Comparative Analysis between Lime and Cement Mortar in Traditional Buildings

Report By:
Savani Heritage Conservation pvt. ltd,
(Member: Ram Savani, INTACH Mumbai Chapter)

Prepared by
Ms. Sravani Naraparaju
M-Arch: Heritage Conservation, University of Sydney, Australia

Ms. Nishigandha Karpe
MSc: Sustainable Building Conservation, Cardiff University, UK.
OLD MUNICIPAL OFFICE BUILDING –

LOCATION:

Beach Rd, Chengal Rao Peta, Port Area, Visakhapatnam, Andhra Pradesh 530001

ACCESS POINTS:

Old Municipal Office in the same compound as the Town Hall. The building can be accessed through the Beach Road and is looking into Visakha Fishing port.

HISTORY:

The old municipal office building is built in the late 1930’s, and boasts off its modern structure which is a curious mix of both modern and colonial architectural styles. The structure is typically characterized with the European Arch, flat cantilevers occupying in equal space and a majestic dome.
over the central staircase. The structure sits in a site of area of 1.7 acres and is made entirely out of cut stone. The GVMC is also one of the first buildings to have a self-supporting steel and concrete enforced roof.

The building has a modern architectural approach in its typically functional and open floor plans both in the ground and upper floors. The building houses six big halls with annexure rooms and spacious open verandahs leading to a central staircase. The roof of the building is steel framed R.C.C in-built with a self-supporting arch enabling it to dip from one perpendicular steel beam to another.

**ARCHITECTURAL AND MATERIAL DETAILS OF THE SITE:**

The Old municipal office is designed on a horizontal axis along two corridors. Rooms are placed on either side of these pathways with central staircase connecting both the axis. One can enter the building either through the central foyer or through a narrow passage in the rear side of the building leading up to the second corridor. All the rooms are opened to either of the one corridor making the building aligned in axial co-ordination.

The exterior of the building is constructed with coarsely finished stone. The stone walls are brought together with lime mortar giving the building its historical grandeur. The rooms are constructed of either random rubble or brick masonry. The wall is finished with a layer of lime mortar. It is interesting to note that the rooms are very wide and the height of the rooms are also around 4.5m, giving each room a spatial dimension. The upper floor can be accessed by an open-well staircase which can be accessed from two points leading to either sides of the central atrium. The central atrium is covered by a semi-circular dome which became the interesting aspect of the structure.
**INTRODUCTION OF LIME MORTAR—**

Lime mortars have been used in the construction of buildings for thousands of years and continue to be used for the repair and maintenance of traditional buildings. Extensive research is done in India and around the globe to understand the materials and chemical composition of lime. It is interesting to note that lime was processed in different ways with different binders and organic additives and applications at different parts of the country. This paper looks into tentative historical evidence of the use of lime mortar in Indian subcontinent. It also lays out the carbonation of lime plaster with case studies of lime plaster being used on various monuments across the country and analysis of the use of lime plaster vs that of the cement plaster.

**HISTORICAL SIGNIFICANCE OF LIME MORTAR —**

Lime was used on occasions in the early period, as evidenced from the deposits of lime plaster lining the ovens and cylindrical pits found within the houses of the site of Kalibangan, Rajasthan (Source: Indira Gandhi National Centre for the arts, IGNCA 2009). These structures dates to the proto-Harappan period, 3500-2500 BC (IGNCA 2009). The use of lime is seen and extensively studied within the structures at the Buddhist settlement of Nagarjuna-Konda, the capital of Ikshvaku dynasty (225-325AD) (Ghosh 1990). Lime plaster is thought to be more commonly used amongst the early civilization of India, and every region has used lime plaster along with sand particles also called as *kankar*. The ratio of lime and aggregates differ along the region as well as the use of organic aggregates.

In India many heritage buildings ranging from religious buildings to forts, havelis and monuments of different architectural styles and time periods are designed in lime mortar. Lime is used as a building material in various applications from masonry to pointing and plastering. Lime plasters of “Arayish
style” and” Chettinad style of plastering” are famous and are widely followed even today as traditional building method.

