



## **Introspecting the Voyage of Lime towards Sustainability: A probe on lime as a building material in ancient and medieval epoch**

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**ABSTRACT:** Since the evolution of homo-sapiens, their habitat has evolved, where; nature has been a source of derivation of materials for habitat construction. Among other materials, lime has been used immensely on the basis of geographical location, climate, availability and technology awareness, playing important role in shaping of the architecture.

In earlier times, when cement was not invented and construction was much more sustainable than today, lime was the frequent material used for construction. Lime, as a construction material, is sustainable and has more life than cement. It can be prepared at local level but with some restrictions like need of skilled labors and knowledge on construction techniques. The use of lime as a construction material is not extinct; it is generally used for the conservation works of repair, renovation and maintenance of the heritage buildings. In today's prospect, incorporation of this material in construction industry is missing. It is lacking in vernacular techniques and focuses on adopting modern techniques, keeping a thought of modernization in mind, which is much more like westernization of Architecture styles and techniques. A need to understand the use of past usage of material and bring better understand off it in terms of properties and techniques of usage while considering present and future of construction industry. The paper gives an overview of the traditional usage of Lime as a construction material through historical examples. The paper further critically discusses the various benefits of lime with specific reference to life span of building. In addition, a comparison with the latest construction material is understood in terms of usage, properties of material, construction techniques, etc. and how these benefit the life span of building. The paper concludes urging the need to introspect the dire need of the construction industry to revisit the traditional construction materials and techniques.

**Keywords:** Lime, Construction, Building Material, Construction Techniques, Ancient, Medieval,

### **I. INTRODUCTION**

Since ages, the use of lime has evolved with diverse construction techniques in different regions around the world. Lime as a construction material has imparted strength to the building in diverse aspects in the form of mortar, as internal plasters external render, in flooring, infilling of walls, casing to water conduits, jointing compounds and decorative applications. (Carran, 2011) Furthermore, it highlights the usage varying as per timeline.

### **II. ANCIENT ERA**

#### *A. Indus Valley Civilization*

The lime usage was restricted to generic finishes, of daily use objects, in the form of plaster as inner lining in ovens and cylindrical pits of the original houses, currently located at Kalibangan, Rajasthan. Dominantly houses were constructed of brick modules from mud and mortar made of wood tar. (Carran, 2011)

#### *B. Egyptian Civilization*

The material was found in abundance along the river Nile, along which the civilization came into existence and evolved. In daily lifestyle, sculptures made of limestone existed (Statue of Harshepsut, statue of Egyptian gods in temples). Faience, made of available sand had limestone as one of the components, apart from clay, mineral particles and it was used for making vases and other decorative artifacts. Limestone blocks, were used for construction of Tombs (Tomb of Perneb). Local quarries used to supply lime stone during the making of monument in Cairo. In present scenario, at Cairo's historical monuments, stones are replaced by limestone for preservation. The pyramids of Giza, situated along the west of Cairo were built dominantly of porous limestone blocks derived from quarry near Cairo.

The limestone was found porous all along the Mediterranean region. The mortar was either made of either gypsum or lime.

(<http://www.metmuseum.org/>) (Fitzner). (University of florida)

#### *C. Buddhist Architecture*

Structures of the Buddhist settlement, along Nagarjunakonda, used lime as a plastering material. Implications of Buddhist settlement were dedicated to rock architecture followed by dressed stones. The Stupa at Vijayapuri, constructed of bricks had external lime plastering. Also, lime plastering has been identified at walls and floors of Chaityas at Bavikonda and Thotlakonda.

Technological advancement through shift from mud to lime mortar after keen observation is significant through set examples. Lime concrete in flooring of Chaitya at Nagarjunakonda and subsidiary use of dressed paved slabs were witnessed. Here, knowledge enhancement of the quality enhancement as lime brought longitivity with dampness control attributes to the buildings. Chaityagrah pillars of limestone were found while lime concrete was used as core to stabilize structure and as a good binding material. (shodhganga) (Shodhganga) (chapter 5)

#### *D. Mycenaean Civilization*

The civilization existed for three thousand years where; dominantly architecture was dedicated to temples and palaces built by sun dried mud block bricks. Additionally, the decline of Mycenaean civilization with power taken over by Greek and Iranian empire, the traditional material i.e. sun dried mud blocks got replaced by bricks and stone binding material as lime mortar which later evolved structural forms i.e. domes and arches. (University of Southern California) Also, the bathroom slabs of the houses were made of massive single limestone block. Relief of the lion on the entrance gate, located on citadel of Mycenae, is of limestone block.

Furthermore, fortification of the Palace was done through huge limestone blocks with crude surfaces, and well-dressed blocks of lime stone, and massive ramp as an entrance, made of limestone block, built in cyclopean style. In addition, the floorings plastered with lime and painted with frescos. Also, the south corridors main court has floors of lime cement. (UNESCO) Moreover, roughly fitted limestone blocks together with minimal clearance in the stone minimized the use of mortar. (Text book Innovation) (Historical and masonry structures)

### **III. MEDIEVAL AGES**

#### *A. Indian Temples*

The Dravidian temple architecture had temples, of which, lower portion was made out of sandstone and

upper part by brick and lime plaster. Monuments that came into existence after Chola dynasty had granite or brick with lime plaster as their construction material. Also, availability of limestone along the coastal area was the dominant factor of governance where the material was quarried and supplied to the construction sites. Furthermore, lime was used as a coloring agent for the markings on stone during construction. (Shodhganga) (Vardia).

