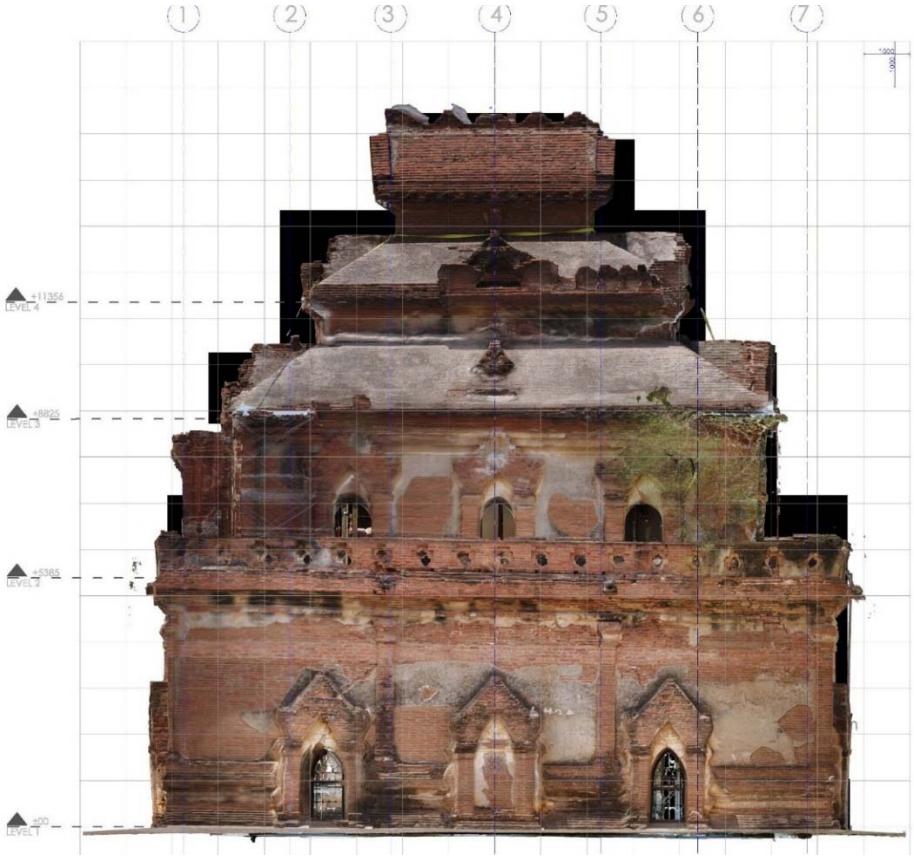
MANUAL FOR THE CONSERVATION OF MONUMENTS AND HISTORIC BUILDINGS AT BAGAN



Prepared by CRCI within the framework of the UNESCO Project "Safeguarding Bagan within the World Heritage Framework" funded by NFUAJ

Contents

1 CONSERVATION PLANNING METHODOLOGY

The preparation of a Conservation Management Plan[1] for a monument in Bagan should be based on comprehensive understanding of the monument, its setting, history, association, significance, architecture, structural system, decorative features and embellishments and construction materials and techniques. The conservation plan should use a 'value based planning' framework derived from detailed research, documentation, investigation, and analysis leading to recommendations.

The following steps should be undertaken to prepare the conservation plan:

1. Documentation of the architectural and spatial characteristics of the building
2. Documentation of the character defining features of the building (architectural details),
3. Documentation and understanding of the architectural vocabulary,
4. Documentation and understanding of the traditional construction system,
5. Assessment of value and their attributes,
6. Mapping types of decay- structural, material and surface,
7. Analysis of cause of decay
8. Conducting investigations non-destructive, moderately destructive and destructive on materials, and structural tests
9. Documentation and assessment of past interventions for restoration including strengthening damage from seismic risk

Analysis of information captured described above shall inform the conservation planning process. The Conservation Management Plan document shall contain the information of the above listed activities presented in the form of architectural drawings, technical drawings (of construction systems), and proposals for interventions for conservation, forms with architectural details, material and condition of the monument.

1.1 Research of Archival records and Secondary Data

History, Spatial Planning, Architecture, Building Embellishments, Significance.

Secondary data comprising archival information and maps, drawings and other relevant records/documentation of monuments should be collated and analysed. This will inform understanding of the building, its construction technique and decays, both passive and active.

The data shall be collected from Department of Archaeology (DoA) and experts who had worked with DoA for past several years. The information can be broadly classified into:

1. **Previous conservation interventions**

Post the earthquake of 1975 there were several interventions made to the monuments in Bagan. These included

[1] Text is adapted from the "Ananda-ok-Kyaung Conservation Management Plan' drafted by CRCI within the framework of the UNESCO Project "Safeguarding Bagan within the World Heritage Framework" funded by NFUAJ.

confinement of structures under distress, reconstruction of lost masonry, filling of cracks.

