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THE LIME COMPOSITIONS FOR TRADITIONAL BUILDING RESTORATION AND DECORATING

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ABSTRACT

Lime has been used as a very versatile binding material for construction all throughout Pakistan since ancient times. Traditional Peshawar structures made of and with lime have withstood natural disasters and continual weathering for more than a millennium or two, demonstrating the longevity and tenacity of the material. The old-fashioned processes of employing them in building construction and decoration, such as stucco work and fresco painting, have a variety of variations based on locally available materials, climatic conditions, and local cultural traditions. It is a readily available substance in Peshawar that may be used to restore and preserve architectural pieces that have been worn over time. The authors have attempted to describe some of the architectural and decorative aspects of lime, as well as the causes of their degradation in many historical buildings in Peshawar, as well as advice for conservation, preservation, and restoration of these major structures.

INTRODUCTION

Lime has been one of the most versatile bonding materials in the construction of structures for over 12,000 years (Kingary 1988:219). The old buildings of Peshawar, which were constructed in lime have endured calamities and lasted for more than a millennium, are tangible testament of the lime's durability and resilience.

Lime is used in masonry walls, protective plaster layers, and artistic works such as stucco plaster, profile plaster, fresco paint, and finishing in old Peshawar structures for both construction and non-construction uses. Different criteria were necessary depending on the kind of usage. Building lime, for example, has historically been made by burning calcium carbonate at 950°C (Sabbioni 2002:83), with the raw ingredients being limestone, marl, *kankar* lime, seashells, and chalk (Sabbioni 2002:83). Historically, limestone was calcined in kilns or wheel clamp kilns, locally known as *chune ka bhatta,* from stone and brick with a variety of additives. These stoves are consistently heated and alternately stacked with lime stones and coal. Crushed limestone pieces are ready to use after being baked, chilled, and scraped. The dirt, referred to as fly ash, is ignored. In tight air bags, the lime is next ground to a fine powder.

Lime Mortars Ingredients and Preparation

The most common components used to make lime mortar are matured lime putty and various blending agents. The kind of mixing material used in the formulation of lime mortar is determined by the functional needs, physical qualities, colour, and texture of the lime mortar. For example, lime mortar for ancient constructions has its own unique process and preparation requirements; the mortar was developed from its usage. The lime mortar components' grinding and mixing methods were meticulous and scientifically devoted to assure the mortar's correct consistency and desired serviceability. In India, a stone grinder is used to grind the components of lime mortar and obtain a fine viscosity for the finishing of cement, stucco, and decorative plaster coatings. Repairing lime mortar using a lime mill (*chakki*), which consists of a channel under the ground and a stone wheel that spins the lime components over the canal to compress and combine with sand, is the most common preparation for these old traditional buildings.

According to craftsmen who still work with lime in Peshawar, they take clay from ponds, process it in kilns, and then grind it into powder form with lime on a stone knob. This is an old custom of extracting and boiling pond clay with lime mortar, but it is no longer practised and has been superseded by the use of brick powder.

Currently, the lime mill (*chakki*) is being used for a few days to make lime mortar for use in all sorts of construction, which results in a much more uniformed product. Researchers should look at the classification of lime mortars and the characteristics of these mortars in order to determine past environmental consequences and the climate response of structures. Using organic lime mortar additives in old Peshawar structures has been a long-standing practise, with the kind of organic lime mortar addition used according to the local climatic circumstances and practical lime mortar needs.

Different kinds of organic blending agents are often mixed in order to improve practical qualities for a specific goal, such as shortening the time required for setting, giving long-lasting intensity, and making the product more useful, among other things. There is currently no production plant, and most construction industry professionals are unsure of the specific location of lime mortar. This art is only known by those who work with it, such as masons and craftsmen, who are required to deal with it in traditional structures. The way they work, as well as the measures in which they are to be mixed, varies by location. In certain places of Pakistan, these practises have been modified to make them more suitable for artisans, to allow them to follow new trends and to hone their talents. In order to research and evaluate the old structures of Peshawar, it is essential to have a comprehensive grasp of conventional procedures and methods.

