodaya, Irla Road, Vile Parle (West)
BOMBAY - 400 056.

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It would be far from being wise, when one is struggling in pursuit of a scarce and also quite expensive, though modern, commodity, while there is a vast expanse of an alternative material very much at hand and also comparatively less expensive. This is the case of cement and lime. If lime can not answer the question, it is because of the defective processing methods. But the material lime, the tested binding material known over the ages, by itself is a very dependable material. The requirement is only to study and bring about some improvements in its burning systems.

Kankar is known to be concretion of the carbonate of lime formed in the soil. It is present in abundant quantities in different regions of the country, especially in the alluvial soils of the arid regions of the Indo-Gangetic plain. Deposits are also found in the plains of Eastern and Western Ghats. Its formation is attributed to the leaching of the calcium carbonate in the form of calcium bicarbonate by the rain water from calcareous deposits and subsequent deposition as calcium carbonates in the soil voids around some nucleus, upon contact with alkaline soil. The nascent material is soft, weak and is formed into small sized particles. However, repeated depositions increase the hardness, density and size of the Kankar nodules.

Kankar has been calcined for producing lime from times immemorial in the country. Presence of clayey soil together with calcium carbonate results in imparting hydraulic properties to the calcinates of kankars. Good quality hydraulic lime had been produced in the past and used on a large scale in the construction of Vani Vilas Sagar Dam, Lloyd Dam, Bhandarbana Dam, Kanki Head Works and Sirhind Canal. Even during recent times it has been used for the lining of the Bhakra Canal in Punjab and Ganga Canal in Rajasthan.

Degeneration

But, during the last fifty years the process of lime burning in India has gone through a degeneration. This has been true of Kankar lime as well. The sprawling lime kilns that used to proliferate in the countryside providing livelihood to the teeming thousands, have gone through disrepute.

On the other hand there is a tremendous shortage of building materials in the country at the moment. In order to meet this situation, it was considered necessary

that all our traditional methods be revitalised. With this aim in view the Central Building Research Institute, Roorkee undertook studies on Kankar and Kankar lime. As a first step studies of Kankar burning systems were undertaken in Haryana, Uttar Pradesh, Rajasthan, Andhra Pradesh and West Bengal with a view to revitalising the traditional processes and to conside improving the designs and operations of the kilns.

The investigations revealed wide inconsistencies in the quality of product and the efficiencies of calcination were also found to be very low. It is felt that there certainly is enough scope for effecting improvements in these rural based industries. Some of the results of these investigations are presented in this paper.

In Haryana

Kankar is known to occur in certain areas of Haryana and it has been an ancient practice to burn it for lime making. The areas ranging from Bhiwani to Charkhi-Dadri were surveyed for this purpose.

The method of burning of Kankar in this area is probably one of the most primitive types in the country. Lime burning is carried out in the open—no kiln, no structure, no pit. Any unobstructed place, free from surrounding trees and away from habitation is selected and used for burning of Kankar. Any locally available fuel viz. cow-dung cakes is first spread on the ground. Over this, a layer of Kankar is placed. This is followed by a layer of fuel; and then again Kankar and the fuel are placed in alternate layers. This process is continued until the desired height is attained. During the study, heaps of 3–4 metres height could be observed having varying diametres—the maximum noticed was about 12 metres. Such an arrangement of material acquires the shape of a cone.

Once the materials are placed in position, the heap is plastered with a thin layer of a mixture of cowdung, clay, ashes etc. Fire is then introduced at the bottom, at several places around the circumference. It slowly travels upwards and affects the calcination of the Kankar. The process continues slowly and for a long time. As the supply of air is irregular, the burning is not uniform and depends upon the speed, direction and access of the air. Presumably the temperature inside is also not high. In one of such kilns the temperature was measured at several points by inserting the thermocouple upto 50 cm. inside; the highest temperature that was recorded was only 650°C. Even if somewhat higher temperatures were reached at certain points, most of the material remained underfired.

Another deleterious practice was also observed in this process of Kankar calcining. Even after the fire dies out and all the material is cooled, it is not withdrawn but allowed to stay as it was. It has to brave the weather, including rains. Some material that had been calcined in summer had been found to weather throughout the monsoon season.

The product is removed from the heap as and when required. The material is removed with a *phavara* (spade) and then placed inside a grinder. Sand and water are also added to this grinder and then the whole thing is ground and mixed thoroughly. This ready-mixed mortar is supplied to consumers.

Western Uttar Pradesh

Not very far off (about 125 km.) from this degenerated calcining system of Haryana,

exists the Kankar-bearing belt of Western Uttar Pradesh. This is supposed to stretch right from Meerut district down to Agra district. The practices in this area were found to be definitely superior to those mentioned earlier.

