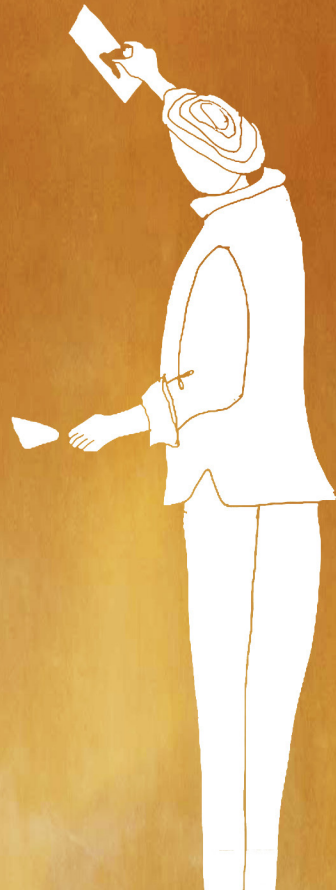




Hunnar of Lime

Information Booklet



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Foreword

The document “Hunnar of Lime” is a timely addition to the literature on Lime. There are any number of books/articles on the engineering properties of Lime. However, none of them discuss the traditional practices of using lime. This booklet gives a fascinating introduction to traditional plasters like ‘Kodi Marble Plaster’ and ‘Araish Lime Plaster’ used in Rajasthan. It is also interesting to note that the booklet recognises the two Lime Artisans for their continuing support to traditional Lime practices. It is to be hoped that this booklet will give a boost to traditional lime practices so that more youngsters are trained in these techniques. I suggest that Hunnarshala could organise workshops where these artisans give training to younger artisans. The booklet also gives basic engineering information on various uses of lime. It is generously illustrated with exhaustive drawings and photographs making it very attractive to the reader. I congratulate the Hunnar Group for this venture.

- K.S. Jagadish

Preface

There is renewed interest among 'building' fraternity about the usage of lime in construction. We are slowly realizing what we have lost during the last 25-30 years, the wealth of knowledge that was accrued after at least 1000 years of experience. It was not only technical knowledge but was skill and deep understanding of its behavior and adoption of a material for the particular region and environment.

For technical purposes also, we don't have sufficient documentation or we are not able to retrieve it from the source. On the other-hand, technical/college education is totally ignorant about the importance of lime. There is a necessity for all who are interested in lime, share our understanding about lime. During the workshop interaction it was felt that a written document could be helpful in addition to the hands-on experience.

This compilation is more an approach to spread the very basic understanding about how lime works. The care is taken to be technically correct but at the same time it may not be precise. We would emphasize that this work is to spread a word about lime, make it more approachable and help us to explore more in the field.

We hope to receive feedback and at the same time invite all of you to contribute to the information that could add to the understanding of lime. We hope to prepare another document on lime application and finishes in near future.

- Keyur Sarda

Acknowledgments

This note is not written on the basis of the research done in the formal laboratory, but with the contribution of hundreds of people through narrating their method, experience and knowledge. Immediately I can recall my start of journey with Nizamudin Chacha. His candid explanation of proportion, method and minute guidance gave the boosting start. Like him Feizu Khan Ji, Lakahram ji and many other artisans have guided and discussed Lime and their experiences.

The formal form of this booklet would have been a dream forever if Sandeep bhai would not have sat with me, discussed and wrote. He sat daily for more than a week and prepared the draft. It is the leadership of Gaurav that pulled out this ultimate presentation from the draft. His teaming up with Annie has done wonders with compilation, interviews with artisans and final presentation.

With a great sense of pleasure and satisfaction, I express my sincere thanks to all the participants of the AINA workshop; students, young professionals without whose participation the workshop would not have been possible.

Last, but not the least, I sincerely thank and congratulate the entire team of Hunnarshala Foundation and wish that this goes in continuation.

'Hunnar of Lime' | The skill and craft of lime.



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An Introduction to Lime Artisan Perspective and Knowledge

Lime has been used as a building material for centuries and has been explored extensively in different parts of the country. There are a variety of techniques associated with lime, each developed thoroughly by generations of artisans. It has a wide range of applications as masonry mortar, plaster, tile bedding and waterproofing; And its advantages are multifold.

It is imperative to **recognise and further explore the potential of lime and its application** in current times. Therefore, to understand the craft and practice of lime, we turn to the immense wealth of knowledge and skills of the artisans and craftspeople.



Figure 1. Lime plastering process at AINA workshop (finishing with float and cleaning), Hunnarshala



Figure 2. Lakharam ji, Jodhpur School

Lakharam ji, an artisan from Khatiasmi village in Jodhpur, Rajasthan has had a 26 years long journey with lime.

His journey has taken him to different parts of the country including Ahmedabad, Ujjain, nearby Bikaner, Nagaur, Hyderabad and Dharamshala.

Tryst with Lime:

His journey started back in 1994 under the mentorship of his teacher, a lime artisan from the nearby village of Kukunda. Craftsmen from Punjab visited Kukunda to undertake residential work, where the craft gained a foothold. He, along with 10 to 15 others started out as helpers and eventually turned masons.

After two years of training, in 1996 he got lime plastering work for a hospital in Jodhpur, five stories of interior and exterior work.

Family and Village:

Out of a large family, around 7 members of Lakharamji's family are lime artisans, including his older brother. Newer generation wants to study and get a conventional education rather than get involved with the informal masonry sector. About 500 people from nearby villages, including 10 from his own village Khatiasmi as well as around 300 from Kukunda village are practicing lime artisans. This leads to a competition in the region, each wanting to stand out and score work for themselves.

Finding Work with Lime:

Most of the work he receives is through word of mouth, through old clients, family and friends. This may include renovation and restoration work for structures five years and older or new works. He also has to undertake other work such as painting along with lime, given the new materials available in the market and persisting demands.

Lime work is not assured throughout the year, therefore most masons, including him resort to farming and cattle rearing during lean periods of no work.

On Technique and Design:

The lime plastering techniques have several names across the region such as Kodi marble, Udaipur jiki, etc., each slightly different in their composition.

The plaster is planned as per the wall surface and sizes, and designs maybe incorporated to match the stones and colours of the structure.

New ventures and avenues:

Despite the competition, Lakharamji looks forward to mentoring and guiding new recruits and anyone interested in learning the technique. He believes in imparting the knowledge he has of the material to anyone willing to learn and take the same forward.



