Procedures Followed in Different Regions of India to Prepare Lime Mortar

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ABSTRACT: The present work takes it's from matter the headline itself, which target to procedures followed in different regions of India for lime-based mortars. There are two periods that gives us better understanding of lime used in building construction as binding material. First from Neolithic age to middle of 18th century (Approx. 8000BC) and second from middle of 18th century to now. Lime was used in early period of Indus valley. Lime mortar has some self-healing power which can lead to resistance. Lime mortar chair recuperation consists of unfreezing. On the other hand, until now there has been little research on its implementation. The research given a good literature review and survey to those who caring about lime and mortars, as well as maintenance of traditional building.

Key words: Lime mortar, calcium, carbonation, aggregates, application

1. INTRODUCTION

1.1 History of Lime

There are two periods that gives us better understanding of lime used in building construction as binding material. First from Neolithic age to middle of 18th century (Approx. 8000BC) and second from middle of 18th century to now (Mainly 1990's but still used).

However hydraulic lime mortars were observed in Ancient Greece and Palestine. But in south America (Mesoamerica), in the areas dominated by Indian tribes, the lime construction was found in 20000 BC. As it is de-habitable, so as per the current research, we consider Hayoinm caves in Israel, which are carbonated to 10400 BC to 10000 BC. Early evidence was found in Indus valley civilization (5500 BC).

1.2 Indian Context

Lime was used in early period of Indus valley. In the site of Kalimantan, Rajasthan deposits and ruined remains of lime plaster lining pits, cylindrical in shape, were found inside the houses of the site. These structures are from proto Harrapan period (3500 BC to 2500 BC). But wide spread of this lime mortar structure was found in Buddhist era (200 BC to 300 AD). Best example is Sanchi Stupa and Nagarjuna Konda Stupa. Scientist experimented with all kinds of lime available in world for whole country (1760's to 1860's) and tried defining lime scientifically.

1.3 Classification of Limestone

Heterogeneity and chemical composition of lime depends on the choice of limestone used in their production; but in the application, the process of burning (production), process of slaking, storing and working technique (preparation) is involved.

Limestone can be classified into various groups according to

1. Origin
2. Texture
3. Chemical composition
4. Porosity of calcium carbonate
5. Geological formation
6. Crystal size

2. RAW MATERIALS REQUIRED

There are 3 types of raw material in pure limestone and impure limestone.

Raw materials for pure limestone are-

1. High calcium white stone (cretaceous series) – It contains 98 to 99% of calcium carbonate and have high calcium quick lime and contains less than 5% of magnesium oxide.
2. High calcium limestone (carboniferous series) - It contains only 2 to 5% of magnesium carbonate and rest of calcium carbonate. It has high calcium quick lime and contains less than 5% of magnesium oxide.
3. Dolomite (magnesian) limestone (Permian series) - It contains 35 to 46% of magnesium carbonate. It has high magnesium quick lime and contains more than 5% of magnesium oxide.

Higher level of magnesium carbonate shows that limestone is not permittable for lime production.

Raw materials for impure limestone are-

1. **Gray chalk stone** – This limestone contains 5 to 12% of clay particles which makes quick lime slightly hydraulic, 0.1<I<0.2, setting time is 15 to 21 days.
2. **High calcium limestone** – This limestone contains 12 to 20% of clay particles which makes quick lime hydraulic, setting time is 5 to 15 days.
3. **Dolomite (magnesian) limestone** – This limestone with clayey impurities contains 20 to 30% of clay particles which makes quick lime eminently hydraulic, I>0.2, setting time is 1 to 4 days.

3. METHOD OF PREPARATION OF LIME MORTOR

3.1 Limestone Burning

From the very beginning of lime structures from Neolithic period to late 19th century, the burning process of limestone was carried out in kilns which were very similar in all periods, but from the beginning of industrial revolution and developments of modern kilns in 20th century have transformed the small-scale production unit to well organized lime industry which has proved itself energy efficient with time. History of kiln design is closely relevant with availability of fuel.

Most of the currently available lime is not as good as it was found in the historic building as lime available today is burnt to achieve requirements other than construction industry which is very small market.

Another reason for disappearance of high-quality lime is because this kind of high-quality lime cannot be produced by modern design kiln (less than 10008C) where lime is likely to be overburnt and may perform as less reactive than traditional wood burnt lime (⟨9008C). The temperature influence and heating rate to the ability of lime to react freely is very important. Most reactive quicklime is composed at the constant flame temperature produced by old wood burning, where process of burning is long enough. This type of quicklime forms because wood burns to long and even with mild flames and moist heat, provides natural uniform calcination.