India map indicating availability of lime plaster in the subcontinent. For reference case study
**Why Use Lime?**

This technical note aims to find out ‘why use lime?’ Conservation professionals are trying to convince all that we have to choose breathable materials such as lime, for the conservation of our historic buildings. We all know that modern materials are not compatible for use with porous structures but most of the time we fail to convince laymen. They believe strong and impermeable material is the best suited for repairs to their historic buildings.

In the last 50–60 years, the specification of mortars or concrete has been based upon relatively new Portland cement–based materials. These have properties such as high compressive strength, faster curing times and greater hydraulic activity.

Today most people believe that the durability of binding material is directly related to its strength and permeability. Thus, porous materials like lime have fallen into disuse. The shift to modern materials is practical and logical for modern construction and for innovative structural forms. Modern high-rise structures, bridges and forms could not have been built adopting lime as the chief cementing material. However, the construction techniques adopted for historic structures or vernacular buildings are very different from modern construction. The use of cement based materials for historic structures leads to moisture entrapment and consequent deterioration of material due to their impermeable and strong behaviour.

Source: Conservation Briefs by Sangeeta Bais for Intach
HERITAGE STRUCTURES STANDING STILL

History shows that the life of heritage structures in lime and stone are much longer than the structures constructed of cement.

The following examples indicates the long lasting life of heritage structures:

Charminar built in 1591 with the oldest technique of lime plaster which is intact till date. For reference case study

Nagaur fort, Rajasthan. Built between 1154AD – 1752 is the perfect example of lime plaster, Arayish technique and wall paintings. For reference case study
Rajabai Clock tower, South Mumbai. Built in 1878 stands at a height of 85m being the tallest heritage structure in India. This tower was added to the list of World Heritage sites in 2018.

Qutub shahi tombs, Hyderabad – 16th century For reference case study
Colosseum, Rome, Italy. The first largest amphitheatre in the world constructed in 80 AD. This structure is listed in UNESCO World heritage sites in 1980 and has been a tourist attraction and a textbook example of lime plaster use in traditional buildings. For reference case study

**Chemical Composition of Lime Mortar** —

Lime is generally obtained from the quarries in powdered form and is worked into building mortar either at site or in the factories.

The building lime is produced from burning the limestone in kiln (this process is done at site based on site conditions or can be factory bought).

**Step 1** –

Burning of the pure lime stone (at around 700°C - 800°C) which will produce non – hydraulic lime undergoing the process of **Calcination**.

\[
\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2
\]

CaO is called Quick lime and is very reactive. It is pure white in colour and easily absorbs moisture from water and becomes Hydrated lime which is called **Lime Slaking**.

Quick lime is soaked in water in lime tanks for a period of 3 months to allow to mature and create lime Putty.

\[
\text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 \text{ (Lime Putty)}
\]

Mature Lime putty from minimum period of 3 months
This lime Putty is then sieved without any lumps and mixed with aggregates (sand of appropriate size), surkhi (brick powder) and organic binders (ranges from region to region and generally include jaggery, fenugreek seeds, plant and fruit pulp, egg shells, curd and etc.). After mixing them in lime chakki a fine workable paste is prepared which is used as mortar in construction and as plaster.

Once the plaster is applied it should be watered regularly (for a minimum period of 21 days). The lime putty reacts with the carbon dioxide in the atmosphere and undergoes carbonation once again.

\[ \text{Ca} (\text{OH})_2 + \text{CO}_2 \]

After application the mortar undergoes carbonation

\[ \text{CaCO}_3 + \text{H}_2\text{O} \]

Lime mortars are usually classified as air-setting mortars, where air can enter the open pores and carbon dioxide react with lime and the material hardens/sets.