Figure 3. Lime plastering at Jodhpur School

Kodi Marble Lime Plaster:

By Lakharam ji, lime artisan from Jodhpur

Ingredients -

- 1kg Kali chuna
- 800g Dolomite (coarse)
- 600g Jiki (fine)
- 100g Kodi Powder (fine marble powder)
- 50g Gund (gum)
- 50g Tarpin oil

Preparation of Mortar -

- Kali chuna, dolomite and jiki are mixed with water for 15-20 days.
- Kodi powder, gund and tarpin oil are added and the mix is seal packed in a plastic bag.*
- For use add water and mix for sufficient consistency and sieve the mixture.

*Entire wall should be done in one go, without a break. The thinner the layers, stronger the plaster.

- After completion and once the wall is dry, the surface is cleaned with soap and wet white cloth, and finally wiped with coconut oil.

**Artisan Notes -**

* The Kodi marble plaster mix can last up to 10 years as long as no air enters, lime in fact gains strength with time.

Regular cleaning keeps the plaster looking young and fresh.

Only structural cracks may show up over time, and hairline cracks only when exposed to the sun.

The process is labour intensive, as compared to working with other materials.

Organic colours (mati ke rang) include haldi, neel, etc. The process is a little complex, where the colour has to be soaked in water and then sieved to make sure no particles remain.



Figure 4. Feizu Khan ji, lime artisan

Feizu ji is an ‘araish’ lime master artisan from Nagaur. He has been working with lime for the past 35 years.

He has worked all over Rajasthan, undertaking both restoration and new work involving lime craftsmanship. He has been working at the Nagaur fort, doing lime restoration work for the past 20 years, requiring full time occupation.

The craft of lime has passed down generations in his family. His large family, including his great grandfather, grandfather, uncles as well as father have continued the tradition of ‘araish’ lime plaster in Rajasthan for ages. His great grandparents even contributed to the centuries old lime plastering at the Jodhpur and Bikaner forts in Rajasthan.

The craft has trickled down to the new generation as well, though in the current scenario and with the growing demands of the construction industry, his children and brothers have to take up work with other materials such as cement as well. While the raw materials for lime plastering are inexpensive, the process is labour and time intensive, requiring skilled artisans and patience.

Feizu ji is an ardent advocate of *chuna* (lime) over cement, given its quality and longevity. While cement lasts only 50 or maybe even 100 years, lime is known to last a 1000 years, with minimal deterioration. Therefore, he is enthusiastic and willing to train and teach students, professionals and anyone interested to learn the craft of lime.

Araish Lime Plaster:

By Feizu ji, master lime artisan from Jodhpur

Ingredients -



1. Molasses | 2. Marble Powder | 3. Brick Grit | 4. Brick Aggregate

5. Fenugreek | 6. Sand | 7. Fine Sand | 8. Surkhi

9. Gugal Gum | 10. Sheep Hair | 11. Jute Fibre | 12. Lime

Araish Plaster Coats:

	Aggregate	Sand	Surkhi	Lime	Marble Powder	Gud, Gugal & Methi	Jute	Sheep Hair
1st Coat	1	1	1	1	-	10 gm /kg	5 gm /kg	-
Depending on levelling requirement of wall (1" to 3"), the plaster thickness may vary between 12mm to 40mm. The first coat is cured (sprayed with water, <i>tahara</i>) for 7 days.								
2nd Coat	-	3	-	1	-	10 gm /kg	5 gm /kg	-
The plaster thickness of second coat should be 8mm to 10mm. The second coat is cured (sprayed with water, <i>tahara</i>) for 7 days.								
3rd Coat	-	1	2	1	-	10 gm /kg	-	2 gm /kg
Surkhi Plaster: The plaster thickness of third coat should be 4mm to 6mm. The third coat is cured (sprayed with water, <i>tahara</i>) for 3 days.								
4th Coat	-	-	-	1	1	-	-	-
Araish Plaster: Lime and marble powder for this coat should be sieved through <i>malma</i> cloth. The final coat of plaster is 2mm thick. No curing required.								

Artisan Notes:

It is important to inspect the raw material with utmost care. One should have knowledge of the quarry and quality of limestone; and the quality of carbon dioxide in the limestone.

The raw materials should be free of soil impurities, salt content and too much 'chikki mitti' (clayey soil), which may cause cracks in the plaster.

Winters and monsoons are most preferable for plastering work. The lack of humidity in summers is a drawback for lime plastering.

Historical Narrative of Lime

Lime deposits were widely available in India. As each deposit had its own chemical composition with varying soil impurities the practice of preparing lime mortar had developed uniquely in each region. The practice was to use lime within a limited radius around the deposit.



Figure 5. Paintings illustrated in Akbarnama depicts use of Lime in the construction of Fatehpur Sikri



Figure 6. Traditional Kiln



Figure 7. Major lime clusters in India



Figure 8. Lime plastered home with a tint of indigo

Traditional practice of lime plastering in Jodhpur involved addition of **indigo blue** colour to the plaster, to give the buildings a pleasant look. The blue colour also helped repel insects and keep the homes cool during the harsh summer months of Rajasthan.



Figure 9. *Hawa Mahal, Jaipur*

Jaipur sourced lime from pure deposits and needed to add pozzolana to make good mortar. They used surkhi (burnt clay) which gave the lime a **pink hue**, famous in old Jaipur buildings.



Figure 10. Adalaj ni Vav, near Ahmedabad, was built in the 15th century

A **stepped well** is a unique form of underground well architecture in which a long-stepped corridor leads down five to six storeys until it reaches the aquifer. The well, at the far end of the L-shaped structure, thus remains filled with clean and naturally filtered water throughout the year. In Gujarat, stepwells are designed to offer more than water. While the tiered structure provides shelter from the hot and dry weather, the structure, usually made of brick, sandstone and lime mortar, keep the surroundings cool.^[1]

Ahmedabad used lime sourced from Abu and Sirohi regions of Rajasthan. This was a relatively weak mortar, but sufficient to provide strength to the structure.