2. **Additions and alterations done in the monument**
3. **Existing Architectural Documentation of the monument**

It is important to take into account interventions undertaken on the monument in the past to understand the 'layering' seen in the buildings, especially any interventions for stabilization after the earthquake of 1975 which are now an integral part of the monument. This is necessary to assess the impact of the interventions to inform the recommendations for conservation. The research and documentation forms the basis of establishing a framework for conservation planning.

Potential sources for secondary data may include studies and surveys of site in the past as enumerated below:

1. Inventory of Monuments of Pagan (Volume I – VIII): a database for 2340 monuments, by Pierre Pichard, EFEO
2. S- Card: Structure Rapid Condition Assessment Card, Bagan.
3. D- Card: Decorative works (mural paintings and decorative architectural surfaces) Rapid Condition Assessment Card, Bagan
4. Propositions for the Conservation-Restoration of Mural Paintings and Carved Stuccoes in Bagan by Rodolfo Luján Lunsford, October 2012.
5. Assessment, Recording and Curriculum for Architectural Decorative Works Conservation at Bagan by Rodolfo Luján Lunsford, May 2014.
6. Guidelines for In-Depth Condition Assessment of Monument at Bagan Archaeological Area, submitted as part of UNESCO / Japanese Fund-in-Trust project "Technical Assistance for the Conservation of Built Heritage in Bagan"; Drafted by Masahiko Tomoda, Salvatore Russo, Mara Landoni, Clara Rellensmann, January 2016.
7. Guidelines for Conducting Rapid Condition Assessment of Bagan Monuments, developed under the UNESCO project "Technical Assistance for the Conservation of Built Heritage in Bagan" (Japan Funds-in-Trust), drafted by Azadeh Vafadari, November 2015.
8. Bagan Archaeological Area and Monuments, Myanmar, Post-disaster Conservation Procedures and Guidelines 2016, 23 October 2016 REVISED 27 OCTOBER 2016
9. Visual Glossary of Damages and Degradation, DoA.
10. Descriptive Manual of How to Apply the Mural Paintings and Decorated Architectural Surfaces Rapid Assessment Card (D-Card) by Rodolfo Luján Lunsford.
11. Assessment and Structural Stabilization of Damaged Monuments with recommendations for improvements and follow-up actions, World Bank- Myanmar Post-earthquake Rapid Assessment and Recovery Planning, UNESCO-Bagan Earthquake Response and Rehabilitation Programme.
12. Instructions for the monitoring of the cracks, Mr. Vittorio Gallinaro.
13. Dr. Arun Menon on behalf of UNESCO, Key considerations: Stabilisation and Seismic Strengthening of Bagan Monuments, Draft Stabilisation Guidelines and Seismic Improvement Issues, International Conference on the Proposed Programme of Bagan Pagoda Post-quake Restoration & Preservation Project.
14. Final Mission Report October-December 2016 Structural Analysis, Monument 2162- Ananda-ok-Kyaung, DoA.
15. Images from Drone Survey.
16. Laser scans from CyArk; Laser scan surveys of the monuments conducted by DoA.
17. Donad M. Stadtner, Ancient Bagan, Thailand, Buddhist Plain of Merit, Bangkok Printing Co. Ltd., 2013
18. V.C. Scott O'Connor, Mandalay and other cities of the past in Burma.
19. Kyaw Latt, Art and Architecture of Bagan and Historical Background (First Edition)

1.2 Detailed survey of the monument

Identification of the monument and its precinct, description of property and context, past interventions and present state of conservation

A preliminary survey of the monument is the first step towards developing a holistic understanding of the building. The survey should aim to establish an understanding the architectural vocabulary, historic construction system, materials used for construction, decorative features and embellishments, and current condition. It should map layering of materials, condition of the historic fabric as well as past interventions Further, it should develop a vocabulary to map types of decay. Information should be recorded on measured drawings as the primary resource. The survey should be undertaken by a multi-disciplinary team comprising architects, conservation architects, structural engineers, seismic engineers, and art conservators.

The following outputs should result from the survey:

1. Identification of the historic architectural features
2. Determine the traditional construction techniques and materials
3. Identification of the embellishments which are character defining of this period of architecture in Bagan
4. Vocabulary of decay of structural, material and decorative surfaces
5. Identification of causes of decay
6. Assessment of the damage due to earthquake of 2016
7. Impact of earthquake on the interventions undertaken post 1975 earthquake
8. Documentation of the existing materials on the monument.
9. Documentation of the existing condition of the monument.
10. Identification of various tests and investigations required to assess the condition of the building and materials used in the past for conservation so as to arrive at a scientific understanding of the building and its condition Consultations with stakeholders

Detailed surveys of the monastery should then be undertaken to document material extant and condition Mapping for each component of the monument (on plans, sections, and elevations) capturing the architectural details and construction systems, determining decay and causes of decay should be undertaken.