It should be noted that lime mortar does not achieve 100% hardening and is generally porous allowing the movement of moisture in and out of the structure allowing the elements to breathe. It is one of the most important factors for using lime as a building material with stone and brick.
Lime Cycle diagrammatic representation

**Lime Plaster preparation and Application at Site**

Savani Heritage Conservation Pvt. Ltd have been a leading heritage consultancy diligently working on restoration and conservation of heritage buildings in India. Among others, one of our expertise is to work with lime. Lime is one of the important architectural elements in most of the heritage structures and we as a team mastered the art of working with lime. Lime is mainly used in pointing, plastering, mortar joints and surface finishes.
Plastering –

Heritage structures are traditionally either built by stone or brick. These materials are porous, which by means they allow the movement of humidity through the surface allowing the building to breathe. Lime plaster also possess the properties of porosity. Lime once applied onto the surface, do not hardens like cement plaster. It moves freely with the underlying structural material. As lime plaster is porous it allows the movement of humidity through the surface responding well with the horizontal and vertical stress of the structure due to which there will be no surface cracks formed.

Reference images of work done by Savani Heritage Conservation pvt.ltd
Lime plaster finish (Source – Town Hall, Visakhapatnam)
Lime surface finish (Source – Town Hall, Visakhapatnam)

Lime plaster or the Araish Plasetr done at the Town Hall, Vishakhapatnam.

Araish plaster or the lime plaster done at the St. Philomena Church, Mysore. For reference case study.
Reasons to use lime plaster instead of cement plaster in heritage buildings when the original plaster is done in lime —

1. Lime plaster is porous in nature as compared to cement plaster which allows the building materials to breathe and moisture to freely move in and out of the structure which is essential for the long lasting of the structure.

2. Natural materials always have long life which results in the survival of the structure for many years.

3. Cement plaster is hard and impervious which does not have bondage with existing lime mortar masonry.

4. Use of cement plaster in lime mortar masonry structure results in aggressive deterioration of heritage buildings.

5. Lime plaster is sustainable material as compared to that of cement plaster.

6. Use of cement plaster may increase the problem of raising dampness resulting in deterioration of cement plaster will be faster in lime-based heritage building.

7. Accumulation of salt deposits on the surface deteriorating stone and causing efflorescence.
### Difference between Lime Plaster & Cement

#### Plaster –

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Lime Mortar</th>
<th>Cement Mortar</th>
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<tbody>
<tr>
<td><strong>Physical Property after setting</strong></td>
<td>Soft – Building materials (stone/brick) are subject to constant ground movement and vibrations. A soft cushioning can accommodate minute movement without cracking.</td>
<td>Hard / Rigid – It cracks badly, letting rainwater in, resulting in increased dampness and potential frost damage. Cement mortar being harder than surrounding bricks, will erode or crack them, damaging the softer historic building fabric.</td>
</tr>
<tr>
<td><strong>Breathability</strong></td>
<td>Elastic – On molecular level lime allows water vapours to evaporate freely, keeping its surface dry.</td>
<td>Compact – Prevents evaporation and traps humidity. Moisture under the cement plaster gradually builds up, &quot;amplifying&quot; dampness problems, making them worse.</td>
</tr>
<tr>
<td><strong>Porosity</strong></td>
<td>Porous – Since the material is porous, it allows the movement of air and humidity in and out of the surface.</td>
<td>Compact – Since the material is not porous, it does not allow the movement of air and humidity is trapped in between the joints leading to cracks or salt efflorescence.</td>
</tr>
<tr>
<td><strong>Elasticity</strong></td>
<td>Elastic –</td>
<td>Rigid –</td>
</tr>
</tbody>
</table>
Lime hardens over time; however, it is more workable. It moves along with the base materials and is prone to less cracks.

Cement sets faster and is too rigid and does not allow the movement of the plaster with the base materials which leads to formation of cracks over time.

| Natural Material | Nature friendly – Lime production results in release of carbon dioxide into the atmosphere, but lime mortar absorbs carbon dioxide from the atmosphere over its lifetime. As a result, lime mortar is considered by environmentalists to be "carbon neutral." | Not Nature friendly – Cement production contributes greatly to global warming, as copious amounts of carbon dioxide are released during its production. |
In the book “The repair of Historic buildings – Advice on Principles and Materials, written by Christopher Brereton for English Heritage”, have stated the importance of using compatible and original material to be used.