A representative kiln of this area was found to be of the shape of a cube, with sides being about 3 metres each. The kilns are constructed with second class bricks in mud mortar and the walls have thickness of about 50 cm. One side of the kiln has a big discharge door, about one metre wide and one and a half metres in height. At the bottom of the kiln there are channel shaped flues which open through the walls. A number of flues are provided in each of these kilns and they run in directions perpendicular to each other.

Although the design of this kiln differs from those in Haryana, the method of loading etc. remains the same. Cow-dung cakes are spread at the bottom, taking care not to fill and choke the flues. Over this the Kankar and cinder are spread in alternate layers. In all about 20 per cent cinder by volume is used.

Fire is introduced into the kiln, after filling it to about half of its height. After the fire is 'established' inside the kiln, charging of further materials is continued until the kiln is filled to a height of about 30–50 cm. above the top of the walls.

Eastern Uttar Pradesh

The kilns are run on an intermittent basis and the fire as introduced above is allowed to travel upwards to the top and ultimately die out. When the charge of the kiln is cooled down the material is taken out and ground. The temperature could be measured at one point a little below the firing zone and a te ture of 500°C was observed.

A number of Kankar burning ki found in the Eastern part of Uttar P In certain areas near the city of All that were surveyed with this point o lot of Kankar was found to be av in the field.

The kilns utilised in this area ar rectangular in shape—akin to the ki the western part of the state. Many o kilns have length of 3–4 metres and w of similar magnitudes. The designs an operational methods essentially are o same type as in the western region. temperatures measured, however, were fo to be higher, ranging between 600-80

These kilns also are operated inter tently and one cycle takes 15-20 days completion. After the materials cool do they are taken out and ground dry.

Some kilns near the towns of Sultan Faizabad and Ayodhya belonged to pattern described above in almost all re as far as the designs and operational pr tices are concerned. One kiln in Faiza however, was found to be taller, the he was about five metres having a width four metres.

In Rajasthan

The state of Rajasthan is not o endowed with huge deposits of limest but a lot of Kankar also occurs in state, distributed over various regions.

Although the sizes of the kilns va from place to place, depending upon demand of the product and the availabi of the raw materials, the essential des

features of the kilns remain the same in most of the places. The kilns are of the shape of a stemless funnel inside and cylindrical or rectangular outside. This means that the wall thickness at the bottom is enormous, as it goes on increasing from top to the bottom. The outer side of the kiln is constructed with locally available stones. The insides are lined with third class bricks or even with unfired bricks — which are allowed to get fired *in-situ*. The space between the external walls and the internal lining is filled with earth and stones which are compacted by thorough ramming.

The heights of these kilns are found to vary between two and five metres. The diameters at the top range between 2 and 3.5 metres, whereas the bottom diameters in most cases are found to be about one metre only. The wall thickness at the top is usually kept at about 0.75 metre.

Cinder from the railways is found to be the fuel used in most of the cases, except in some occasional instances where steam coal is utilised. The Kankar and the cinder are charged in alternate layers in the kilns. They work in a continuous fashion and are discharged twice a day, in the morning and in the evening. The run of the kiln material is sold as it is without further processing.

In Andhra Pradesh

Kankar occurs in several areas of Andhra Pradesh. Kilns in Anantpur district where Kankar is available quite in abundance were selected for these studies. In local language the kiln is called 'gudu'.

The kilns found in this area in general are small. However, there is considerable variation in the shapes and sizes with production capacities ranging from one to three quintals of lime per day. The shape of the kiln is oval and is built with stone boulders in mud. The inner diameter is of the order of 60-80 cm. and the height varies from 100 to 300 cm. The wall thickness is small—15-20 cm. usually. Each kiln is provided with generally one, but occasionally two, discharge doors, each 20 cm. in width and about 30 cm. in height.

Kankar as dug out from the field is not uniform and shows a fair amount of variation in size and colour. The fuel used for burning is a fibrous type of wood–10-15 cm. chips of the stems of locally available date palm trees. The Kankar mostly is in the form of pieces below 2.5 cm. or even very small. The packed Kankar to fuel ratio is mostly 1:2 by volume. The kilns are operated in batches and each cycle of loading, firing, cooling and unloading takes 4 to 5 days for completion.

The measurement of temperatures could be possible through the open tops and through the discharge doors only, as there are no poke holes. These ranged between 600°C and 800°C at the maximum. The kiln walls become fairly hot and the fire passes to the top, all wastage of heat. The kilns have seasonal life and are usually reconstructed each year.