Some of the most popular organic components used for plastering surfaces that often include organic elements are jute fibres, beans and grammes, milk products, fruit pulp, jaggery (*gur*), aloe vera, and seeds. Jute aids in the reduction of shrinkage produced by the carbonation process and gives the lime flexibility. Before the lime mortar is squeezed, combined, and thrown, 25 to 100 mm of unpolluted fibres are incorporated with it. Because jute has never been mixed previously, it tends to become brittle when immersed in water for a long time with non-slaked lime. Split black gramme is the most commonly used in lime mixes and coatings (*Urad dal*). It generates a highly sticky fixative when mixed with water, which improves the serviceability of lime putty, especially for decorative plaster. The gramme is packed into a powder phase, then soaked with water the night before its action, and the lime travels by.

Lime as Decorative Ingredient in Historical Buildings of Peshawar

Peshawar, in the province of Khyber Pakhtunkhwa, is one of the oldest commercial and trade centres in South and West Asia (Gazetteer of the Peshawar District, 1897-98, p. 1; Dani, 1995, p. 15; Nadiem, 2007, p. 10; Gill, 1986, p. 250). It is positioned on a key thoroughfare that connects Central Asia and India. In the Achaemenian Literary Records, the Northwest Frontier of India is referenced (Durrani & Taj, 1997, p. 185). Peshawar lies around 12 kilometres east of the Khyber Pass. It's located between 3°55’ and 34° 05’ degrees north latitude and 71°20’ degrees east longitude (Gazetteer of the Peshawar District, 1897-98, p. 1; Dani, 1995, p. 15; Nadiem, 2007, p. 10). It's the main route between India and Afghanistan in the north. For decades, the pass has served as a vital link for travellers, traders, priests, tourists, pilgrims, and Central Asian explorers. It is strategically, militarily, and historically significant as it is the entrance to India's vast and diverse subcontinent. Residential zones, industrial hubs, and religious and civic centres in Peshawar have all been under significant pressure from socio-cultural, traditional, and religious elements.

A comprehensive investigation leads to a knowledge of the settlement created in order to comprehend the region's urban fabric, which contains several factors that have a significant influence on the area's socio-cultural, religious, and political forces, as well as how these aspects interact. Every country's local tradition and culture are shaped by many former civilizations and royal empires, all of which leave their imprint and contribute to the development of their own culture in some manner.

During the 8th century, lime plaster was widely employed to coat the walls of temples and castles, much as it was in Buddhist art and architecture, and even in pre-Islamic Iran and Iraq. Muslim masons and crafts people incorporated Iran's techniques and designs into early Muslim construction. By the 11th century, embellishment of stucco work on wall surfaces had become quite popular in the Near East (Hill, 1964, p. 74).

Lime as a Finishing Material

For almost 2000 years, lime has been utilised in the building industry in the form of mortar, inner and outer plaster, walls, floors, wall infill, water duct housing, hybrids, and ornamental applications (Elsen J. B., 2004, p. 289ff). Lime wash, which is effectively a solvent thinning of calcium hydroxide compounds, has been employed on the external walls of old structures. The lime plaster, like the lime wash, is a porous substance that allows moisture to enter thick masonry walls and circulate through the air again, enabling old dwellings to breathe. According to research conducted on old structures in Peshawar, lime wash is a long-lasting substance.

Quick turnaround is required to increase serviceability. Lime is cleaned and combined with organic components after being submerged in hot water. The most common organic component for lime washing is plant-based glue, which is being phased out in favour of chemical adhesives. Dry organic glue is soaked in water overnight and then cleansed the following day to eliminate fibres before being blended with lime wash to increase sticky strength. Lime wash is prepared from non-hydraulic lime putty that has been processed and unpolluted water that has been diluted to get the desired thickness or thinness of the cream for enhanced consistency. The lime putty cracks the water mixture during preparation. Freshly produced lime wash must be let out for a day to soak up the lime. To guarantee a full thinning out, the remedy is rigorously whipped.