The book highlights the unsympathetic restoration methods used (using cement mortar in place of lime mortar) which have damaged the structure. It is important that any material used in the repairs are as close a match as possible with the original to ensure compatibility and integration with the old base. Restoration with incompatible materials can cause damage to adjacent parts of the original structure and are to be avoided.
According to Indian Conservation architect, Ms. Sangeeta Bais, in her book “Why Use Lime” published by INTACH, she explained in detail about the permeability of lime plaster.

She presented case studies showing deterioration of cement plaster in various structures. She has also explained in scientific methodology and through schematic representation the advantages of lime plaster over cement plaster.

According to her book: Portland cement has a dense pore structure and a needle-like crystal structure that has the same expansion and contraction coefficient as steel, the unyielding joints and stucco will eventually crack in various places. A mortar with great strength like Portland cement may survive the testing conditions, but is more likely to cause damage to the masonry units. Lime mortar bedding acts like a wick to draw moisture out of a wall and provide a good surface for evaporation. Softer mortar like lime will contribute to long life of the structure by tolerating the small deformations in a building.
In the book “Historic Preservation technology written by Robert A. Young, PE” have provided various photographic evidences (as shown in the above pictures) of the deterioration of stone caused by using cement plaster and pointing.

It can be seen that the deterioration is caused due to trapping of moisture content in between the stone and the mortar which in turn deteriorated both the plaster and the stone surface. Most of the common deterioration affects are material corrosion, surface deterioration, salt deposits, efflorescence and moisture capillary rise.

The cement-based masonry allows the moisture to be trapped with in the masonry unable to let it to escape. This with the combination of natural materials like brick or stone will cause damages like spalling of the bricks/stones exposing the outer surface to weathering and severe erosion which in turn damages the surface.
In the book “Building limes in Conservation, edited by Ian Brocklebank”, many examples of stone and brick deterioration due to cement plaster in England are cited. The reasons of deterioration are explained as a result of lack in compatibility between dense, impermeable cement-based repair and traditional lime-based construction, causing masonry failure by cracking, water penetration and surface scaling.

Repairs using Portland cement which are not part of original fabric, has resulted in lack of compatibility between dense, impermeable cement-based repairs and traditional lime-based construction causing masonry failure by cracking, water penetration and surface scaling.
The book “Conservation of Historic buildings, written by Bernard M Fielden”, provides yet other examples of damages caused by cement mortar in traditional construction. These examples are quoted from Canada, Italy and England, which stress the importance of using compatible mortar for the purpose of restoration.

The author has analysed and stressed on the deterioration of stone due to wrong restoration methodology and in all cases, the use of impermeable cement plaster.

The author states that the object of restoration is to revive the original concept or legibility of the structure and further discusses about the fundamental factors of architectural conservation which are as follows:

1. Architectural work involves dealing with materials in an open and virtually uncontrollable environment – external climate.
2. Scale of architectural conservation is larger and need various conservation techniques and methodologies to be implemented.
3. Structural conservation is an amalgamation of experts from different educational backgrounds and expertise who needs to come to a common ground and work for a singular goal.
4. Architectural fabric has to function as a structure, resisting dead and live loads and must provide a suitable living environment.
Defects caused by using Cement Plaster

(Indian Examples)—

RGT College (Porbandar, Gujarat)

Porbandar is the coastal city of Gujarat best known as the birth place of ‘Mohandas Karamchand Gandhi’. The city is located with a stunning view of the Arabian ocean. The RGT College shown below has similar weather conditions to the old municipal office. This example is shown to draw the similarities between the two structures while highlighting the damages done to the building material due to the use of cement plaster. This structure can be used as a reference to the OMO, both as similar building structure and geographical setting.
During intervention cement plastering is done which have caused damage to the stone surface. There is spalling effect on the stone along with blistering and surface cracks. The building is located in the costal region, hence there is high level of moisture content in the atmosphere.
The use of cement plastering has damaged stone surface causing pitting, blistering and cracks on stone surface. There are also cracks which are formed on the stone. The plaster has peeled off exposing the stone to harsh weather conditions.