Figure 11. Traditional Chettinad building

Traditional **Chettinad** buildings used plaster composed of naturally available materials in its mix including sea shells, conch shell powder, lime and egg whites. Chettinad plaster is used in the final stage of wall finishing. The bricks are covered with multiple layers of white lime mortar and plastered with the egg-lime mix. Egg whites have been an integral part of wall plasters of Chettinad homes for centuries, imparting a mirror-like shine to interior walls along with beating the scorching heat of the region. ^[2]



Figure 12. Lime Stucco work on the facade of Bara Imambara, Lucknow

Developed as a substitute to stone work, the art of **lime stucco** in Lucknow evolved in multiple aspects both functional and ornamental. Foremost distinction was in the use of lime plaster and stucco not just for interiors but extensively on the exterior facades of the buildings. The use of lime stucco was extensive in the buildings belonging to the Nawabi period in the entire Awadh region. ^[3]



Figure 13. Extensive fresco work at Sheesh Mahal, Nagaur Fort, Rajasthan

The plaster follows a traditional technique, '**arais plaster**' still in use in Rajasthan. In accordance with primary sources and current practice, various aggregates are bound in lime, with trace amounts of proteins and gums. The final white plaster layer – containing a high quantity of powdered marble – was polished to produce a compact, shiny surface. The painting palette of the fresco work includes, among others, red and white lead pigments, applied with vermilion in the flesh-tones and garments, smalt, a green copper chloride, as well as gold and tin. Organic colorants (red, yellow and blue) were extensively used though are now mostly faded. ^[4]



Figure 14. Jami Masjid, Gulbarga Fort

Gulbarga deposits were famous for its bonding properties. The deposits had the ideal proportion of lime and soil that imparted hydraulic properties to the mortar. It is for this reason that even today this region has many cement factories that use this deposit.

A tale as old as civilisations' buildings,
Of a binder made by generational bidding.
Adorning kings' palaces galore,
And forging a peasant's humble abode.
Diversity of place and tides of time,
Have only proven the strength and beauty of lime.

A home rendered beautiful and alive,
Drawing breath, in and out, same as you and I thrive.

Healthy, wondrous and full of charm,
Lime heals its maladies (cracks) on its own!
Rest assured, a little water does no harm,
Within the climatically controlled comfort zone.

A tale as old as that of lime,
Is lived in fresco painted halls and pigmented walls,
Retold by generations of artisans over time,
To be witnessed and explored by one and all.

A poem on Lime
By Annie Aggarwal



What is Lime and Lime Wash?

Limestone is one of the abundant minerals in the earth's crust. It is available in several forms. There are limestone deposits generated by sediments in geological times. There is shell lime produced by marine organisms, which is mainly available in coastal areas. There is also 'kankar' lime where naturally leached out limestone is mixed with clayey impurities.^[5]

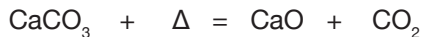
Limestone is Calcium Carbonate (CaCO_3). However, we want this rock Calcium Carbonate in applicable form as a paint finish, which is used as lime wash or whitewash.



Figure 15. Limestone Mine

The various processes involved in producing lime wash or white wash from the rock form of Calcium Carbonate (CaCO_3) are defined here. Lime wash has been used extensively as paint finish throughout history.

CALCINATION OF LIME



Calcium Carbonate + Heat = Calcium Oxide + Carbon Dioxide
 (Lime Stone) (Quicklime)

The rock is heated in a country kiln or a mid-sized continuous kiln to 950-1000 °C. This process releases the carbon dioxide leaving lumps of calcium oxide CaO. Burning (Calcination) of these minerals in a lime kiln converts them into the highly caustic material burnt lime, unslaked or quicklime Calcium Oxide (*Chuna*).

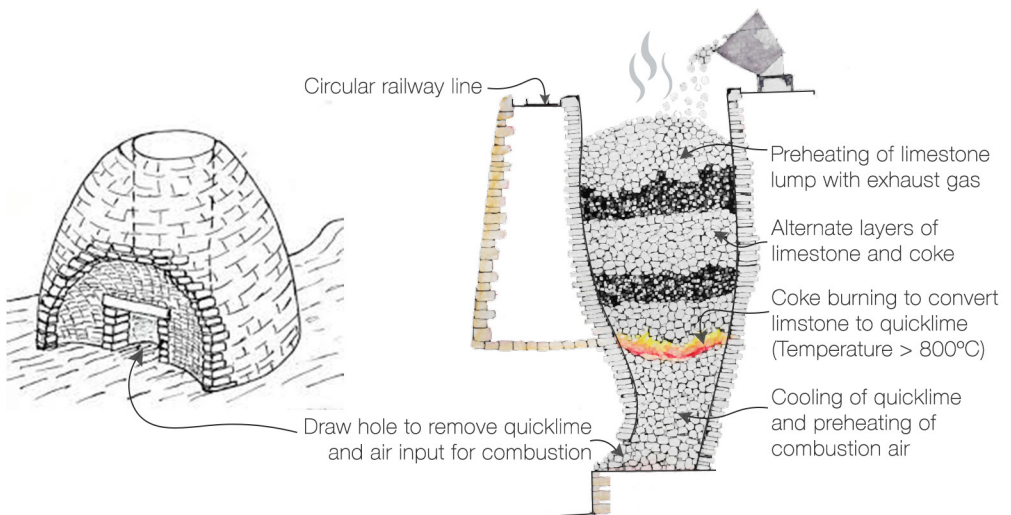
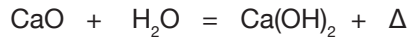


Figure 16. Calcination of lime in a lime kiln

SLAKING/ HYDRATION OF LIME



Calcium Oxide + Water = Calcium Hydroxide + Heat
(Quicklime) (Slaked Lime)

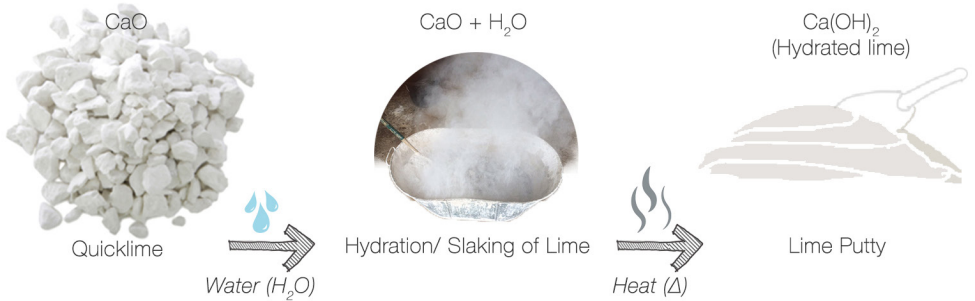
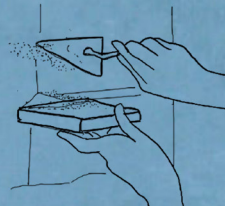
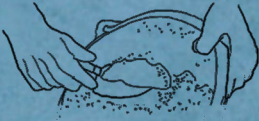
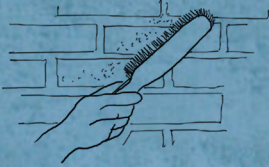


Figure 17. Slaking of Lime process

Subsequent addition of water causes an exothermic reaction and turns quicklime into the less caustic slaked lime or hydrated lime, Calcium hydroxide (*Lime Putty*). The lime putty is sieved through a cotton cloth to remove coarse particles leaving behind the lime wash ready for application.



