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Review on Herbs used as Admixture in Lime Mortar used in Ancient Structures

KEYWORDS: Admixtures, Lime mortar, Herbs Strength, Durability

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ABSTRACT *Lime is arguably the world first true green and versatile building material. With the introduction of Portland cement during the nineteenth century the use of lime mortar in new constructions gradually declined, largely due to Portland's ease of use, quick setting and compressive strength. Lime posses' greater qualities such as stickiness, ease of applications, breathability moisture resistance, natural antiseptic, self -healing, durability, low thermal conductivity, incombustible, solar production, harmonious balance. The traditional lime binder offers greater durability but less strong compared to cement. Now-a-days various chemicals are used as admixture to improve the strength and performance of concrete. The cement and chemicals used in modern construction causes environmental pollution and its effect is significant. But a variety of plants and animal products used in traditional lime mortar not only improves the strength but also proves its durability for centuries. This review article helps to identify the various herbs used in traditional construction and its role in modifying the fresh and hardened properties of lime mortar. It also helps to retrieve the traditional concept of additional of admixture to concrete. By shifting ourselves to use such eco-friendly (natural) admixtures in mortar will lead the construction industry towards sustainable development.*

Introduction

Cement forms an integral part of the modern construction industry for past 100 years. Though cement mortar offers early strength, faster construction, it has number of disadvantages such as it is too strong for most of the building, the environmental impacts during its manufacture, energy consumption during manufacture. Also the long term durability and serviceability and behavior under seismic forces is under great question[1].

Traditional structures in India are contemporary of all ages and their synergic aspects can be adopted by the people of all generation since the fundamental nature of construction is always flexible and in tune with the rhythmic spatial forms to suit the taste of every generation. Indian traditional structures built with lime mortar, which are more than 4000 years old like Mohanjedero is still a heritage monument of Indian civilization. It is more appropriate to blend the traditional concept with modern structures.

Traditional Indian structures exist beyond all ages and can be utilized by the people of every generation. Traditional construction concepts will definitely provide inputs to supplement modern construction methods and this will pave a flexible run way by extracting the essence from ancient texts and interpret it to suit modern constructions[2].

Lime is versatile building material used in traditional temples and monuments Lime allows the building to "breathe". Water can escape by evaporation, unlike cement where the only way the water can escape is by being absorbed into the bricks and therefore, risking damp and erosion of the building substrate. Lime is soft and flexible. It allows the building to move without cracking and letting water in (unlike cement) it has been stated "self-healing" because of this ability. Lime also has considerable economic advantages over Portland cement. The cement is relatively expensive to produce and critically for developing countries, often requires expensive imported technologies and fuels. Lime has none of these disadvantages and is normally considerably cheaper to produce, needs much lower or even negligible capital inputs to get started, and requires far less imported technology and equipment. Lime mortar is carbon neutral. Like cement it gives off carbon dioxide during manufacture. Yet, unlike cement, lime mortar actually re-absorbs carbon dioxide when it sets. It has many other benefits, such as:

- Lime mortar is easy to remove from bricks and blocks allowing the reuse of the bricks.
- During manufacture lime produces 20% less carbon dioxide than cement production.
- Lime is essential in the building of any natural house (any house built using straw bales, timber, earth etc).
- Lime is biodegradable and recyclable.
- Lime is burnt at a lower temperature than cement in the production process (900°C as opposed to 1300°C), therefore making lime production not only more environmentally friendly but also more economic as well[3].

Ancient structure

The ancient Egyptians proved themselves highly proficient with Lime. About 6,000 years ago, they used lime to plaster the pyramids at Giza, the Egyptians also incorporated various limes into their religious temples as well as their homes. The Greeks have enabled all of us to witness the beauty and incredible durability of true lime stuccos. Innovative Greek builders used these fine lime plasters in creating the Parthenon and many other classic structures that survive into the present day[4].

Lime was used extensively throughout the Roman Empire. The builders during that time possessed a firm knowledge of lime's many beneficial features, as a mortar and as a decorative finishing material. As the Empire grew, the Romans influenced architecture and structures throughout the civilized world. Consequently, many more people learned to appreciate the benefits of lime and embraced it as a building material.