As seen in the above pictures, there is damp rising in the walls. The cement plaster is peeled off exposing the stone surface directing it to the weathering and atmospheric humidity. There are also structural cracks and exposed reinforcement seen which is a result of moisture rise, uneven expansion and low breathability of stone caused due to cement plaster.
Example of Iran Shah Atash Behram (Udvada, Gujarat) – done by Savani

The stone surface is previously painted and later plastered with lime. First Fire temple of Parsi community

This renovation project is a very good depiction of the visual attraction that can be achieved through lime and Arayish plastering.

Arayish layer is a very smooth overcoat layer which gives a smooth and finished look unlike paint and gives an sophisticated look to the structure.

Lime plaster surface finish For reference case study
**Importance of Lime Plaster over Cement**

**Plaster —**

Lime is a natural material which was being used in plastering of stone structures from time immemorial. Lime is a natural material with porous components and is sustainable, being the main reasons for long life and compatibility with traditional materials.

**Longevity due to Porous material character** — The cement being a contemporary material does not bind well with the stone. The cement is manufactured artificially and its bonding with the natural material is questionable. The use of cement plastering as an intervention in the pretext of conservation, have affected the breathability of the stone. The Cement pore structure is supposed to be compact or smaller thus trapping the moisture. Thus, trapped moisture can cause dampness on the stone surface and further lead to deterioration of the stone. The cement as a plaster material to the heritage structures fails to provide the desired porosity for the exchange of moisture. It is often seen that the moisture accumulates at the centre of the stone block. When the stone plaster surface which is considered as a moisture exchange gateway is blocked, the movement pattern of the moisture is either trapped or damages the stone. In either case, the surface of the stone is severely deterioration causing the loss of surface layer. The long-term ill effects of cement plastering are that replaster can be done but the deteriorated stone cannot be brought back.

Delamination of cement plaster from stone surface [For reference case study](http://www.underoneroof.scot/articles/986/Wallhead_chimneys/Stone_Defects)

The risk of rising dampness is caused when the cement is used for replastering which confines the breathability of the stone and thus the trapped moisture finds its way through the stone surface. A lime-based plaster helps in the expansion and contraction of the stone joints which ultimately avoids the spalling and disintegration of the stone. Whereas, the cement qualities lead to premature deterioration of soft, historic bricks and so the traditional, low temperature fired, lime mortars are recommended for use.

(Rising dampness of cement plaster - For reference case study)

(Source: RGT College, Porbandar, Gujarat)

The appearance of the facade due to cement replastering can also be affected severely. Since the dampness in the stone can exert pressure on the cement plaster, the plaster can become loose and start spalling and falling off, thus giving an uneven and unfinished look. The missing plaster can aggravate the deterioration of the stone. Besides, the permeability of the plaster should be greater than the masonry to which it holds onto. In comparison to cement, the lime has time and again proved again that the soft and porous properties of lime mortar provide certain advantages when working with softer building materials such as natural stone.

The historic structures are prevailing evidences of the lime as a material that withstood the weathering over centuries. The failure of the cement mortar can be understood from the loose and falling fragments which is a common sight for the cement plaster. The cement restricts the evaporation of the
moisture causing erosion (stone or brick) and irreparable damages to the blocks. The cement plaster being hard introduces stresses on the facade and does not allow the flexibility of contraction and expansion due to weather conditions such as rain and sun. Cement has less affinity towards heritage building as observed from its failure. Hence, lime as material has given enough of evidences of its longevity from the past and for the coming years.


**Analysis:** This graph indicates that cement mortar has high rigid strength and lime mortar have less rigid strength.

**Result:** Cement mortar cannot be flexible with the movement of natural materials whereas lime can be flexible.
Analysis: This graph indicates water permeability of the materials. Cement plaster is not porous hence, there is limited availability of water vapour to pass through the mortar. On the other hand, lime mortar exhibits acceptable values of water permeability.