The hydraulic properties of material can be assigned to dicalcium silicate (belite) and aluminates. The reactive ingredients of early Portland cement and hydraulic lime mainly were calcium sulphate and calcium oxide. The percentage of silicate and aluminate is related with percentage of silica and alumina available in impure limestone.

3.2 Slaking of Lime

The process of slacking occurs very slowly and violently. Slaking of hydraulic lime is very slow process due to tendency of their hydraulic part to set in presence of water. This hydraulic quicklime is manufactured by dry slacking only. The hydration process takes place in 2 stages i.e.

1. During dry slacking, only calcium oxide slakes.
2. Like process of hardening of port land cement, the aluminosilicate reacts with water and calcium silicate and hence aluminates are formed.

3.3 Carbonation

1. Carbonation of hydraulic lime – In the absence of silica and alumina hydraulic reactions cannot be performed. In the process of burning, lime reacts with alumina and silica, an anhydrous calcium silicate and aluminate are formed. Then they are converted in calcium hydro silicate rapidly (depending on reactivity) in the presence of water.
2. Carbonation of air hardening lime – Generally this is an exothermic reaction which has 2 phases – a) drying process and b) calcium crystal formation (carbonation). This reaction occurs only in humid conditions and water as a catalyst. Contraction of volume begins with evaporation of water with continuous drying process.

4. LIME BASED MORTAR

Mortar are artificial agglomerates of binding agent (clay, lime, cement, gypsum, etc.), aggregates (natural or artificial inert), water and additives (natural and artificial) in suitable proportions so that the fresh agglomerate will have physical-mechanical properties and durability.

There are different types of mortar.

1) Structural mortar: for jointing, bedding and grouting
2) Covering mortar: for protection and rendering
3) Decorative mortar: for plasterwork, fresco, etc.

In historical building technology, lime was the main and very common binding agent in traditional mortar until the discovery of hydraulic binders (Cementous material). The water used in production of mortar must be free from all types of impurities such as chemical compounds, efflorescence causing salts, organic impurities, suspended material, etc. More use of water gives more workability but causes more shrinkage and less strength.

TYPES OF LIME BASED MORTARS

1. **AIR HARDENING LIME MORTAR**

These are differentiated –

1. Based on inert aggregate and air hardening lime
2. Based on inert aggregate, air hardening lime and natural additive

This solution is prepared just before application in construction. Exothermic reaction starts hardening process followed by drying of lime and calcium crystallization (carbonation).

Drying process- $CO_2 + H_2O \rightarrow H_2CO_3$

Carbonation- $Ca(OH)_2 + H_2CO_3 \rightarrow CaCO_3 + 2H_2O$

2. **HYDRAULIC MORTAR**

These are differentiated –

1. Based on hydraulic lime and pozzolana

2. Based on inert aggregate and hydraulic lime (in this, pozzolanic material is added to improve hydraulic rection by offering some amount of silica and alumina)

The most important reason for hardening of all type of hydraulic lime mortar is carbonation of calcium hydroxide and partly hydration process of aluminosilicates.

5. TYPES OF MORTAR USED IN INDIA

MAHARASHTRA: (Desh region- rest of Maharashtra)

Maharashtra has very old heritage of building and using lime in it. The material used for building construction include lime, jaggary, rice husk and sometimes wheat husk (according to availability), grass, fenugreek and okra. Chuna ghana (mixer run by bulls) was use as equipment for mortar making.

Procedure:

Hydrated lime, jaggary, rice/wheat husk, okra was added in ghana and then mixed with the use of roller mixer pulled by bulls. After proper mixing mortar is ready to use.

MAHARASHTRA: (coastal area- KOKAN)

Most of the places, the above-mentioned method is used for mortar making but in few areas of Ratnagiri and malwan, few families perform below process. In this process, seashells, lime and wood are used for mortar making.

Procedure:

In the 1st stage, fine lime is made by burning shells that are thrown away after shellfish consumption. This is burnt in different types of kilns which are dug into the ground and then lime-shell mixture and wood is layered alternate and burnt for period of 5 to 6 days. The ash is mixed with lime in appropriate ratio which is not documented but known inherently and them same procedure is followed.

SOUTH INDIA:

There are many types of lime mortars used in from south India from ancient times. We are going to look at 2 special types of mortar from south India. They are- a) Gacchi and b) Chetinad plaster.