Materials and their decay should be identified by giving specific nomenclature and corresponding hatch patterns on architectural documentation drawings. If resources are available, the architectural documentation of the monument can carried out using 'Terrestrial Laser Scanning' techniques (a combination of scanning[2], photogrammetry[3] and aerial data[4]), in order to produce ortho- images which record the extent of damage and

[2] Scanning - Light Detection and Ranging (LiDAR) devices are used to scan the surface of each Feature to +- 2mm single point precision. Individual scans are registered to one another, as well as to photographs to create a complete 3D point cloud of the surface of each feature.

[3] Terrestrial Photogrammetry - Photogrammetric cameras and methods are used to capture photographs of features at a predetermined detail level. Each photo has at least 60% overlap with another photo, then post processed along with scan data into 3D photo-textured models.

[4] Aerial - Drones are used to capture oblique aerial photographs above, around, and at least 50 meters to each side of site features unless drone flights are impossible, dangerous, expressly restricted by local law or site regulations. Aerial photos are used to fill in missing data from Scanning and Photogrammetry as well as support creation of a seamless photo textured

decay.

In terms of documentation of the current condition of the building, the following drawings should be produced for material extant:

Drawing 1: Material Extant
Drawing 2: Material Extant – Historic Material
Drawing 3: Material Extant – Non Historic Material

The following condition mapping drawings should be prepared to identify decay, causes of decay and past interventions:

Drawing 4: Condition mapping – Decays on Structural and non-Structural Works
Drawing 5: Condition Mapping – Structural
Drawing 6: Condition Mapping – Non Structural
Drawing 7: Condition Mapping – Later Additions
Drawing 8: Condition Mapping –Decays on Decorative Surfaces and Embellishments
Drawing 9: Condition Mapping – Decorative Elements – Base and Preparatory layer
Drawing 10: Condition Mapping – Decorative Elements- Paint layer
Drawing 11: Condition Mapping – Decorative Elements- Deposits and formal interventions

Simultaneously, detailed tabulation should be undertaken to organise information for ease of analysis leading to the conservation plan. This recording should use the provided forms as follows:[5]

Form 1: Description- Identification of Historic Materials
Form 2: Description- Identification of Non - Historic Materials
Form 3: Description - Identification of Decorative Features and Embellishments
Form 4: Condition Mapping - Current Condition and Causes of Decay
Form 5: Condition Mapping - Past Interventions & Policy Considerations
Form 6: Conservation Planning – Past Interventions and Impact

3D model.
[5] The detailed forms are given in the annex.

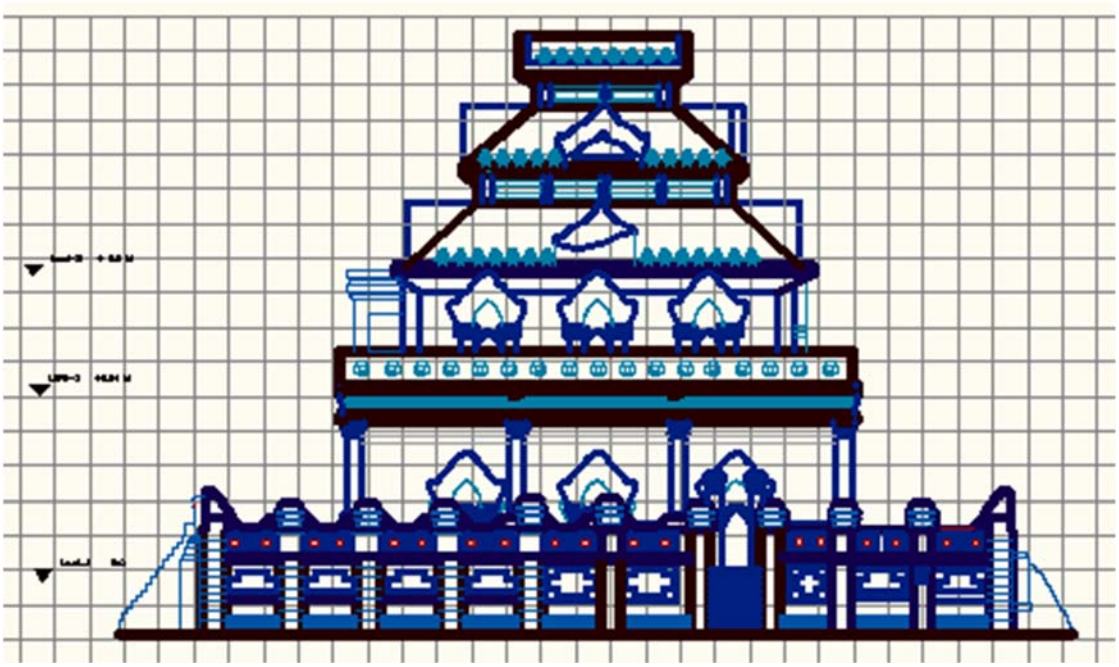
1.3 Documentation and Mapping

Architecture: Plans, Elevations, Sections, Structural Components, Construction Details and Features, Building embellishments and Decorative Features, Materials Extant and Current Condition, Previous Repairs and Interventions