West Bengal

Available in several parts of West Bengal Kankar at many places is calcined to produce lime. In some of the kilns in Bankura and Purulia districts that were examined, the calcination is carried out on a very small scale - one to two quintals per batch. Underground clamps are used. The fuel—firewood, cowdung cakes or sometimes cinder–is placed in the middle and is covered on all sides with the Kankar.

After introducing the fire, the material is allowed to stay for two-three days. Later after allowing another day for cooling further, the lime is taken out and ground before using.

Obviously the process is grossly inefficient with the calcinate containing a considerable amount of unburnt material.

Quality of the Product

Kankar, being a naturally occurring material, varies considerably in quality, physical form as well as the chemical composition from region. This is reflected in the properties of the calcinates, when the Kankars are fired to Kankar limes. As a matter of fact, the properties of the samples of Kankars from different parts of the country vary so much that at one time there was much difficulty experienced in evolving suitable acceptable standards for Kankar limes. The difficulty arose mainly because, although Kankar lime is a time-tested building materials in the country, its chemical compositions as well as physical properties showed a very large degree of variation in samples from different regions. The final Indian standard for Kankar lime called Class E–is actually a sort of compromise to bring this material in the orbit of the standard, mainly on the basis of its performance.

The efficiency of any process is the effectiveness it has been able to achieve to serve its desired objective. Evaluated on this criterion, the efficiency of a Kankar burning kiln lies in the quality of the lime that it produces. With this point of view Kankar lime samples from the various kilns studied had been collected. These were brought to the laboratory and tested. Also tested were the samples of Kankars from these very sources. The results of these tests are given in table 1.

Table 1

EFFICIENCY OF CALCINATION PROCESSES

No.	Type of Kiln	Loss on Ignition in Kankar %	Loss on Ignition in Lime Collected %	Efficiency %
1.	Haryana-I	36.85	22.38	39
2.	Haryana-II	36.85	20.48	44
3.	West Uttar Pradesh	26.73	12.54	53
4.	East Uttar Pradesh-I	27.22	20.11	26
5.	East Uttar Pradesh-II	39.42	20.79	47
6.	Andhra Pradesh	41.08	20.50	50

It is obvious from these results that a large portion of the carbonates remain undecomposed in the limes produced from these kilns. As a matter of fact the burning efficiency is consistently low and comes down to as little as 26 per cent in some of the kilns; even the best of the results did not produce more lime than about half of what could have been produced. Although no specifications are applicable to these types of materials, they do not satisfy even those that are given for better quality limestones, although it must immediately be mentioned that they are strictly not applicable.

Some of the properties of Kankar lime sampels obtained from the field were examined in the laboratory. The results are given in table 2.

As is to be expected from largely uncalcined samples, these limes are highly inferior in quality. Their setting times are extremely slow and they develop very poor strength. Even after curing for 90 days the best of the compressive strength that could be achieved was only 8.75 kg. / cm^2. These

Table 2

PROPERTIES OF KANKAR LIMES

	Haryana-I	Haryana-II	West Uttar Pradesh	East Uttar Pradesh-I	East Uttar Pradesh-II
1. Residue on slaking (% Retained on)					
I. S. Sieve 2.36 mm.	24.0	26.0	0.75	1.0	5.1
I. S. Sieve 850	5.0	6.0	12.5	10.0	7.0
I. S. Sieve 300	3.5	4.0	17.5	12.5	10.5
2. Setting Time (hrs.)					
Initial	47	49	42	21	12
Final	143	146	167	136	77
3. Compressive Strength (kg./cm2)					
14 days	2.05	2.90	2.05	1.61	3.10
28 days	4.13	5.25	4.28	2.46	5.69
90 days	6.86	7.31	5.75	3.70	8.75

limes, therefore, do not satisfy the requirements of IS 712 Class E.

Conclusion

Dave, Mehrotra and Verma have studied these Kankar samples in detail in laboratory and have produced very good Kankar limes, which conform even to Class A limes in several cases. It is, therefore, obvious that in reality it is the indifferent burning that is responsible for poor quality product from these kilns.

Very high quality limes from Kankars were produced in the past as the many ancient buildings in India stand monuments to the eloquency and sturdiness of the binding material of the time, viz. lime used in their construction. However, the systems have degenerated through ages and the existing Kankar burning kilns are producing materials of very inferior quality. There is tremendous scope for carrying out improvements in this rural industry, which can come in very handy at the present juncture of the scarcity of, even while being expensive material, cement.

This paper forms a part of the regular research programme of the Central Building Research Institute' Roorkee and is being published with the permission of the Director.

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