The age-old craft of lime is a beautiful and mindful practice. It requires patience, skill and knowledge passed down generations of artisans and craftspeople.

Lime Mortar

Lime putty ($\text{Ca}(\text{OH})_2$) mixed with sand produces a mortar, which on hardening is a weak binder. The binder (CaCO_3) with sand as a filler works as a weak mortar.

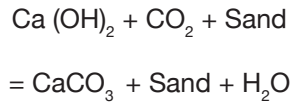


Figure 18. Bullock driven traditional mill for lime hydration

TRADITIONAL MORTAR

Traditionally the lime deposits had impurities in the form of soil, which got calcined (Heated) with lime. This calcination converts the crystalline soil into amorphous state which can now react with lime in presence of water.



These lime lumps were hydrated and muller in a bullock driven mill. This process of hydration initiates the reaction and the mulling improves the efficiency of the reaction to create C-S-H.

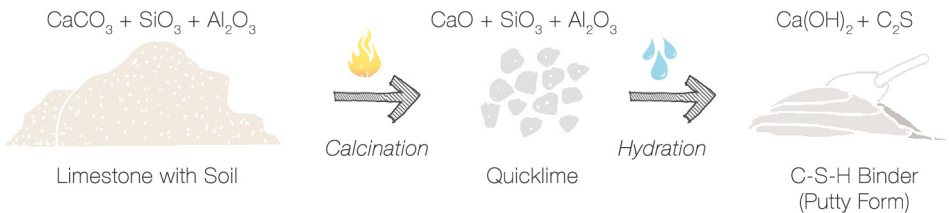
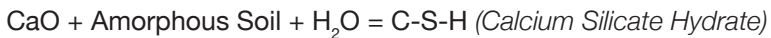
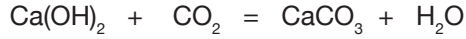


Figure 19. Traditional lime putty, C-S-H

This C-S-H is a very good binder and is in putty form. It is mixed with sand and used as a mortar. Traditional practice was to hydrate it for a few days and muller with sand and other additives. The C-S-H gel now binds with the sand to give us durable mortar. The mulling action also helped develop good workability for the mason to apply the mortar on the wall.

LIME CYCLE



Calcium Hydroxide + Carbon Dioxide = Calcium Carbonate + Water

The Calcium Hydroxide is applied to the wall where it reacts with Carbon Dioxide from the air and releases water as vapor, leaving behind Calcium Carbonate; the original lime stone again!

As Limestone is formed under extreme environmental conditions of heat and pressure, it forms in rock form; however, man made calcium carbonate is soft.

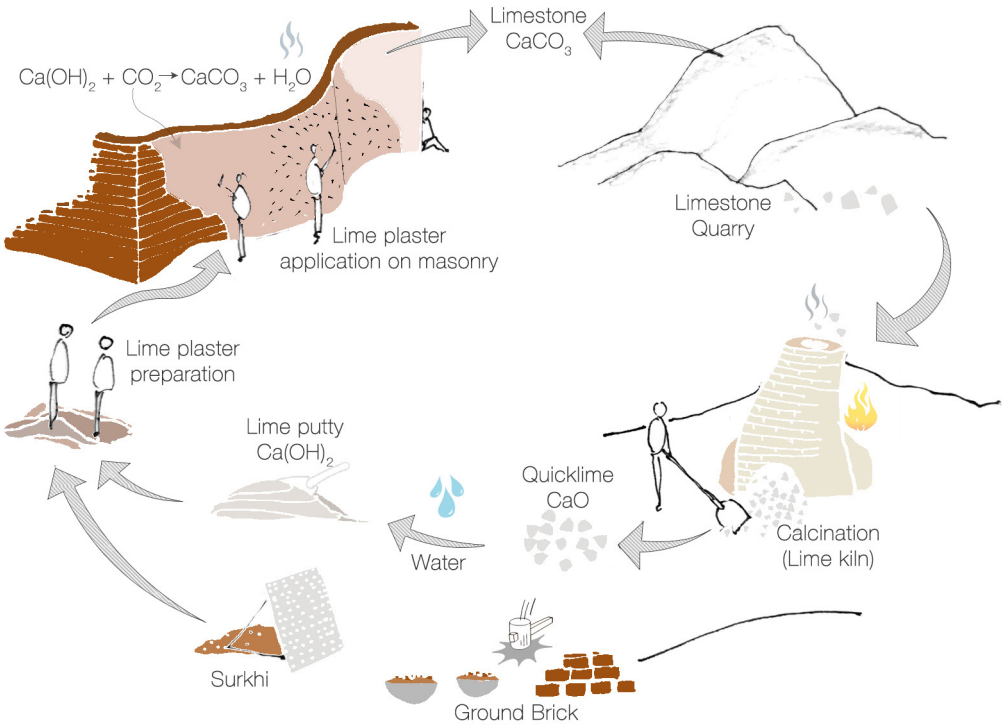


Figure 20. Lime cycle

Three Types of Lime Mortar:

(Summarised as per notes from Prof. K.S. Jagadish)

Fat Lime Mortar

Fat Lime (CaO) sets by absorbing CO_2 from air and the resulting CaCO_3 has relatively poorer strength compared moisture cured Hydraulic Lime. Fat Lime is ideally used for white wash. It can also be used as masonry mortar but leads to relatively weaker masonry.

Hydraulic Lime Mortar

There is *kankar* Lime which has clay impurities. It is this Lime which leads to hydraulic Lime which sets in the presence of moisture, forming cementitious products like C-S-H.

Lime Pozzolana Mortar

This is produced by mixing Lime (preferably fat Lime) with finely divided pozzolanic material. One can consider a variety of pozzolana such as burnt clay, brick powder, fly ash, rice husk ash and bagasse ash. Clay has to be burnt at temperatures between 600 to 700 °C for good pozzolana. Lime pozzolana mortars generally lead to quite strong mortars if the pozzolana is of good quality.