Many of the monuments at Bagan are extremely complex with decorative surfaces, both inside and outside the building, and with its layered information of later interventions. A combination of manual measurement, laser scanning, terrestrial photogrammetry[6] and aerial drone survey can be useful to document, assess condition, and plan for conservation (wherein each line is true to the building).

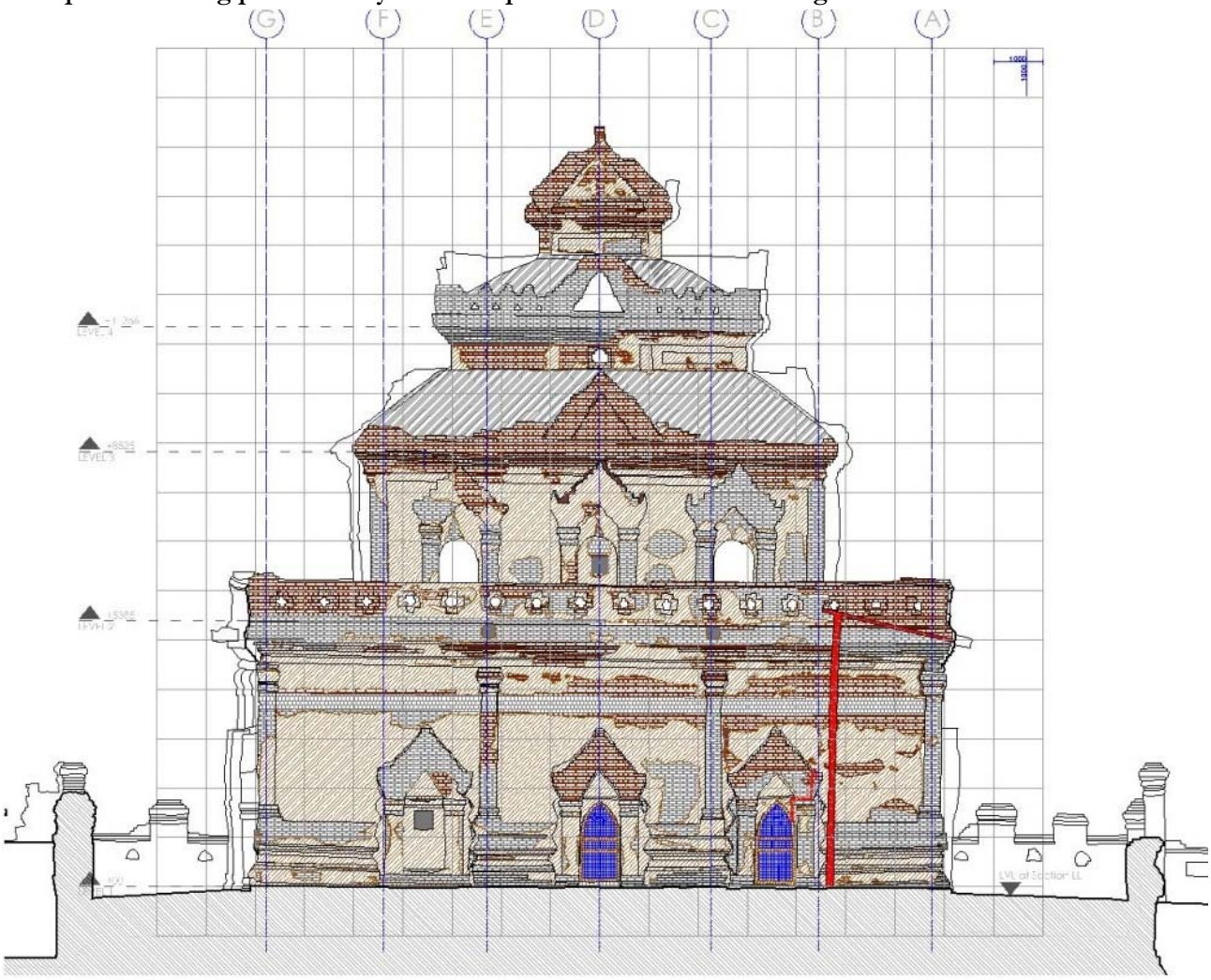
This documentation in the form of ortho images can be used to map/ record information about decay of structural and non-structural aspects of the building including architectural details, material and condition mapping of the surfaces. Ortho images should be produced with the highest level of precision and quality so that they can be vectorised to record the layered information to inform the conservation plan. Building embellishments and decorative features, of stucco and mural paintings should be mapped separately and in more detail by the art conservator.