The Pont du Gard at Nimes in southern France, a Roman aqueduct built in 18AD with hydraulic lime-based mortar, is still water- proof; the excellence of the mortar is attributed to the selection of the materials used as well as to the time spent tamping the mix into place during construction[5].

The Charminar in Hyderabad was the first monument in

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the world constructed using lime mortar and granite. It was only after its construction that the architects throughout the world recognized the strength of lime-mortar in raising huge structures. High workability, water retentivity, plasticity, more adhesive power and a few other qualities seem to have encouraged the qutub shahi kings to make extensive use of lime-mortar in almost all the monuments and palaces built by them. Having a strong belief the plants and animal derivative used as natural admixture in the lime mortar will definitely improve strength and durability of the mortar.

Properties and Characteristics of Lime Mortar
Low mechanical strength due to the low affinity of the calcite and quartz crystal, as well as to the weal linkage among the calcite particle.

- Easy Workability due to the allow process of setting (Carbonation) that depends on the environment conditions
- High capacity of deformation (low modulus of elasticity). It allows the material to absorb small movements of the adjacent material.
- High permeability of water and water vapour.
- Low resistance to freeze and thaw cycles.

Admixtures
Admixture is used to modify the properties of fresh and hardened mortar. There is variety of admixtures broadly classified as chemical and mineral admixture. Admixtures are added in the lime mortar to entrain air, to improve workability, to increase hydrophobic properties and to modify the pore structure etc.

Chemical Admixture
The chemical admixtures are hazardous in nature producing negative impact on environment during its manufacturing process as well as in its life span. In modern days different chemicals such as calcium chloride, synthetic derivatives, Lignosulphonate, Gluconate, Naphthalene etc. are in use to modify the properties of mortar / concrete.

Mineral Admixtures
Mineral admixtures are naturally available which may be inorganic or organic. The inorganic admixture includes flyash, silica fume, rice husk ash, granulated blast furnace slag (GGBS) and metakaolin etc.

Organic Admixtures
Organic admixtures (herbs) are locally available plants and animal derivative which was only used in traditional lime mortar. The information about herbs and its importance in usage in construction industry is little known. Some reports indicate that mortar may contain organic adhesive such as egg white, blood, milk of figs, egg yolk, casein, animal glue, beer vegetable juices, tannin, urine etc. In this article herbs used in construction of ancient building to enhance various properties of mortar is discussed.

Effects of Herbs used as Admixture in Traditional Mortar
The various herbs indentified as admixture across the world is discussed below:

In china, study of typical mortar used in ancient architecture shows that sticky rice is used as admixture. The sticky rice plays a crucial role in the microstructure and consolidation properties of lime mortar. Due to the excellent performance, such as high adhesive strength, good toughness, water-proof and so on, traditional mortar represented by sticky rice mortar should be one of the greatest technological contributions of the day in the world. It was found that the sticky rice acted as a matrix of bio-mineralization which affected the microstructure of the calcium carbonate crystal and there was cooperation between sticky rice and calcite produced during the solidifying of the sticky rice mortar, which maybe lead to the excellent performance of the mortar. Because of excellent performance and importance in science, sticky rice mortar can be regarded as one of the greatest inventions in construction history of China. Relative research of sticky mortar will be of importance for the exploring of ancient momentous invention and the repairing of ancient construction[7].

Shetty[8] has discussed the various natural polymers used in different forms of construction around the world. Polished gelatinous rice paste, viscous liquid obtained from elm shavings in water, pluses, molasses, boiled stems and leaves of banana plants, oils, egg whites cashew nut shell, liquid resin, gluey fluid from cactus plants, natural rubber latex are some of natural proteins and polymers mentioned in the book. Starch and starch derivative have been widely used in lime mortar is described as rheology modifying admixture. This kind of additive is able to fix water in the structure, reducing the amount of free water in the mixture and producing an increase in viscosity. The starch alters slump value, air content, density, water retention capacity, setting time etc. The starch is called as water retaining admixture or viscocity enhancing admixture.