Stucco Work (Munabat-Kari) as Decoration Material

In the old structures of Peshawar lime, which are often used for decorating reasons and termed "stucco work," the technique of repairing the plaster and its manner of application is particularly unique (*munabat-kari*). Quick lime has been steeped in water for over two years in a precise setting; the yoghurt and lime combination are used for sanitization and mineral removal throughout the soaking phase. Ceramic items include water and lime, which may be found in dimly lit areas. Lime is added to different coatings for decorating. For each coat application, new specifications and processes have been included (Encyclopaedia Britannica IX, p. 623). The bottom layer is *kada* plaster, which is made out of local lime, sand, and a tiny amount of marble scrap to make pure white paint for finishing work and decorating.

Continuous thin plaster coatings are known as *jhinki*, and they are made by mixing lime plaster with *jhinki* powder, among other additions, and processing it into a rough paste that is placed over the previous layers of lime plaster using proper equipment.

Prior to the turn of the twentieth century, lime was often utilised as a binding agent in the lime mortars of these ancient structures. Lime is a very adaptable frame and finishing material. Lime's physical quality is that it is porous, allowing structures to "breathe" and allowing moisture to escape. Historic structures were constructed with lime mortar filled and bonded with wood-framed brick, allowing the former material to deteriorate.

The relative high absorption of lime permits the structure of old structures to moisturise, absorb moisture or water, and then release it as vapour, making the hot, dry environment pleasant and hospitable for the residents. It has an elastic consistency that protects walls and foundations from seasonal fluctuations while also increasing compressive strength due to moisture; it also keeps multi-story structures safe against high earthquake voltage.

Fresco Painting

1. The phrase "fresh" derives from the Italian language. According to most experts, there are two types of fresco paintings: buona fresca and secco fresco. The two types of frescoes use quite different methods. As shown in the picture below, the bono frescoes are painted on wet plaster, while the secco frescoes are painted on dried plaster (Eliane 2009:115).
2. Painters use the bono technique to create the desired look by painting on wet lime mortar or plaster with colour that has been mixed with water. This method eliminates the need for additional plaster since the pigment, when mixed with water, forms a connection with the wall.
3. Powder colours were combined with water and then applied straight to a damp lime plaster layer by painters. As with this approach, the colour binds with the damp line plaster, making it permanently water resistant and lasting for a long period.
4. Secco painting, on the other hand, is done on dried pigment, and as a consequence, the painting's longevity is not in your favour. To keep the colours together in a secco painting, you'll need a medium. The frescoes will be preserved for a long time. On the other hand, an artist who wants to leave a lasting mark of his or her work on the walls of a structure would choose this kind of fresco painting. The secco paintings have a shorter lifespan than the bono frescoes. They were mostly used to give the final touches to a work of art or to correct any imperfections that could have been obvious in the original bono fresco.
5. This is an old procedure that was used in ancient times on the rocks and caves of Ajanta Cave and is being used now. Later, the Ajanta frescoes' style and techniques spread to the east and west, including Afghanistan, Iran, Central Asia, China, and Japan, among other locations. Throughout the western and European countries, many antique frescoes from the ancient Greek and Roman eras have been uncovered in palaces and temples (Allen 1988:17). The style of fresco painting is best suited to warm regions. The usual colours used in fresco painting are white, black, red oxide, yellowish oxide, and green. However, additional colours may be employed. Red (derived from iron oxide), yellow (derived from iron oxide), white from lime (made from lime), and black colour (created from suits of light bulbs) were among the natural mineral pigments used to generate the colours. An example of utilization of such pigments can be seen in a Sethi *haveli* (fig.1) The colour black is often used to create contours or a deeper tone for hair,

eyes, and the outlines of objects and people. The green hue comes from Mallachite stone, Teraverta soil, Vernacular compost, which offers a brilliant green, green shade, and Terdigris soil, which is primarily used to give green shadow and is also known as *Zangal* in Persian and was initially employed in Indian art in the 15th century. It's also found in paper, and it's become more popular in recent years.