Preliminary documentation



[6] Photogrammetric cameras and methods are used to capture photographs of features at a predetermined detail level. Each photo has at least 60% overlap with another photo, then post processed along with scan data into 3D photo-textured models.

A sample of drawing produced layered on top of the detailed ortho images is shown below:



MATERIAL EXTANTS

M1	HISTORIC BRICK IN MUD MORTAR
M2	HISTORIC BRICK IN LIME MORTAR
M3	HISTORIC BRICKS WITH LIME MORTAR POINTING
M4	HISTORIC BRICKS WITH COMPOSITE (LIME + CEMENT) POINTING
M5	HISTORIC BRICKS IN CEMENT POINTING
M6	MODERN BRICKS IN LIME MORTAR
M7	MODERN BRICKS IN COMPOSITE MORTAR (LIME + CEMENT)
M8	MODERN BRICKS IN COMPOSITE MORTAR POINTING
M9	STONE
M10	LIME PLASTER
M11	CEMENT PLASTER
M12	COMPOSITE PLASTER
M13	LIME CONCRETE
M14	PLAIN CEMENT CONCRETE
M15	CEMENT CONCRETE
M16	REINFORCED CEMENT CONCRETE
M17	LIME WASH
M18	NATURAL PIGMENTS / COLORS
M19	TIMBER
M20	METAL GRILLS
M21	SCAFFOLDING SYSTEM (TUBULAR + TIMBER)
M22	ELECTRIC CONDUITS

Ananda-ok-Kyaung East Elevation Material Extant
Source: CRCI

1.4 Scientific Investigations

Material of High Value, Behaviour Analysis and Causes of Decay – Structural and Material, Scientific studies and In Situ Investigation, Conservation Policy and Guidelines, Materials for Conservation, Technology and Method statement

Non-destructive, moderately destructive and destructive tests, both structural and material, foundation studies by making of trenches & trial pits, crack monitoring (structural health monitoring system), material studies of historic plasters, mortars, pigments, strength of materials of bricks should be undertaken. These tests will help to determine strength, behaviour of the overall structure, and to understand current condition and material decay. Interpretation of data shall inform the conservation interventions. Tests should also be undertaken to determine detailed technical specifications for conservation works.

Inputs from the structural experts and art conservator informed the list of tests and investigations. The tests are categorised based on criticality:

- whether it would inform the conservation plan and hence listed as **practical;**
- if it would inform **research** and for the purpose of **documentation** and hence a better understanding on the monuments of Bagan;
- for **academic** purposes.

It is recommended that all tests listed as of 'practical' use must be undertaken.

The comprehensive list of tests recommended to be undertaken are as follows:

S.no.	Material	Property	Name of Test	Criticality
1	**Brick units**	**Composition Porosity Mechanical Strength**	Physical Composition	Practical
			Chemical Composition	Practical
			Density	Practical
			Initial Rate of Absorption	Practical
			24-hr Water Absorption	Practical
			Efflorescence	Practical
			Compressive strength	Practical
			Flexural tensile strength (Modulus of rupture)	Practical
2	**Mortar (mud)**	**Composition**	Physical Composition	Practical
			Chemical Composition	Practical
			Particle size distribution (PSD) - Sieve analysis	Practical
			Density	Practical

			Microscopy (SEM)	R&D
			FTIR	R&D
			EDX	R&D
		Mechanical Strength	Compressive strength	Practical
			Split tensile strength	R&D
3	**Mortar (lime)**	**Composition**	Physical Composition	Practical
			Chemical Composition	Practical
			Particle size distribution (PSD) - Sieve analysis	Practical
			Density	Practical
			Microscopy (SEM)	R&D
			FTIR	R&D
			EDX	R&D
		Mechanical Strength	Compressive strength	Practical
			Split tensile strength	R&D
			Transverse strength	R&D
4	**Plaster (lime)**	**Composition**	Physical Composition	Practical
			Chemical Composition	Practical
			Particle size distribution (PSD) - Sieve analysis	Practical
			Density	Practical
			Microscopy (SEM)	R&D
			FTIR	R&D
			EDX	R&D
		Mechanical Strength	Compressive strength	R&D
			Split tensile strength	R&D
5	**Masonry assembly (Brick + mud)**	**Strength**	Compressive strength (Prism)	Practical
			Compressive strength (extracted from existing)	Academic Research
			Flexural tensile strength (Perpendicular - Bond wrench)	Academic Research
			Flexural tensile strength (Parallel - Modified bond wrench)	Academic Research
			Shear strength of joint (In-Situ)	Practical
			Masonry shear strength (Diagonal compression test)	Academic Research
			Single and Double Flat Jack test (In-Situ)	R&D