The influence of natural proteins on properties of cement mortar. Natural organic materials were incorporated in building materials in ancient times. The major content in these materials are proteins. Some proteins have been tested in Portland cement mortar as admixture, Air entrainment, adhesiveness and hydrophobic properties introduced to cement mortar by the proteins are measured. It is seen that the proteins worked like an air entraining agents, improved the adhesiveness and hydrophobic property. Air Entraining admixture improve the cohesion of fresh mortar by entraining significant volume of air into the mortar. The air bubbles ct like minute ball bearings and lubricate the mortar making it easier to work. The plasticizing properties of the admixture resulting decreased mix water demand, subsequent reduction in shrinkage and enhanced resistance of the mortar to the destructive effects of exposure to freeze thaw conditions. They also acted as retarders because of complex formation with calcium by cross linking[9].

Chandra[10] has investigated the natural polymers have been used in ancient times to improve the durability of the lime mortars and concrete. The cactus extract (Nopal extract) from Mexico has been tested in Portland cement mortar. Cactus extract increases the plasticity, improves water absorption and freeze salt resistance. Calcium hydroxide produced by Portland cement interacts with the components of cactus extract forms complexes of polycharides of proteins.

The retrofitting of centuries old Vadakkunnathan temple at Thirrsur, Kerala was done using powdered shells, nine different herbs and jaggery. The whole preparation, which took 40 days, required skilled traditional craftsmen which are very few. Keeping in mind the hugeness of the temple, a separate workshop had to be established and labour had to be trained to make the special plaster[11].

Manmadhan Nair[12] discussed about the revonation work carried out at Fort at Vettimurichakotta, Pazhavangadi, East Fort, West Fort, Puthen Street, Sreevaraham and Virakupurakkotta using different composition of the plaster mixture which was discovered from a palm leaf manuscript found in the Padmanabhapuram Palace. An assortment of elements including a variety of herbs and fruits and a particular species of cactus were blended with palm jaggery and left to ferment for 15 days. This concoction was mixed with lime to prepare the plaster. The materials had to be sourced from different places. Some of the rare herbs were available only in the hills. In the first phase of the renovation project, the seven entrances of the as well as the entrance near the Fort Government Hospital were reconstructed.

The various herbs were used in traditional construction. A mixture of lime, mud medicinal herbs for plastering, gums collected from the bark of tress for the base of the floor. The

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mortar used for plastering in ayurveda bhavan is composed of mud and herbal concoction. The mud for the bricks was selected from uncontaminated sites to ensure that it is organic .It was then mixed with various gums and herbs and taken to a kiln to be baked as bricks. Natural dyes made form red clay were used to colour the bricks and natural gum was used to coat them. The medicinal herbs used for preparation construction materials were procured in the tribal belt bordering the Maranallur panchayat, Kerala. The lime mortar makes an incredible plastering material. It heats up during the rains, keeping the occupants warm. During summer, it keeps the house cool. It also endures for centuries. That why lime was used in construction from time immemorial and lime building can breathe just like other living organisms[13].

The different dosages of a commercialized potato starch were added to aerial lime-based mortars in order to check its efficiency as a rheological modifier[14]. Several fresh state properties of the mortars were studied such as consistency, density, air content, water retention capacity, setting time and evolution when applied on support. The effect of the starch on ζ-potential of the lime particle surface as well as the particle size distribution and viscosity changes in lime pastes were also assessed in order to elucidate the action mechanism of the polymer. The behaviour of this starch polymer was found to be strongly dosage-dependent: it acted as a thickener when the incorporated dosage was up to 0.30% of lime weight; conversely, above that dosage, it behaved as a plasticizer. The thickening effect took place because polymer molecules were adsorbed onto lime particles acting as a flocculant, as confirmed by zeta-potential and particle size distribution results. For large amounts of polymer, steric hindrance and electrostatic repulsive forces appeared, leading to a dispersion mechanism which explained the plasticizing effect as well as the fresh mortar behaviour.

Chandra [15] has used Black gram has used as binder in mortar and plaster in ancient time in India, was mixed in cement mortar, structural light weight aggregate concrete and normal concrete. Air entrainment, adhesiveness and hydrophobic properties it imparted to cement mortar and concretes were tested. It is seen that it worked like air entraining agent, has improved the adhesiveness and hydrophobicity of cement mortar and concrete. Addition of oil along with black gram worked as a defoaming agent and has substantially improved the hydrophobic property of lime mortar and concrete. The herbs which impart hydrophobic property are water repellent admixture or permeability or water proofers. They may produce a hydrophobic lining in the pores of the cement matrix thereby reducing capillary forces and reducing the rate of passage of water through the hardened mortar or acts as filling and blocking the pores of the Lime matrix.