6. Throughout Pakistan's history, frescoes have been painted in temples, mosques, palaces, and private dwellings. In Peshawar, the fresco may be seen in Mughals (religious/ mosques and secular), Sikh, and British constructions.

Exterior Facades

Lime also serves as a stucco mortar, enhancing the building's appearance. The consistency of the lime, such as at Gor Khatri, Peshawar, makes the surfaces translucent and appealing to the eye (Fig.2). The delicately creative and beautifully painted frescoes are one of the most stunning decorative parts of old structures. The front façade featured the most elaborate wood carving, while the side and north walls had a lot of stucco and fresco paintings in the courtyard around the walls that were used to embellish the walls. The religious, cultural, and social values of the population, as well as their enhanced economic standing, are reflected in paintings on the exterior and interior of ancient buildings. The Mahabat Khan Mosque is richly adorned with stucco work that was created in moulds rather than being stamped (Fig.3).

Interiors of The Historic Buildings

The Roose Keppel hall, the Islamia College of Peshawar (Fig.4), the niche cluster (*chini khana*), and the mirror mosaic were all made by placing mirror-cut forms over wet lime and painting the ceilings with lime stucco plaster (Fig.5).

Lime Mortar Deterioration

Lime mortar degradation is defined as a stage in the deterioration of mortar materials that begins to display symptoms at some point. They'll almost certainly be definitive (Lubelli, 2014:103). Damage is defined as a time of degradation as well as a drop in the architectural function's quality. The method focuses on architectural elements that cause degradation, such as biological, physio-chemical, electrical, and mechanical components. This decay might be ornamental or architectural in nature. All architectural materials, according to Price (1975:350), are prone to degradation within their own timescale, depending on the material's endurance.

The degradation of mortars and inorganic building materials is influenced by a number of circumstances. Moisture, air quality, soluble salts, and biological activity are the most significant factors affecting building materials.

Moisture

Moisture is the most important factor in the building's deterioration. If there was no moisture, the construction material would not deteriorate at all, except to a very minor degree. Mortar degradation is mostly caused by its porous nature, with three primary sources of moisture in philtres (Camuffo 1995:1).

i. Condensation of water vapour
ii. The emergence of the capillaries
iii. Precipitation

Condensation is influenced by the temperature of the mortar surface, whereas capillary activity is the most common method of entering moisture and causing surface tension. Rainfall is one of the system's vertical faces in the form of water, and it is dependent on meteorological and material circumstances (Amoroso 1983:20). The weathering of dissolved acid gases on the outside serves an intermediary function as a result of rain.

Air Pollution

Although this is not a contemporary concern, Brimblecombe (1991:51) found that air pollution has harmed buildings since antiquity. Sulphur oxide and nitrogen oxide are two common contaminants that dissolve in water and destroy limestone components. Lime mortar oxidation is more likely to occur when fossil fuels such as coal or oil burn with a high level of sulphur dioxide or when water deterioration occurs as a result of human activities (Bernal, 2004, p. 51ff).

Soluble Salt

The formation of salt crystals in the porous lime mortar would increase the pressure necessary to overcome the lime mortar's tensile resilience and make it brittle enough to produce powder. Salts may come in a variety of ways. Wind from the sea can blow, and soil water can permeate masonry, resulting in air pollution (Price, 1975, p. 350f).

Biological Colonisation

As compared to the oxidation reasons discussed above, the microorganism degradation process is quite sluggish (Guilia et al. 2004: 227ff). Environmental effects, as well as the physical and chemical features of mortars, are concerned with various forms of material colonisation, the development of cyanobacteria, mushrooms, lichens, mosses, or big plants (Krumbein et. al. 1993:589ff).
At the same time, the causes of the above-mentioned degradation are mostly focused on its upkeep, as well as the lifetime of historic architecture and accompanying buildings. Building modifications on a daily basis extend the life of the structures and minimise the need for maintenance programmes.

Values and Authenticity

When conserving a historic structure, there are a few rules to observe. A monument's "authenticity" is often touted as a factor in its value. There is a common conviction that the "authenticity" of architectural heritage should be understood and preserved to the greatest degree possible. Even after ICOMOS published the Nara paper (NARA Document 1994) on authenticity in 1994, the definition of "authenticity" is still debated.