6	**Masonry assembly**	**Strength**	Compressive strength (Prism)	Practical
	(Brick + lime)		Flexural tensile strength (Perpendicular - Bond wrench)	Academic Research
			Flexural tensile strength (Parallel - Modified bond wrench)	Academic Research
			Shear strength of joint (Shove Test)	Practical
			Masonry shear strength (Diagonal compression test)	Academic Research
7	**Soil**	**Standard characterisation**	Shear strength (Cohesion and angle of friction)	Practical
		(disturbed sample)		

1.5 Risk and Value Assessment

To support and address: Conservation Planning, and Priority

Conservation work should be prioritized by a method based on assessment of values and risks, guided by a multidisciplinary team of specialists. Values should be determined by significance – historical value, materials and construction system, architectural value, etc. Risks should be determined by the condition and threats. Consultations with DoA engineers and officials, onsite investigations and tests must inform the assessment. The multi-disciplinary team of specialists should address the diverse needs of the monument in the area of structural conservation, conservation of material fabric and that of decorative features and building embellishments, landscape/ immediate setting which impacts the building

Identification of issues and logging of the information in a matrix of value against risks will yield a classification of risk classified from severe risk to least risk. This should be undertaken for structural aspects, material, and surfaces.

This classification will allow interventions to be categorised into four domains:

Emergency Measures are identified to be undertaken for preparatory works before the rains or any conservation work to protect the building from any further damage during the rains or an adverse impact to any fragile part and attributes of value while conservation works are in the process of being undertaken.

Urgent Measures are for stabilisation as well as other conservation works such as protecting the building from water seepage, retaining/ recovering the historic levels of the structure, structural conservation (to make the building safe) etc. For instance the structural defect of the monument which determines the stability of the structure has been identified as a priority intervention as 'urgent' while conservation of plasters have been listed as 'necessary' intervention.

Necessary Measures include the civil work such as needful plaster, consolidation of stucco render, restoration of stucco mouldings, reconstruction of turrets and parapets, redoing of flooring, removing of inadequate additions.

Desirable Measures include plaster works in missing areas, reconstruction of plain stucco surfaces where lost (not decorative surfaces as it is not advisable to reconstruct decorative, more specifically figurines as it would amount to conjecture).

1.6 Conservation Planning and Recommendations

Analysis, Recommendations and Technique

As described above, the conservation plan should be prepared by a multidisciplinary team. Drawings for conservation works should be prepared after mapping and analysis of decay. The extent and intensity of damage shall determine the urgency for intervention.

The conservation management plan is recommended to include the following chapters:

1. Conservation Policy and Guidelines
2. Historic materials and later additions
3. Behaviour Analysis and Causes of Decay – Structural and Material
4. Scientific studies and In-situ Investigation
5. Conservation Plan
6. Materials for conservation, technology and method statement
7. Phasing and Implementation strategy
8. Performance Indicators and Periodic Maintenance and Monitoring

1.7 Implementation and Monitoring

Phasing and Implementation Strategy

Implementation strategy is prepared comprising the method statement for successful and timely completion of conservation work. Operation and maintenance as good preventive conservation protocol is also recommended. Performance standards/guidelines are established to monitor impact of intervention. Method statement for interventions are specified, including the precautions to be taken to prevent any damage to the monument during conservation work. Discussions should be undertaken with DoA to make the conservation plan. Their inputs will ensure that the implementation is responsive to the existing systems and methods used in Bagan by DoA. Workshop/s can be undertaken to inform material sourcing, preparation of materials following recommended specifications, and post implementation care.

2 CONSERVATION APPROACH

The aim of conservation interventions are:

1. To preserve historical, architectural, archaeological, artistic and social significance of the structure.
2. To prevent any further decay of the structure
3. To stabilize[7] structural parts of the building
4. To consolidate[8] and restore[9] the damaged and missing parts.
5. To preserve and protect the decorative features and embellishments.
6. To protect and safeguard the architectural value of the structure i.e. material and construction style
7. To establish a framework and methodology for conservation of site (in form of its architecture, construction details and techniques, decorative features and embellishments) as well as other structures where conservation planning is required by bodies and individuals responsible for conservation and implementation in Bagan.

Conservation Policy and Guidelines

A. Multi-disciplinary, holistic analysis and recommendations: Gain a holistic understanding of the site encompassing the structural and non-structural components as well as decorative works and building embellishments.

B. Protection of Authenticity: Significance of the structure should be sustained and enhanced by way of identifying attributes of value leading to a strategy for their protection, improvement and safeguarding through the conservation of the physical fabric compatible with historic materials, process of construction etc.