Result: Cement mortar cannot let the movement of moisture through the structure, whereas, lime mortar allows movement of humidity to pass through. Stone / bricks are porous materials and they absorb humidity and they need material with high water capillary co-efficient to allow the humidity to pass through.
Analysis: This graph indicates elastic property of the materials. Cement plaster have very low or no elastic properties whereas lime mortar has elastic properties with compatibility limits.

Result: Cement mortar cannot move along with the materials whereas lime mortar can.

Environmental Factors & Sustainability –

Taking into consideration the sustainability and environmental effects, lime a naturally occurring, sustainable and environment friendly material. Being a soft material can gel well with various natural additives and creating a beneficial composition. Lime plastering has proved its sustainability by holding the masonry together over the years. The porosity of the lime can reduce the water intake which can eliminate dampness of the building fabric. The incidences of cracks developing on the walls are reduced drastically as the walls are able to breathe and adjust to the climatic conditions.

Cement manufacture causes environmental impacts at all stages of the process. Cement manufacturing releases CO2 in the atmosphere both directly when calcium carbonate is heated, producing lime and carbon dioxide, and also indirectly through the use of energy if its production involves the emission of CO2. In certain applications, lime mortar reabsorbs some of the CO2 as was released in its manufacture, and has a lower energy requirement in production than mainstream cement.

(Source- [https://en.wikipedia.org/wiki/Cement](https://en.wikipedia.org/wiki/Cement)).
**Permeability of the lime plaster**

The rate of evaporation depends upon the permeability of the material used for plaster. The schematic image depicts the introduction of the hard cement mortar for plaster which has altered the moisture movement. Porosity and plasticity of the lime is makes it more workable material and can give a finishing to any kind of masonry arrangement such as ashlar or rubble masonry.

Image showing a comparative analysis of lime and cement material. For reference case study

(Source - [https://www.wtbf.co.uk/old-building-information.php](https://www.wtbf.co.uk/old-building-information.php)).
Intervention –

- Cement is a non-porous material, its use can be a temporary solution, and however the use of lime can be an efficient, sustainable and long-lasting solution.
- The addition of additives especially the natural ones such as jaggery, guggul (*Indian bdellium-tree*) and fenugreek seeds etc. Lime finish is a prevalent method in the restoration of somewhat similar structures in the surroundings belonging to the same era.
- Movement is accommodated in the bed joints, reducing the need for vertical movement joints; which greatly improves the aesthetics of buildings.
- The building will have more tolerance to movement particularly in high buildings / structures.
- Lime will improve breathability, which allows moisture vapor to move freely through the mortar joint effectively reducing the likelihood of frost damage in the brickwork.
- High permeability to water and water vapour
- The stones plastering with cement can exert pressure/weight on the stone masonry below and this could be the reason for the development of the cracks. Whereas lime being lighter, and a homogenous mixture can bond well with the stone structurally and aesthetically.
- The geological characteristics of the lime finish (consisting of quartz sand and brick aggregate) is beneficial for homogeneity and cohesion purpose. The above materials are naturally occurring and hence sustainable restoration can be achieved.
Cement plastering in old municipal office —

In the Old Municipal office building, all the external façade has exposed stone with lime pointing and plastering on the other side. Most of the walls in the structure are of this fashion.

Using cement plaster on one side of the wall with exposed stone surface on the other creates a barrier to the moisture movement. Water which is absorbed from the stone surface cannot transmit out through the cement plaster on the other end, resulting in trapping of the moisture which will cause dampness, scaling of the stone, salt deposits, spalling and deterioration of the stone and the plaster surface. This will eventually lead to structural weakening and failure.

Elevation showing exposed stone façade with plaster on one side.
The use of cement plaster at the Old Municipal Office is a step which will affect the fabric of the structure. The primary evidences of the Town Hall show that the lime was present initially when the restoration works began.

The use of cement is an intervention which will prove brutal to the fabric and will affect the breathability of the structure. It is important to hold on to the original material without abiding the ethics of conservation. Distracting from the traditional material for a heritage restoration is not just ethical but also equivalent to a crime! The introduction of a modern material for heritage structure will severely affect the longevity of the structure.