The term refers to the understanding of heritage values, or the reasons why we would consider a building or object to be part of our history rather than simply another artefact. The term "authenticity" was described in the Nara text as a multi-layered (or complicated) set of values that may be divided into many categories:

Other internal and external aspects include shape and design, materials and substance, usage and function, traditions and methods, craftsmanship, place and context, spirit and sentiment, and other internal and external factors. Each of the variables may be handled using a number of conventional ways, which, apart from "social," are the most common "modern" approaches to architectural historical values:

The role of aesthetic, historic, social, and scientific factors

The figure 1 below displays the many pieces and dimensions that make up a table.

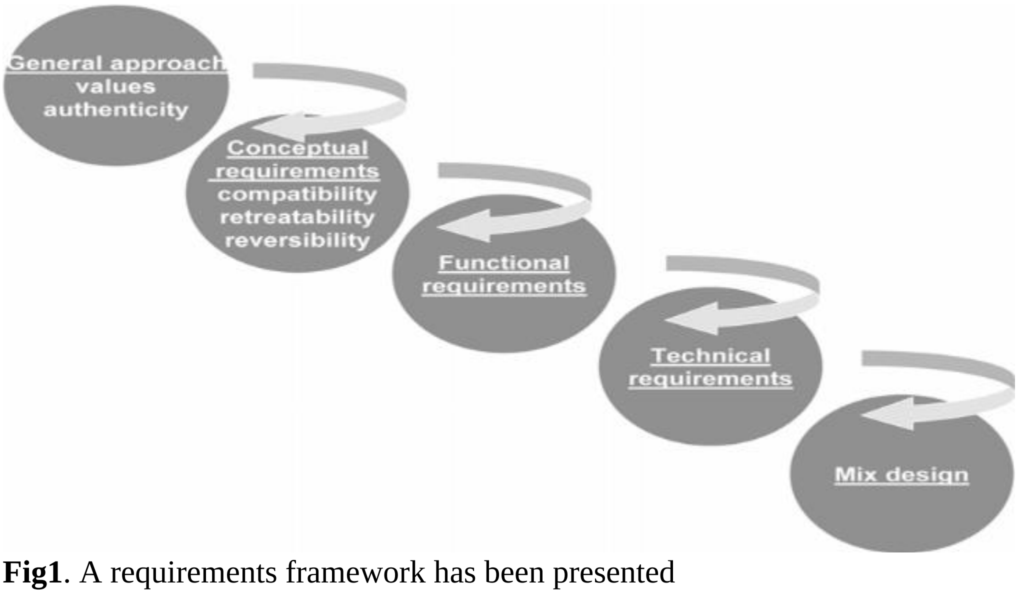

Fig1. A requirements framework has been presented

Figure 2 may be used as a checklist to help the user identify the many viewpoints on heritage values.

To correctly detect and repair mortar, one must consider the characteristics described above, as well as acknowledge the inter-disciplinary technique of heritage conservation analysis, in order to make additional development and documentation about how those variables and features may be understood (Van Balen 2001:75).

ASPECTS/DIMENSIONS	Artistic	Historic	Social	Scientific
Form and design				
Materials and substance				
Use and function				
Tradition, techniques and workmanship				
Location and setting				

Figure 2: Based on the Nara Document 1994, a schematic depiction has been created.

Requirements Based on Concepts

It has been widely accepted for many years that interventions in ancient structures should be reversible (Venice Charter 1994), but this is not always the case. The compatibility between the new repair material and the old structure is one of the most significant aspects that should guide the design of the repair mortar for any intervention in a historical building.

The idea of "retreatability / repairability" that contains the compatibility concept should thus be used as further guideline in conservation measures, bearing in mind the previously mentioned principles. It was in 1997 when scientists at the Dahlem seminars in Berlin proposed those ideas to overcome the absence of "reversible" conservation procedures (Teutonico 1997:293). "Retreatability/Reparability" should be utilised as a further guideline in conservation efforts, taking in mind the prior concepts. In 1997, scientists at the Dahlem seminars in Berlin suggested those concepts to overcome the lack of "reversible" conservation processes, which had previously been established.