C. Protection of Integrity: Conservation of the overall character and integrity of the site as well as its constituent parts is a guiding principle to all recommendations. Proposals will endeavour that the wider setting is adequately protected from development which in any way undermines or is at variance with its unique status, dignity, and character.

D. Minimal intervention, reversibility, and process documentation: All interventions should follow the principle of minimal intervention and reversibility, supported by documentation of the process of repair as good practice

E. Risk –Value based approach: Adopt an approach which correlates risks and values for conservation planning and design interventions primarily to ensure the authenticity and integrity of the monument is protected and upheld.

F. Maintenance Strategy: The condition and vulnerability of all sites and structures should be reviewed periodically to guide future management and action priorities.

[7] Stabilization refers to structural interventions, to prevent the structure and the embellishments from any further loss.
[8] Consolidation refers to strengthening of the damaged part of the structure in order to prevent them from further decay.
[9] Restoration implies to reconstruction of parts of building to its original appearance. Restoration is term used to recreate the architectural features to match the original finishes and appearances. The restoration is to be done after complete understanding of the details, materials, construction style through detailed historical research and investigations on site.

G. Community engagement and capacity building: Monuments need to be perceived as public good and the local community- including government (DoA), local educational institutions, NGOs and community based organisations, as well as citizens who live and work in its vicinity- are recognised as their true custodians and thus be engaged in the process of conservation in a way that they can lead the process in perpetuity.

2.1 Historic materials and later additions

Intrinsic to a conservation plan which respects the authenticity of the built fabric is an in-depth understanding of the constituent historic materials and how they work together in the building. A complete understanding of 'compatibility' and 'condition of each material' was understood, component by component to arrive at conservation measures to retain, remove, rebuilt, restore, and consolidate etc. Assessment of materials and surfaces to determine which are historic or later interventions as well as interventions that are compatible or incompatible shall inform what requires to be retained in best possible ways.

Samples from historic materials should be tested for composition in a laboratory. The results shall inform the understanding of the constituent materials. This would inform preparation of materials to undertake the conservation interventions.

Non-historic materials identified in the monuments are primarily those that were introduced in the course of undertaking stabilization and consolidation of the monument, post 1975 and 2016 earthquakes as part of emergency works.

While the masonry of the load bearing structure of Bagan monuments is built in brick with mud mortar, there is pointing in lime mortar done at the surface to ensure proper binding with the plaster atop. This fine layer of lime mortar grouting is essential to binding the plasterwork (both plain and decorative) to the masonry.

2.2 Behaviour Analysis and Causes of Decay – Structural and Material

Materials, geometry, and architectural details are character-defining elements in a building. Behaviour analysis of 'structure and material' as well as cause of decay is an essential part of the conservation planning process. Several types of decay such as cracks due to lateral oscillation during the earthquake are a result of the geometry of the building and decay such as the dislodging of the bricks as decay is largely to do with the construction system of the vaults. Nature of interventions to remedy the decay is determined by the cause of decay, construction system, materials, and geometry of the building (structural behaviour).

2.3 Scientific and In-situ Investigation

For understanding historic materials, determining strength of the materials, behaviour of the components, decay, and condition several tests should be undertaken. Interpretation of data informs the conservation plan including technical specifications. Excavations should be carried out with care to prevent any damage to the building or the findings in the course of the excavation.

Total station survey of the building and its setting can help to capture the footprint, slopes, manmade and natural features of the site inform interventions for preventive conservation.

2.4 Conservation Plan

The conservation plan for the monument should be based on 'value-based planning'. The assessment of significance articulates the historical, associational, archaeological, architectural, aesthetic, artistic, religious, social, economic value and further identifies the attributes of value. Conservation is based on respect for the historic fabric, use, associations, and meanings. Later additions, alterations, and earlier treatments to the fabric of a place need careful assessment of their impact. Historic layering needs to be carefully understood to develop an appropriate strategy. Conservation action should assist and not obstruct the layered history.

The conservation plan includes the assessment of decay (point c above) in the areas of:

- Risk to property (affecting the attributes of value of the historic structure)
- Risk to the user (posing a threat to the safety of visitors) and
- Important aspects of aesthetic/ presentation/ imagibility of the historic building to ensure protection and preservation of aspects of authenticity and integrity of the historic building

Based on the above risks, that may range from high to low; causes of decay have been categorized into:

- Non-Benevolent (NB) – indicating high/active risk impact
- Benevolent (B) – indicating low /medium risk impact. 'NB' indicates a cause of decay which is dynamic in nature and has a severe adverse impact on the historic building and 'B' indicates a cause of decay that is not severely harmful or poses a threat to the property and user and does not have a cumulative impact over time.

The areas of decay determined as NB & Urgent demand immediate attention and action, while those determined as B & Desirable require intervention at a later date.

Missing / damaged elements or features, which form an integral part of the historic architecture, can be considered for rebuilding using compatible materials to restore the integrity of the building.