1. Gacchi: In this, lime, jaggery, guggal gum extract, gallnut, fiber natural (tree of asparagus) is used.
   Procedure: slake lime is prepared. Fine lime powder and sieved sand are added in pan mixer in 3:6 ratio, half liter of gallnut powder and gum extract mixed water is added in pan for strength. Also, jaggery mixed with water is mixed with lime mortar which prevents from cracking and then natural fibers are added and mixed properly. 3 to 4 liters of water is added. This is mixed for 16 to 20 min. This mortar is stored on sheets so that load surface
   should not absorb water in mortar.

2. Chetinad plaster: In this, lime, shells, egg and curd water are used.
   Procedure: this procedure contains 4-to-6-layer plaster. 1st layer being rough layer, which will act as base coat which will be hydraulic lime and sand. Other layers are of shell lime and quardzide stone powder. Each layer should have finer consistency. In the last application layer, mixture of shell lime, stone powder and egg white are added which has soap like nature. Egg white makes mixture soft. This eliminates the chances of shrinkage. In this stage, curd water (water squeezed out of curd) is mixed. In few cases, color pigments are added.

RAJASTHAN:

Rajasthan, the area of Rajputana, is rich of heritage where due to natural condition there is very identical procedure followed all over the Rajasthan. In this process, lime, jaggery, guggal bark, fenugreek and surkhi is used.

Procedure:

In this process, lime is added in surkhi and then mixture is mixed with solution prepared by heating jaggery, guggal bark, fenugreek together and left for few days. This gives it basic working strength. The addition of herbs increases the transverse, tensile and compressive strength. This gives very fine finish.

6. CAUSES OF DEGRADATION

For lime base mortar following are the causes of degradation-

1. Mechanical stresses
   A) External
      These are caused due to Expansion due to Load and moisture, Thermal expansion, Stress caused by working technique and Differential thermal expansion.
   B) Internal
      These are caused due to Frost crystallization, Corrosion of iron cramps, Efflorescence and Alveolar erosion.
2. Chemical component degradation
   These are caused due to Wetting and drying process, Attack by rainwater, Attacked by polluted environments and Sulphate attack.
3. Bacterial attack
   These are caused due to Algae, Moss, Bacteria and fungi.
4. Vibration
   A) Imposed
      These are caused due to Sonic boom, Trans and Machinery.
   B) Accidental
      These are caused due to Earthquakes or Hurricanes.

7. REASONS FOR AIR HARDENING LIME MORTARS USAGE IN CONSTRUCTION

1. It is difficult to achieve balance between water content, workability, strength and shrinkage.
2. High deformability can be merit in certain cases as the local stress concentration can be accommodated in the mortar joints of the masonry and small cracks can potentially reheated by redistribution or recrystallization of calcium carbonate.
3. Lime may set poorly compare to ancient masonry.

8. WHY PORLAND CEMENT SHOULD BE AVOIDED IN ANCIENT TRADITIONAL HERITAGE CONSERVATION?

1. Too rigid and high strength for conservation.
2. The authentic material will result in failure due to mechanical stress.
3. Masonry walls will not be able to breath.
4. Water will be trapped between impermeable cement layers which will increase all kinds of mechanical stress and chemical reactions.
5. Soluble salts can be transmitted into adjacent lime mortar causes damage when water evaporates.
6. Formation of expanding materials causing major disorderly stress which will destroy mortar and then original mortar.
7. Aesthetic harmony with the original material is very difficult.

9. CONCLUSION

In this paper, we learnt about procedures followed in different regions of India for lime-based mortars. The production of lime is multi step procedure which includes limestone burning, slaking of lime, its carbonation and at the end, using it as a coat to protect the surface from weathering. In India, as we travelled to different regions, we learnt that the process for production of lime is same but the amount of raw material and additives used, are different. Addition of herbs in making lime has greatly enhanced the tensile as well as compression stress of mortar formed. And hence, can be used to make building eco-friendly.

10. REFRENCES

1. Kingary W. D., P. B. Vandiver, and M. Prickett. 1988. The beginnings of pyrotechnology, Part II: Production and use of lime and gypsum plaster in the pre-pottery Neolithic Near East. Field Archaeology 15(2):219–44

2. Indira Gandhi National Center for the Arts (IGNCA). 2009. Excavations–Important– Rajasthan. IGNCA. http://asi.nic.in/asi_exca_imp_rajasthan.asp (Accessed December 10th 2009)

3. CZERNIN W., 1980, "Cement Chemistry and Physics for Civil Engineers", 2nd ed., 1980.

4. P. Thirumalini, R. Ravi, S. Sekar, and M. Nambirajan, "Study on the performance enhancement of lime mortar used in ancient temples and monuments in India," Indian Journal of Science and Technology, vol. 4, pp. 1484-1487, 2011.