Thus, it is necessary to specify repair mortars' features and their surroundings, as they find the appropriate design parameters for further functional and technical needs. Longevity, durability, and resistance to deterioration is also an idea that has a significant impact on the economy.

Repair mortars must be able to withstand corrosion and other harsh conditions. Because traditional materials applied as adhesives generate feeble mortars with a slow hardening rate, they may not be able to fulfil today's construction constraints.

The study of historical mortars has indicated that local materials were chosen in building that needed less energy to make or supply, even if sustainability was unknown in ancient culture. We only employed advanced materials that required more power where absolutely necessary (Van Balen 2005:781). Other methods used by ancient masons included adding fibres or other additions or combining materials to increase the strength of their bricks and mortar.

The current proposal to utilise as much locally sourced or low-energy materials as feasible is in reality an idea that has been used in the past.

New repair mortar and old substrate must be in harmony in order for this approach to be used (see Fig. 6: example of unsuccessful aesthetic harmonisation).

In addition to the materials, methods, workmanship, and historical context that have been discussed above, this is a multifaceted issue. While this criterion is generally left to the architect, it is sometimes disputed by a broader audience as well (local community and society).

Technical Requirements

Values/Authenticity, Concepts, and Functional criteria must be improved and turned into technical requirements that serve to define the design of mortars from a practical standpoint. Material qualities and performance are the focus of these new repair mortar standards. The final bullet point in the functional criteria seems to be overlapping with this.

There is a difficulty with how to utilise all of this knowledge in developing a repair mortar that meets both conceptual and functional needs once the technical investigation has been completed. In addition, the technical specifications for a repair mortar should be based on current understanding of contemporary mortar behaviour (science and technology) (e.g. lime-based mortars including lime-pozzolan, hydraulic lime, lime-crushed brick). How long does it take various lime-based mortar types (Schäfer 1993:605) or their long-term deformations (Binda 1991:1058; Binda 1999:382), for example, or their porosity development over time (Papayianni 2001:457), for example, or their rate of strength development (Ibid).

Repair mortars can only be used if the old and new materials are technically compatible, and this is a fundamental belief. The following are the most critical technological features for ensuring that new and old mortar are compatible:

1. Colour, texture, and finishing of the surface
2. Composition (binder, aggregate and grain size uniformity)
3. Compression, Tensile and Bond Strength
4. Elasticity (elasticity modulus, durability)
5. Porosity characteristics (overall and specific porosity).
6. Gravity, the distribution of pore size, and the absorption of water by vapor transfer and total porosity
7. Temperature expansion factor

I. *Surface characteristics / Harmony (colour, texture, roughness, technique of finishing)*

The properties of mortars may be seen with the naked eye or microscopic investigation can be used to determine them.

II. The kind of binders, type of aggregates, and grain size distribution of the mixture

Local raw materials (binders and aggregates) should be investigated as well. Local natural mortars might be utilised after grinding, or local sand could be washed and utilised (if there is a risk that it might contain salts).

State of Conservation in Peshawar Historical Buildings

The Department of Archaeology and Museums is the chief custodian of Peshawar's built heritage and operates under the KP Antiquities Act 2016. The Act (2016:1) begins with the following expression:

"Khyber Pakhtunkhwa Province to protect, safeguard, expand and preserve antiquities."

In 2017, the authors of this paper carried out a field study in which 71 major buildings in Peshawar were studied. Some of these structures are in a good condition, and others will disappear in a matter of years if they are not restored and reconstructed.

The preservation and conservation work of the Archaeology Department was limited to a small number of significant historical monuments and ancient sites due to lack of resources and staff shortages. The Department is usually operated by geological conservators and archaeological engineers. The Department lacks architects and structural engineers who could be interested in the renovation of buildings.

REFERENCE

Allen, T. (1988). *Five Essays on Islamic Art.* CA, Sebastopol: Solipsist Press.