Hydraulic Lime mortar is similar to Lime pozzolana mortar although the strength of Hydraulic mortar depends on the quantum and quality of the soil present as an impurity.



Unique practices of making mortar with different proportions of organic matter to impart better workability and water proofing properties developed across the country.



Gur (or molasses, a waste of sugar factories today), was used in the mortar to improve workability and provide water proofing to the wall.



Methi was used as a binder and imparted pesticide properties to the mortar.



Gugal gum a plant extract, was commonly used in Gujarat and Rajasthan for its binding properties.



Urad pulse was commonly used in Maharashtra as a binder in traditional lime mortar.



Bael fruit was another natural ingredient used as a binding material in traditional lime mortar, specifically in Maharashtra.



Egg whites were used (Tamil Nadu) in lime plaster to impart a shine to the plaster and keep the interior spaces cool.



Sea shells were used to make lime mortar along the South-Eastern coast as there were no lime deposits nearby. This practice was famously called, Chettinad.



Curd or Dahi was used in the finishing layers to impart water repellent properties to traditional lime plaster. The practice was called 'Khamira'.

The advantages or usefulness of different ingredients mentioned above is experience based and need to be verified/ascertained at Laboratory.

Further, Prof. K.S. Jagadish notes that, "With the addition of such materials the strength gain is reduced. Probably these additives may make the mortar impervious. The traditional Lime-surkhi mortar also uses these additives while laying a water proof layer over temple roofs or modern concrete roofs. However, this practice is now abandoned in favour water proof additives to cement mortar."

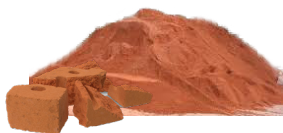
COMPOSITION OF LIME MORTAR TODAY

Today most of the lime deposits for building lime have been closed. Most of the available lime today is commercially produced for industrial purposes. This is used largely in pharmaceuticals and acid neutralization. This is **pure lime – CaO**. We need CaO and **amorphous silica and alumina** for hydraulic reaction, which imparts binding properties to lime mortar.

CaO (*Pure Lime*) + Amorphous Silica & Alumina

Silica and alumina are the most commonly available material on earth. The basic requirement is that soil should have been calcined and cooled down in a certain time period to have amorphous silica and alumina. Fortunately, amorphous silica and alumina are available as waste from many industrial processes. As many natural materials used by the industry have impurities of soil in them, the soil gets heated (calcined) along with the primary material, and if cooled in a controlled manner, the soil, as waste, is the pozzolana required for producing lime mortar.

Pozzolanic materials like brick surkhi (in India) and volcanic ash (in Roman architecture) have been used since ancient times in different parts of the world.



Surkhi is available in most brick kilns throughout India. Burnt clay brick bats are ground to a very fine consistency and can be used as Surkhi. This is possible as the bricks have been heated to temperatures of 1000 °C.



Volcanic Ash is an effective pozzolanic material that has been used historically and is used even today. Some volcanic ash deposits are extremely reactive. The famous Roman architecture used the volcanic ash of Vesuvius.

Today a wide range of **pozzolanic materials** are used. These are by products from various growing industries. Some of the pozzolanic materials used today are fly ash, silica fumes, GGBS, etc. These provide the silica and alumina component to the lime mortar.



Pulverized Fuel Ash (PFA) or Fly Ash has very good pozzolanic properties and is well explored.

Today's modern coal based thermal power plants use pulverized coal to fire the boilers. The soil as impurities in coal is also heated to the temperature of about 1000 °C and subsequent cooling arrest the Silica and Alumina in amorphous phase.

This pulverized fine material is collected from the smoke with help of a filtration device, an **electrostatic precipitator (ESP)**, that removes fine particles, like dust and smoke, from a flowing gas using force of an induced electrostatic charge minimally impeding the flow of gases through the unit.

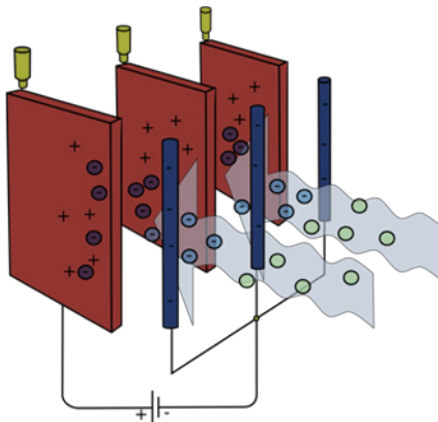


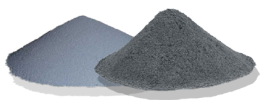
Figure 21. Electrostatic Precipitator diagram



Ceramic tiles finely ground are another very good source of *Surkhi*. Here, selected clay (like, feldspar, metakaoline) is taken and baked to form tiles. The waste available from this industry can be ground to make *Surkhi*. This is largely available in Gujarat, a major producer.



Ground Granulated Blast Furnace Slag (GGBS) is produced during the process of iron ore deoxidisation in a blast furnace. The ore is heated to 1350 °C with lime stone and coal. The hot molten impurities float on the surface of molten steel as slag. This slag is immediately put into water, known as water quenching. This process arrests silica and alumina in amorphous phase. This is in sand like granular particles, which can be ground fine to use as pozzolana. As this mix also contains lime, this pozzolana is self reactive and provides considerable strength to final mix.



Silica Fumes are a byproduct of Silicon and Ferro Silicon metal used primarily in solar panels and electronic chips. This is mainly silica and a very effective pozzolanic material. However it is imported in India and limited in quantity therefore, very expensive.

PREPARATION OF LIME MORTAR

Ingredients:

A general-purpose mortar can be prepared with the following proportion.

- *1.0 part* Pure Lime
Quick lime or pure hydrated lime
- *1.5 part* Surkhi
Finely ground, should pass through 150 micron sieve size
- *1.5 part* Sand
Coarse sand is preferred over fine sand as it improves the gradation of mortar
- Water based solvents prepared from molasses, *Methi* and *Gugal*.



1 part Lime : **1.5** part Surkhi : **1.5** part Sand

Preparing lime mortar:

- Quick lime is hydrated and mixed with *Surkhi* and sand in the given proportion by volume in a lime *chakki* (pan mixture).
- Sufficient water should be added to create a homogeneous uniform mix in the chakki.
- At the same time, water based solvents can be added to the mortar.