Whereas, the evidences at the Town Hall found was lime plaster. During the restoration, the replication of the material i.e. lime plaster has been implemented, which is ethically right. Thus Town Hall is an example of a sustainable restoration.
Ethics of Conservation —

According to “INTACH: Charter for the conservation of unprotected architectural heritage and sites in India, published in November,” there are few conservational ethical guidelines which needs to be followed in all the heritage structures.

Guideline: 3.11 Legibility — The new work should be in complete harmony with the old and should not be distinguished from it.

Guideline: 3.2.2 – An exact replacement, restoration or rebuilding must be valued when it ensures continuity of traditional building practices.

Guideline: 4.5 Local material and traditional technology —

4.5.1. The use of local material and traditional technologies must invariably be preferred.

Images from the charter taken showing the rules of Ethics.
According to the book “Conservation of Historic Buildings written by Bernard M Feilden”, Conservational ethics are described as follows:

1. The condition of the building must be recorded before any intervention.

2. Historic evidence must not be destroyed, falsified or removed.

3. Any intervention must be governed by the unswerving respect for the aesthetic, historical and physical integrity of cultural property.

4. All methods and materials used treatment must be fully documented.
**Recommendations —**

In the case of Old municipal office, the original plastering in lime have permitted the exit of moisture from the wall, owing to the porosity of the plaster, therefore keeping the masonry wall in good structural health.

In case of cement plastering, cement mortar being impervious will trap the moisture and retain it within the masonry walls causing the rise of damp and the formation of cracks and structural weakness.

![Images showing behaviour of moisture on brick/stone masonry wall with lime plaster and with cement plaster](For reference case study)

The use of cement plastering in such a building can be described as the single most deleterious intervention that gradually lead to the structural failure of the building (NCSHS, 2015)

In OMO, mortar joints and pointing are done in lime mortar. If cement plastering is done, there will be no cohesive bonding between the two materials which will result in uneven expansion of stone and cement plaster along with capillary moisture rise creating cracks on stone and plaster surface. Hence, it is necessary to use lime as a plaster material.
Taking all the above into account, it can be scientifically accepted that lime plaster should be used in restoration of stone masonry. It is the porous nature of the material that allows the structure to breathe maintaining a systematic way for moisture to diffuse.

On the other hand, cement is a poison to stone masonry degrading the structural strength of the member leading to failure in the long run. It is important to understand the nature of the building materials, while respecting their physical and natural properties. It has been tested in time that lime is the perfect mortar to be used for a strong structure to let it stand tall for decades to come as it did.

The most effective methods of repairing and maintaining traditional masonry buildings almost invariably involve the use of materials and techniques employed in their original construction. The BURRA charter states that the conservation policy of the building should identify the most appropriate way of caring for the fabric. (The BURRA Charter, 2013).

Glossary

<table>
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<tr>
<th>Terms</th>
<th>Description</th>
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<tr>
<td>Limestone</td>
<td>Sedimentary rock consists primarily of porous calcium carbonate, which may also contain deposits of organic remains such as shells, molluscs, or corals.</td>
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<tr>
<td>Surkhi</td>
<td>Calcined or burnt clays were the earliest pozzolan used, in the form of crushed reject clay bricks, tiles, or pottery which were mixed with lime to produce cement for mortars.</td>
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<tr>
<td>Aggregates</td>
<td>A granular material that is used during construction. The sand, gravel, and crushed rock are the most common natural granules of fine-grained minerals.</td>
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<tr>
<td>Mortar</td>
<td>A material that is used in construction to bridge the gaps between masonry blocks. Mortar acts both as a medium of adhesion and as a means of protecting the</td>
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building's interior from rainwater entry. When fresh and set to form a hardened material, mortars are 'plastic' or pliable.