The individual and combined effect of latex (rubber milk) and superplasticiser on Portland cement mortar in the fresh state were studied by Indrajit Ray. et.al[16]. The compatibility of five commercial superplasticisers with four latexes of the vinyl polymer group and SBR latex in varying dosages was studied with respect to setting time, consistency of fresh cement pastes, subjective workability (surface texture, segregation), bleeding, air content, water reduction capacity and the flow-time relationship of fresh mortar. It has been observed that superplasticisers of melamine formaldehyde and a blend of melamine and naphthalene formaldehyde eliminated shortcomings like delayed setting, high air entrainment in the fresh latex-modified system whereas lignosulphonate and a blend of lignosulphonate and naphthalene formaldehyde aggravated it.

Just 55 seconds in duration, it left 1000 people dead. The earth quake, measuring 6.1 on the richer scale , which devastated the hills of Uttarkasi, Tehri Garhwal and Chamoli districts in UP last October, also left 20 percent of the houses in the region totally destroyed or severely damaged. Old temples in the area provide valuable clues to the building methodology of the past. For instance, the Vishwanath temple, a local attraction, has a conical dome built on wooden planks piled one above the other in hexagonal fashion. While the modern structures in the temples complex are collapsed, the temple itself as survived with only superficial cracks on its walls. According to the temple's mahant. The secret lies in the mishala (mortar) used in the structure. A lime mortar was prepared without any mud and ten mixed wit a paste of jaggery and pulses. But the high costs and the erosion of traditional skills are rendered such technology obsolete[17].

One of the best structure, in Lahore fort belongs to Jahangir's period. In this lime plaster, Lime prepared by burning kankar which is a type of clay, glue, gum preferable of babbool or neem, shell lime, sand jaggery water were used. 36 liters of his paste is mixed with whites of ten eggs, 225 g. of ghee and sour curd in soap stone are additionally used[18].

In Indo – Muslim Architecture, Jharoka[19] has investigated and identified mortar is the mixture of gypsum or baked lime, sand and ash. The following admixtures which are listed in Table 1 are used to modify the properties of lime mortar.

Table 1. Mineral admixture and its purpose used in Indo – Muslim architecture

Herbs	Purpose
Curd	Soft finishing
Dal urd	Plastersizer
Jute fiber	Better bonding
Gum from plants	Retarder
Raw Sugar	Bonding agent
Straw	Reducing cracks
Glue	Increase bond strength
Jaggery sugar	Hardening

Summary of Literature

- Similar to chemical admixture in modern construction, herbal admixture had been added in traditional construction. The herbs were used in lime mortar is subjected to its local availability.
- By exploring the traditional knowledge of herbs used in concrete, we can blend the traditional concept with modern structures. Traditional construction concepts will definitely provide inputs to supplement modern construction methods and this will pave a flexible run way by extracting the essence from ancient texts.
- From the various studies conducted on ancient structures it is evident that organic proteins and carbohydrates are used in concrete to enhance the fresh and hardened properties of concrete.
- The sticky rice paste, potato starch, black gram and other pulses, rubber milk (latex) viscous liquid obtained from elm shavings in water, pluses, molasses, boiled stems and leaves of banana plants, oils, egg whites cashew nut shell, liquid resin, gluey fluid from cactus plants and powdered shells were some of the natural material used in the traditional construction .
- In India different plant extract has been used as admixture whose role in lime mortar is not known. The buildings in ancient times are constructed not to with stand the external forces but also well being of inhabitants. The ingredients used in plaster and mortars makes the environment healthy because the building itself breathe like an organism.

Conclusion

The lack of traditional knowledge and skills has made eco-friendly construction techniques and practice obsolete. The indigenous knowledge of various plants and animal derivative used in construction industry must be retrieved and its

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role in enhancement of properties of concrete has to be studied in detail. If traditional admixtures are used in concrete; the environmental negative impact of use of chemical admixture can be eliminated.

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