During Vijaynagara period, joint between two slabs is filled by lime or mud mortar. The ceiling made of stone, has layer of lime mortar which provides water proofing. Lime stucco sculptures existed in Hampi. (Shodh Ganga) (Government of Odhisha Official Portal)

#### *B. Early Christian and Byzantine*

The use of concrete by romans in a semi fluid mixture of lime, pozzolan with brickbats was achieved as mention by J.H. Middleton in "The remains of Ancient Rome". Lime coating on the rough mud walls as stucco coverings were made. Concrete made of lime and with sand or pozzolan was made. Documentation of lime by Vitruvius in de Architectura shows usage variation with time with respect to the handling and preparation of lime concrete and mortar. (<http://www.romanconcrete.com/>, 2002)

Religious places and shrines like St. Molaise's house on Inishmurray used lime mortar. (Bibliotheca Mechanico-Architectonia) Additionally, the Tith Church also had brick wall with lime mortar which was later found in School of Constantinople in Middle Byzantine period. (Penn Arts and Science)

#### *C. Romanesque Architecture, Gothic Architecture*

Trading, quality assurance and sanctioning by the central authority, for the use of material in city premises came into existence.in warfare purpose, and for fortification, special emphasis on quality of lime existed. The material, lime, was either provided by the mason or by the client getting the structure made. Use of hydraulic lime was not applicable for masonry mortar. The usage of lime existed in the form of plaster, wall, floor finishes, beams etc. (16Au)

#### *D. Renaissance and Late Renaissance Architecture*

18th century authors, C. Perrault, documented the understanding of lime in context to composition and methodology of preparation of superior quality of lime. Later, Alberti (De re aedificatoria.), gave further insight to the handling of lime during construction at various stages while; Vitruvius significantly highlighted the slowing of the process of drying in case of use of sea sand. Lime plaster as a source to improve state of masonry houses.

Also, lime plaster was used as an internal wall finish over rough stone, which had better adhering qualities for further decoration.

Furthermore, lime plaster was used as finishing material in internals as it provided great reflectance of light which was greatly admired, hence increased the usage. Later, timber base for walls with lime plaster came into existence depicting the standard of living. (16Au) Lime mortar as a soft mortar helped dealing with the cracks. (<http://researchrepository.napier.ac.uk/>)

**IV. SUSTAINABILITY THROUGH LIME AS A CONSTRUCTION MATERIAL**

Lime has been useful in establishment of buildings which have developed great structures of the above mentioned eras and many more which is fairly visible through the life expectancy of the buildings. Sustainability on the basis of extraction of the resource, and its decomposition back to the nature has been imparted to all the structures from the current era.

Contributing to no harm or minimal exploitation of the natural resources, in comparison to the trending material as in cement, gives better development of building component contributing to the nature and users.

Lime having soft texture is best suited for mortar, Self-healing which overcomes vibrations and develops smaller and more number of cracks in comparison to larger cracks as of cement with big cracks. Flexibility and weatherproofing of lime makes its use vulnerable in many building components from expansion joints to plasters. (Tadamun)

Availability of the material, in natural form and breathing of the material makes the material more vulnerable for use with its existence since ancient periods in mega structures. However, the uses of material in context to the current trends need to be understood and validated for the masses and to provide the details.

**Table 1.**

	Epoch	Wall	Floor	Roof/ Ceiling	Pillars	Other	Structure
<b>A</b>	<b>Ancient era</b>						
1	Indus					Inner lining-oven	Proto houses
2	Egyptian	○				▣ ●	Tomb of Perneb, Great pyramid, City at Cairo
3	Buddhist	■	■		○	□ ●	Chaityagrah at Nagarjunakonda, Bavikonda and Thotlakonda
4	Mycenaean	○	▮	○	○	◇	Palace of Mycenae
<b>B</b>	<b>Medieval era</b>						
1	Indian Temples	■ ●	○	●		●	Vijayanagara period, Hampi Temple-Dravidian
2	Early Christian and Byzantine	■ ●	■ □			●	St. Molaise’s house, Tithe Church
3	Romanesque, Gothic	■ ●	●	●■	■	¥ □	Basilica of St Denis
4	Renaissance and Late Renaissance	■ ●	■	■	■	●	Bergamo, Colleoni Chapel

Table 1 Analysis of ancient and medieval era using lime in structural elements, in the form of visual depiction, as per their below mentioned classification:

- Stone block- ○;
- Slab- ▮;
- Mortar- ●;
- Ramp- ◇;
- Plastering- ■;
- Concrete- □;
- Sculpture- ▣;
- Burial- ●

**V. RESULT**

The usage of lime in architecture started as plastering material to extensive and gigantic use of massive stones. With time, advancement came in knowledge about lime composition, physical appearance, and its benefits over the construction etc. in the form of

mortar, plastering finishes. The usage of lime kept on varying but diversity came into existence with the passage of time. The ancient and medieval eras gave an insight to the use of materials refining with the passing time, exploration of material and their possibilities were looked on.

**VI. CONCLUSION**

The usage of lime as a construction material came into existence with the passing time and was embraced not only in the construction of structural element but also for decorative artifacts, finishes. The knowledge about lime grew with time as per established documentations by various authors from different eras.

This also demarcates the understanding about the material in diverse use of lime such as its deriving process, manufacturing, and handling; playing a significant role in each era. As per the increase in demand and enhancement of the architecture of each era, more structural elements started coming into existence for which quality assurance at central level for the material started happening. The structures of ancient and medieval era still exist with wear and tears, but have retained a glorifying survival history.

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