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<tr>
<th><strong>Calcination</strong></th>
<th>Heating material for releasing volatile substances or altering the structure of crystals.</th>
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<td><strong>Hydraulic lime</strong></td>
<td>A chemically impure type of lime with varying hydraulic properties, containing large amounts of silica, alumina, and typically some iron, chemically mixed with most of the lime. For plaster and mortar commonly used as binder. It can be used where structure is in contact with water.</td>
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<tr>
<td><strong>Non - Hydraulic lime</strong></td>
<td>Non-hydraulic lime has impurities like silica and alumina in quantities of less than 15%. In the process of slaking, it undergoes less expansion.</td>
</tr>
<tr>
<td><strong>Araish lime</strong></td>
<td>Lime araish is an exclusive technique of producing an extremely smooth, glossy and crack-free surface by using marble powder, sea shells, egg shells etc.</td>
</tr>
<tr>
<td><strong>Carbonation</strong></td>
<td>Carbonation is a chemical reaction in which Carbon DiOxide is added to produce carbonates, bicarbonates and carbonic acid.</td>
</tr>
<tr>
<td><strong>Hydrated Lime/ Slaked Lime</strong></td>
<td>Slaked lime is obtained by the process of slaking, where quick lime is combined with water. Slaked lime is also known as Hydrate of lime. This is available as pure lime in the form of a white powder.</td>
</tr>
<tr>
<td><strong>Lime Putty</strong></td>
<td>Produced by slaking quicklime in an excess of water. Lime putty is fully slaked and typically allowed to ‘fatten up’ for at least 48 hours prior to use in a lime mortar.</td>
</tr>
<tr>
<td><strong>Slaking</strong></td>
<td>The process of adding water to calcium oxide to produce calcium hydroxide is referred to as hydration process or lime slaking. The hydration of CaO, commercially referred to as quick lime, is an exothermic process releasing a great quantity of heat.</td>
</tr>
<tr>
<td><strong>Lime Chakki</strong></td>
<td>It is an ancient method of producing lime plaster by making a circle.</td>
</tr>
<tr>
<td><strong>Deterioration</strong></td>
<td>The degradation of construction material due to physical, biological or chemical weathering mechanisms.</td>
</tr>
<tr>
<td><strong>Breathability</strong></td>
<td>A measure of the flexibility with which humidity can pass in the phase of vapour, through a material. Even known as the permeability of vapours.</td>
</tr>
<tr>
<td><strong>Cement</strong></td>
<td>A binder formed at high temperature, from the combustion of limestone and clay. The concentration of calcium-silicates and calcium-aluminates provides a fast setting for cement. The impenetrable system of these components in cements provides them with low permeability and breathability.</td>
</tr>
<tr>
<td><strong>Permeability</strong></td>
<td>It is a measure of a material’s ability to transmit fluids.</td>
</tr>
<tr>
<td><strong>Workability</strong></td>
<td>A measure of the ease with which a fresh mix of mortar can managed and placed</td>
</tr>
<tr>
<td><strong>Porosity</strong></td>
<td>Presence of pores in the material allowing humidity to pass through the material.</td>
</tr>
<tr>
<td><strong>Plaster</strong></td>
<td>Mixture of one or more inorganic binders, aggregates, water and other admixtures that can be used as an internal masonry covering.</td>
</tr>
<tr>
<td><strong>Pointing</strong></td>
<td>Mortar injection into the outside portion of masonry mortar joints after the masonry has already been in location. The term also defines the total depth of mortar that was added at a later stage than the traditional bedding mortar</td>
</tr>
<tr>
<td><strong>Durability</strong></td>
<td>The extent to which a substance would be able to endure use, weathering or vicious elements for a prolonged time.</td>
</tr>
</tbody>
</table>
Conclusion —

Old Municipal Office building is a heritage structure with lime plastering being done during the original construction.

In the process of conservation according to the guidelines provided by Archaeological survey of India (ASI), INTACH and ICOMOS:

It is mandatory to apply lime plaster in the process of conservation and restoration. Using cement plaster is deemed to be harmful to the well being of the structure as it causes rapid deterioration and structural failure. Cement plaster application is a result of violating conservational ethics and should be prevented at all costs.

In accordance to the above study, it is advisable to use lime plaster in the restoration of old municipal office as it is justifiable and in line with conservational ethics and practices. Using of cement plaster will deteriorate the structural stability and is against conservational ethics.

In addition, lime plaster will prevail the structural stability and is in accordance with the original design of the structure.