Amoroso, G. F. (1983). *Stone Decay and Conservation.* Amsterdam: Elsevier.

Authenticity, N. D. (1994). Nara Conference on Authenticity in Relation to the World Heritage Convention. Nara, Japan.

Bernal, J. L. (2004). The Effect of Relative Humidity and Foreign Matter on the Reaction between Sulphur Dioxide and Calcium Carbonate. . *10th International Congress on Deterioration and Conservation of Stone.*, (pp. 51- 58.). Stockholm, Sweden, .

Binda, L. A. ((1991)). An analysis of the time dependent behaviour of masonry walls',. *Proceedings 9th Int. Brick/Block Masonry Conf. 2 (DGFM)* , (pp. 1058-1067.). Berlin .

Binda, L. T. (1999). 'Mechanical behaviour at different ages of masonry prisms with thick mortar joints reproducing a Bizantine masonry', . *8th NAMC (North American Masonry Conf.)* , (pp. 382-392.). Austin, USA .

Brimblecombe, P. (1988.). *Air pollution Ð historical trends. In: Air Pollution and Conservation.* . Amsterdam,: Elsevier, .

Brimblecombe, P. (1989). History of air pollution and damage to the cultural heritage of European cities. In C. S. N. S. Baer (Ed.), *the European Symposium*, (pp. 51–66.). Bologna, Italy: Butterworth-Heinemann Oxford.

Camuffo, D. (1995). Science of the Total Environment. . *167*(1), 1-14.

Dani, A. H. (1995). Peshawar Historic City of the Frontier. Lahore: Sange-Meel Publications.

Durrani, F., & Taj, A. I. (1997). Excavation at Gor Khuttree A Preliminary Note. *Āthāriyyāt (Archaeology), 1*, 185-212.

Eliane A., D. L. (2009). Study of mural paintings by Fulvio Pennacchi in São Paulo City by mineralogical techniques. *Annals of the Brazilian Academy of Sciences, 8*(1), 115-126.

Elsen, J. B. (2004). Microscopical Study of Ancient Mortars from Tournai (Belgium). *Material Characterisation, 53*, 289-295.

Elsen, J. B. (2004). Microscopical Study of Ancient Mortars from Tournai (Belgium). ,. *Material Characterisation, 53*, 289-295.

Encyclopedia Brtannica IX. (n.d.). 623-4. (Micropedia).

Gazetteer of the Peshawar District. (1897-98). Lahore: Sang-e-Meel Publications.

Gill, B. G. (1986). Peshawar and Trans-Frontier Trade under the British: An Analytic Account. *Punjab History Conference, 20*, pp. 250-254.

Giulia, C. D. (2004). Stone Cavity and Porosity as a Limiting Factor for Biological Colonisation: The travertine of Lungotevere. *10th International Congress on Deterioration and conservation of Stone.* , (pp. 227-232.). Stockholm, Sweden,.

Hill, D. a. (1964). *Islamic architecture and its decoration, A.D. 800–1500. 88 pp.,.* London: Faber and Faber. doi: https://doi.org/10.1017/S0041977X00059097

IX., E. B. (n.d.).

K. Van Balen, I. P. (2005). Introduction to requirements for and functions and properties of repair mortars. *Materials and Structures, 38*, 781-785.

Kingary, W. D. (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.

Lubelli B, v. H. (2014). Salt crystallization dam-age: how realistic are existing ageing tests? In van Breugel K, . *Proceedings of the international conference on ageing of materials and structures* (pp. 103–111). Delft: Koenders EAB.

Nadiem, I. (2007). Peshawr: Heritage, History, Monuments. Lahore: Sang-e-Meel.

Papayianni, I. a. (2001). 'The evolution of porosity in lime-based mortars', ,. *Proc. 8th Euroseminar on Microscopy Applied to Building Materials*, (pp. 451-497). Athens.

Price, C. (1975). Stone Decay and Preservation, Chemistry in Britain, . *11*, 350-353.

Sabbioni, C. B. (2002). Damage on Hydraulic Mortars. *the Venice Arsenal. Culture Heritage,, 3*, 83-88.