*If the mortar is made from hydrated lime powder, the dry ingredients are mixed first in same proportion by volume and water is added as per requirement.

*With this process and proportions lime mortar it is expected to get strength in the range of 3.5 to 5 MPa at 45 days age.



Figure 22. Lime chakki, wheel fixing at centre, pouring of material in track at Sacred Groves, Auroville

- **Storage:** The prepared mortar should be kept wet at least for a day. While being stored it should be covered properly to protect it from wind as well evaporation. On drying it accelerates hardening and it loses its property. This mortar can be used for 6-7 days if it is kept well protected and knocked down/remixed every day.

* Though IS codes prescribe that after hydration the mortar should be used within 24 hours as the setting process has begun. However, traditionally mulling would help in restarting the reaction thus breaking down the initial setting of CSH. This allowed the mixture to be used for 7-10 days.

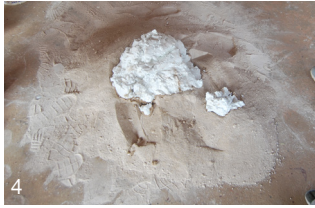


Figure 23. Process of Lime mortar preparation, AINA workshop, Hunnarshala

APPLICATION OF LIME MORTAR

The process of applying lime mortar is similar to the application of cement mortar. As in cement, a height of 1m high masonry can be done in a day. As the lime mortar is more cohesive and very workable, the mason can easily butter the brick with mortar before applying it on the wall.

Cure the work for at least 10 days.



Figure 26. Lime mortar masonry



Figure 25. Lime mortar masonry



Figure 24. Hydrated lime pointing

APPLICATION OF LIME PLASTER

Lime plaster on brick walls

1. Remove all loose particles from the wall and wet the surface (not drenched).
2. Take the lime mortars in medium thick slurry form and apply with trowel; a thickness of about 6mm. The surface should be kept rough and uneven. It should not be smoothed with a wooden float. The process is called 'Chaant'.
3. The 'Chaant' should be allowed to get some initial setting before the next layer is applied. This period depends on the season; in summers it can be about 1-2 days and in winter it can extend to 3-4 days. During this period it should be cured regularly (by no means it should dry out). If time permits allow a longer curing period of up to 8-10 days.
4. The second layer of 10-12 mm should be applied after initial setting of 'Chaant'. This should be finished with line, plumb and level. Compared to cement, lime plaster needs to be applied with some pressure as it tends to slide off the wall. Give sufficient drying/setting time. Unlike cement the improvements to the plaster can be done for a day or two as the setting time is longer. Masons recommend that the finish be done with wooden floats, guthkha, muster, plaster patti etc. but not with metal float (pataru).



Figure 27. Application of Lime plaster, AINA workshop, Hunnarshala

5. Allow this coat to set and dry for a few days. In case cracks appear on the surface repair the cracks by wetting the plaster and compacting with the edge of wooden float/gutka.
6. The final level layer is finished with a wooden float.
7. In case one wants to do special finishes this coat can be left rough by applying edge strokes of wooden float.



Figure 28. Lime plastering at AINA workshop, Hunnarshala

Lime plaster on RCC walls

1. The concrete surface should be made rough with dents (tancha) and be clean from all loose particles. The concrete surface should be moist not drenched.
2. To create a sticky surface for the lime, a viscous liquid of slaked lime and Molasses ('rasio gaud') in equal proportion should be brushed onto the RCC surface. First coat of plaster (Chaant) should be applied when this coat is tacky (sticky dry).
3. All other processes should be as described above. The thickness of the layer should not exceed 6-8mm at any time of application.
4. For very large concrete surfaces (like lift shafts or water tanks), it is often the case that lime mortar doesn't stick to the surface. In this case one may apply a 6-8 mm thick coat of cement plaster first to create an absorbing surface that will bond with lime.
5. It is not advised to apply lime plasters on RCC ceilings.

TOOLS FOR LIME PLASTERING and MASONRY

The various tools required for the different processes of lime plastering and masonry are listed here.¹

Mortar Mixing and Application Tools:



Figure 29. Mason's trowel (Chunaidu)

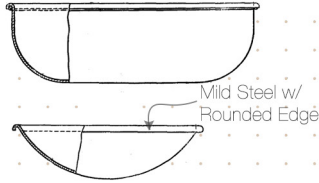


Figure 30. Mortar mixing pan (Ghamela)



Figure 31. Spade (Phavada)

Surface Preparation Tools:

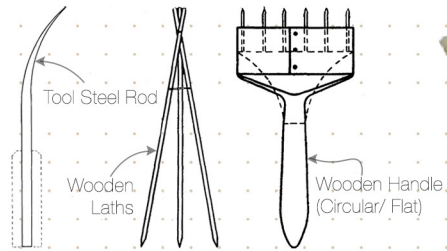


Figure 32. Raking needle; Fan type scratcher; Comb type scratcher



Figure 33. Brushes

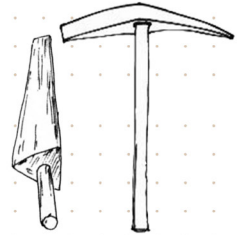


Figure 34. Pitni & Taancha

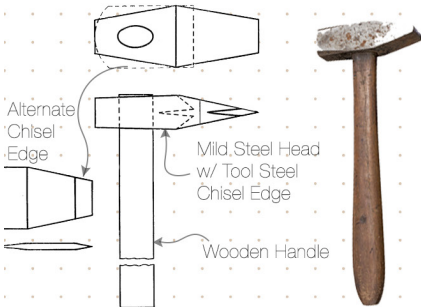


Figure 35. Hacking tool with chisel edge; Chisel and hammer



Figure 36. Hacking tool with point edge

Levelling and Setting Out Tools:



Figure 37. Mason's Square (Kat Khuno)

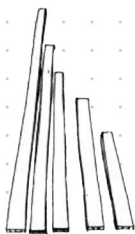


Figure 38. Aluminium Plaster Patti



Figure 39. Plumb Bob (Valambo)



Figure 40. Straight edge; Spirit Level

Pointing and Finishing Tools:

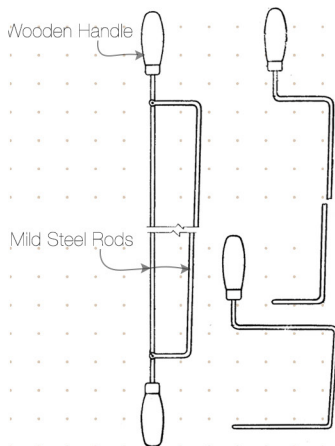


Figure 41. Large, medium and small Nayla



Figure 42. Hand Rammer



Figure 43. Rounded Wooden Hammer



Figure 44. Brick Jointer

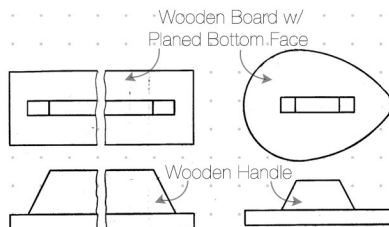


Figure 45. Steel floats (Malo) and wooden floats (Randho, randhli)

Advent of Cement

It is a widely held misunderstanding that cement is made from entirely different raw materials than lime. It is interesting to note that it was a result of persuasion of scientists to improve the performance of lime which led to the invention of cement. They found that certain proportions of limestone and soil at high temperature gives very good bonding (strength) and fast setting.

Cement began to be available in Indian markets from the nineteen fifties. However, it was a controlled commodity by the government, and available only in small quantities. Until the eighties, the building practice evolved to use cement in concrete roof slabs. It was a period when frame structures had not replaced load bearing structures so walls continued to use lime mortar and plaster.

However, **between 1985 and 1990 all restrictions on the use and availability of cement ceased, replacing lime completely in all aspects of building.**

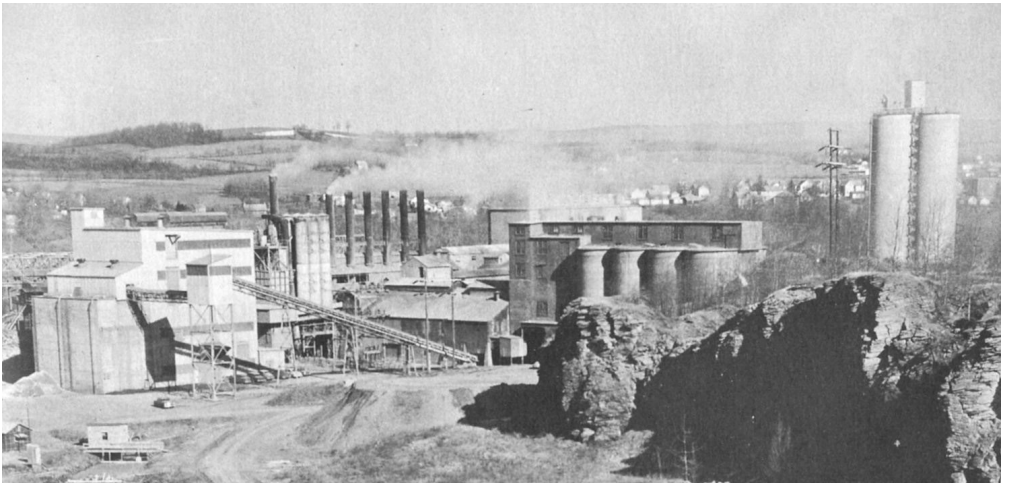


Figure 46. Lehigh Portland cement manufacturing plant, 1961

WHAT IS CEMENT?

Cement is made by fusing the raw materials of limestone and silica in a 60:40 ratio at temperature of 1450 °C. This controlled process forms 20 mm aggregate called Clinker. The clinker is fine ground with 5% gypsum to get cement.

Thus, lime and cement as binder – both use limestone and soil to get C – S – H (Calcium Silicate Hydrate) binding material.

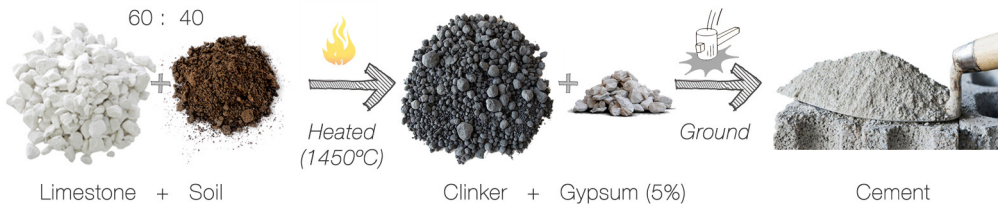


Figure 47. Process of making cement

Cement manufacturing is a highly sophisticated process and can be produced with the same standards across regions. Over the years tremendous research has been carried out to improve as well as to understand the product.

Normally, lime and cement are good in compression but the bonding of cement with reinforcement enables the material to take flexural stress. This has made spanning with RCC (Reinforced Concrete Cement) very easy.

Lime and Cement

A Comparative Study

Lime is a wonderful material but unfortunately forgotten to a large extent today in the quest of pursuing cement as a high and early strength gaining substitute. Though looking at the self-healing property, long term strength, breathability of wall and hygienic self-life, lime needs to be re-explored. Conventional masons are also pleased by its better workability and long initial setting periods as compared to cement mortar.

MANUFACTURING

The base materials for making both the binding materials are the same and therefore resource value for both lime and cement is the same. However there is a major difference in manufacturing and production of the two materials.

Lime

- Lime is still produced in a decentralised manner, in country kilns or mid-size kilns.



Figure 48. Lime kiln at Pollachi, Tamil Nadu

- The kiln achieves a temperature of 950 -1000 °C for calcination of lime.
- The scale of burning as well as unsophisticated kilns for lime production result in a lot of energy wastage.

Cement

- Cement is an industrialised product, with large infrastructure and centralised manufacturing. A cement plant annually produces 3-4 lakh metric ton of cement.



Figure 49. Jaypee cement plant, Gujarat

- Cement production requires a higher temperature of 1450 °C.
- Organised and regulated production minimises wastage of energy. However, the resources and energy invested in building infrastructure and manufacturing plant is relatively very high.

WORKABILITY & PROPERTIES of MORTAR

Lime

- Lime is hydrated before making the mortar, so heat of hydration is released before application.
- One of the best properties of lime is, it holds the water for a longer time, known as water retention of lime. This helps in the hydration process.
- Once mixed with water, the mortar can be used for about 24 hours as per IS codes, however practically if the mortar is mixed every day it can continue to be used for 6-7 days. This resolves the practical problem of the time gap between preparation and application.
- Lime being a very fine material has very good workability. It's cohesiveness along with workability makes it an ideal masonry material.