Schäfer, J. a. (1993). *Ancient and new lime mortars-The correlation between their composition, structure andproperties'in Conservation of stone and other Materials.* RILEM/UNESCO Congr.

Teutonico, J. C. (1997). *Group Report 'How Can We Ensure the Responsible and Effective Use of Treatments (Cleaning,Consolidation, Protection)?', Dahlem Workshop on Saving Our Architectural Heritage: Conservation of Historic Stone Structures.* Dahlem: Baer, N.S. and Snethlage, R.

Van Balen, K. H. (2001). Mortar characterisation, from values to compatibility, in Maintenance of Pointing in Historic Buildings: Decay and Maintenance of Pointing in Historic Buildings:. *Decay and Replacement, Final Report, EC Environment Programme, contract ENV4-CT98-706, unpublished,,* 75-84.

Venice Charter. (1994). International Charter for the Conservation and Restoration of Monuments and Sites (Web site:. Retrieved from http://www.icomos.org/docs/venice charter.html

Plates

Plate.1. Intricate fresco paint bouquet design panels in the courtyard of Ahmed Gul Sethi *haveli*

Plate.2. Stucco work *(Munabat-kari)* on western gate of Gor Khatri, Peshawar

Plate.3. The Congregational Mahabat Khan Mosque, Peshawar

Plate.4. Stucco work (*manabat kari*) at Roose Keppel Hall, Islamia College Peshawar

Plate. 5. Chini-khana ornamented with mirror and glass mosaic immersed in lime putty at Ahmed Gul Sethi haveli, Peshawar

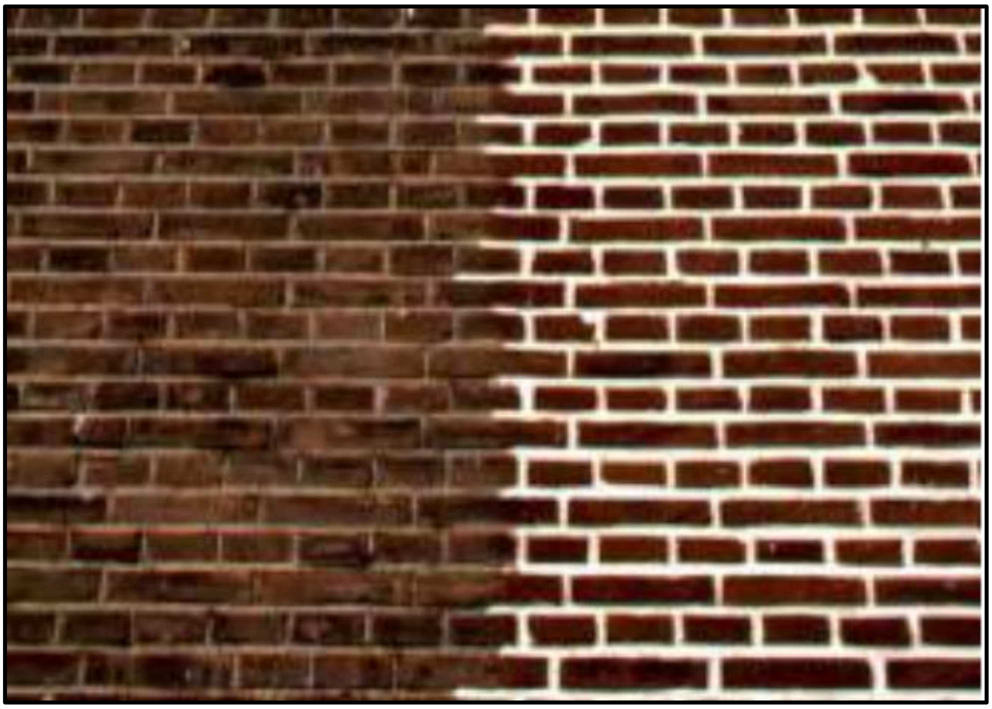

Plate. 6 - Unsuccessful aesthetic harmonisation.