Cement

- Cement hydrates during the application period, so there will be heat of hydration that will cause thermal shrinkage and cracks.
- Due to poor retention and heat of hydration water evaporates from the mortar and it hampers the hydration process; which results in poor durability.

*In practice, the water in the mortar evaporates before the complete strength has been achieved. Therefore internationally, the practice is to make cement-lime mortar, so that the lime retains water and also improves workability.

- Initial setting of cement starts in 45 minutes after water is mixed, and final setting takes about 4-5 hours. This gives limited working time from mixing to application. The practice is to prepare the mix in the morning that gets used throughout the day, therefore compromising on the strength of the mortar.
- Compared to lime, cement mortar is relatively harsh to work with.

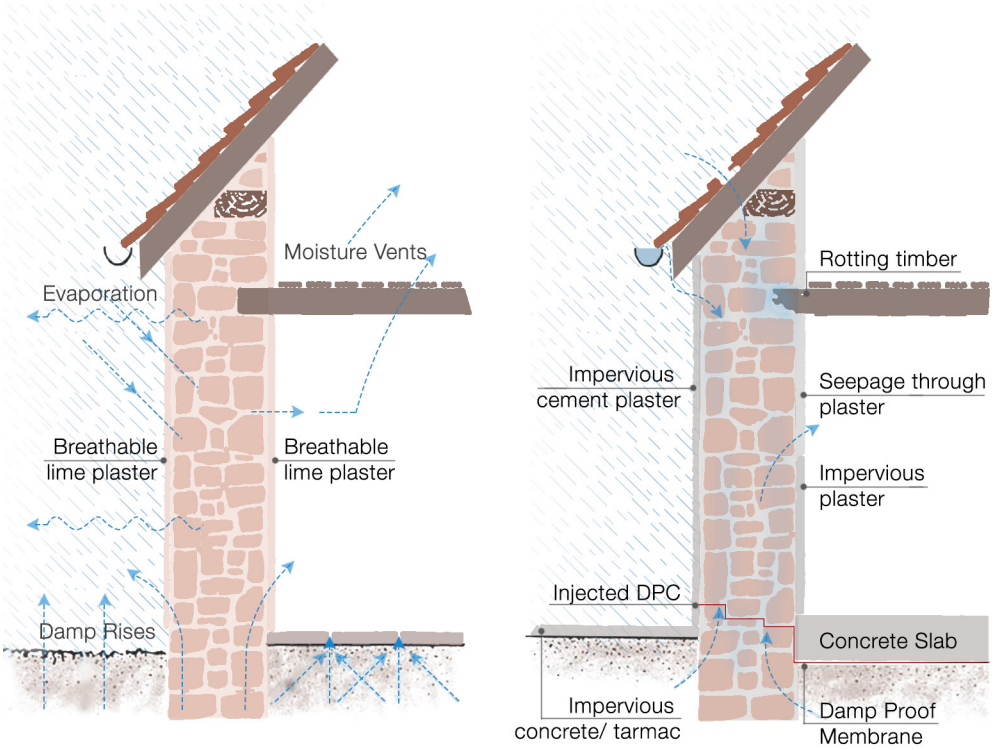


Figure 50. Lime v/s cement plaster properties

LONGEVITY & GREEN PROPERTIES

Lime

- Autogenous Healing: Lime mortar hardens in two different processes, by C-S-H reaction and by converting to CaCO_3 . There is free lime in hardened mortar, which leaches out in micro cracks formed in the mortar. This leached lime will react with atmospheric CO_2 and water to form CaCO_3 , which seals the cracks. This process continues indefinitely increasing strength and durability with time.

'Chuna saw sal pe jawan hota hae!'

(Lime becomes young when a hundred years old!)

- Lime mortars are slow-hardening and remain elastic or flexible. Lime, therefore, enhanced the ability of the masonry to accommodate stresses caused by building movement and climatic cyclical changes without excessive cracking.
- Soft lime mortar with low density is ideal material for thermal insulation.
- Lime has the property of absorbing vapour from the atmosphere; this provides properties of cooling and good air quality. Lime has an alkalinity of pH 12. This provides natural pesticide properties to the surface of rooms.

Cement

- There is very limited autogenous healing with cement mortar.
- Cement is relatively very rigid. So any major movement/stress will be released through cracking.
- High density of cement mortar has lower thermal insulation.
- Walls with cement mortar cannot “breathe” and trap moisture, which can cause problems with mold on interior finishes and deterioration of bricks.



Figure 51. Centuries old forts laid in lime mortar have withstood the tides of time, structural change and climate



Figure 52. Cement mortar is rigid in nature and cannot withstand any major stresses/ movements lending the structure a short life span

The advantages of lime mortars are not necessarily in manufacturing energy, but have multifold benefits in application, health, beauty, cost, durability and longevity. The various advantages of lime over cement can only be explored further by the revival and advancement of this age old and wonderful material that is lime.

Way Forward with Lime

In recent times, with the advent of cement and the immense growth of the construction industry requiring cut-throat speeds and efficiency, lime and its practice are slowly being forgotten. Given the numerous benefits of lime as well as its green properties, it is imperative to recognise and further explore the potential of lime and its application in current times.



Figure 53. Students at lime plastering AINA workshop at Hunnarshala

Another worthy note by Prof. K.S. Jagadish, states that the extent at which Cement has made inroads to our life it is impossible to reverse the situation. Moreover, it's neither economical nor feasible to produce Lime mortar at that scale. However, we need to look at its positive values and take advantage of the same.

Few other uses of lime are:

- As an additive to cement mortar to increase its setting time and plasticity for masonry construction. India is the only country to specify pure 1:6 cement mortar. This mortar starts setting in half an hour, requiring addition of water for plasticity, thoroughly weakening the mortar.
- Lime is also useful as a stabiliser for soil in stabilised mud blocks or in stabilising black cotton soil foundations.



Figure 54. Lime plaster finishes at Jodhpur School



Figure 55. Lime plaster finishes at Jodhpur school and Hunnarshala campus



Figure 56. Lime plaster finishes at Jodhpur School

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Hunnar of lime attempts to offer a glimpse into the beautiful craft and age old practice of lime in India. The information booklet serves as an introductory guide for students, young professionals and those wanting to explore the wonderful material that is lime and the skills associated with it.

This booklet covers the very basic understanding of lime, though we do hope to continue this exploration of the material through documentation and compilation in future publications.