Conservation interventions are recommended to be reversible as far as possible, and its long-term performance is ensured, without destabilizing the original materials. Reversal of incompatible materials (specifically the NB ones) that compromise the authenticity and integrity of the monument is recommended.

Materials for conservation, technology, and method statement

The materials identified for conservation interventions must be compatible with the original materials. The materials used for conservation should match both, in physical and chemical composition with those of the historic fabric.

A historic building is the embodiment of traditional knowledge of construction- materials and construction systems. It further represents the vernacular method of construction and skills. Scientific investigation and on site studies inform the nature of interventions. Understanding of material, construction system and structural building behaviour of the building as a whole and its parts inform the protocol/ method for intervention.

2.5 Phasing and Implementation strategy

The values, identified types of decay, its location, and assessment of intensity and extent of decay will determine

the priority of interventions. Depending upon the immediacy of action required this ranges from:

1. **Emergency measures:** This may include provision of temporary support for damaged vaults, any overhanging pieces of masonry, fractured door or window lintels. Measures that require to be undertaken to provide weather protection and preventive conservation of murals are also part of emergency works.

2. **Urgent work:** This may include structural stabilization, stitching of cracks, confinement of the upper floor, anchoring the dislodged masonry, consolidation of loose masonry, protection from rain and underground water. All intervention which are necessary to prevent the structure/ or component of the structure from structural failure or to aggravating the structural issue are required to be addressed under the category of urgent interventions.

3. **Necessary work:** This may include removal of incompatible masonry used for reconstruction, consolidation or pointing, rebuilding of lost architectural elements such as forepart porch, turrets etc., removal of concrete flooring from internal floors, removal of cement plaster etc.

4. **Desirable work:** This may include redoing the plaster works on whole of the structure and pictorial integration of paint layer.

Sequence of work in the form of a detailed work plan should be developed based on the final comprehensive recommendations from the specialists in structural, non-structural, and decorative work / building embellishments.

2.6 Performance Indicators and Periodic Maintenance and Monitoring

Performance indicators are measurable features or outputs that demonstrate the effectiveness of the intervention to prevent structure from further decay.

Few of these key performance indicators that emerged in consultation with the structural engineers are listed below:

Moisture content and humidity: When monuments show signs of distress due to presence of water (seepage as well as rising damp), scientific data can be collected to measure the content of moisture before conservation and periodically after the work is over in different seasons to monitor content of water present in the structure.

Tremors: Real-time tremor monitoring is able to pick up small tremors, which are induced sue to movements in sub terrain, which may affect the foundation, walls or other structural elements of the building. The tremors should be recorded prior to conservation. Undertaking the tremor test after the conservation work would give results indicating impact of the interventions on the structure.

Crack monitoring: A Tell-Tale crack monitoring gauge that monitors horizontal and vertical movement across a crack on a flat surface to an accuracy of +/-1.0 mm and by interpolation to +/-0.5 mm are also recommended to be used as performance indicators. Prior to monitoring the crack, the widths and location of the cracks are measured.

3 RECOMMENDATIONS FOR CONSERVATION INTERVENTIONS

3.1 Provision for weather protection and preventive conservation of elements of high significance as Emergency Measures

There are several cracks in the walls and roofs of the buildings due to the impact of time and human and natural actions such as the earthquakes. Infiltration of rainwater into the structure through cracks and gaps/voids, moves along the path of least resistance i.e. via the cracks and dislodged areas. This movement of water induces loss of material thus causing damage to the monument. The overall structural strength is lowered because of loss of joint material. Poor drainage around the buildings can also induce weathering in the bricks in the plinth (due to capillary action) resulting in an unstable state of the entire wall by weakening of bricks and joints in the masonry. Therefore, first and foremost, at the commencement of any conservation and restoration work, it is necessary to provide a weather protection/rain shelter for the entire structure so as to protect the highly vulnerable areas as well as stopping water infiltration from the top of the building.

3.1.1 Provision of bamboo and metal scaffolding framed structure for rain and wind protection

Impact of earthquakes, weather conditions, and inadequate maintenance over time has resulted in decay observed in the form of cracks, settlement in the foundation of the plinth, loss of plaster (in-depth lacunae), detachment/ separation of plaster, dislodged and broken masonry, blocked water outlets etc. These conditions have further increased the probability of water infiltration into the buildings.

a. Guidelines for intervention[10]:

1. Precautionary measures to be undertaken during the assembly of the weather protection system, so as to prevent any damage to the historic fabric of the monastery.
2. For erection of temporary structures on floors or roofs, it is important to ensure that the supporting structure can safely bear the weight or that precautions are taken to ensure that the extra loads are adequately supported.
3. Any kind of permanent fixing on the surface of the historic building should not be approved.
4. At all points of contact between scaffolding (metal/bamboo) and historic building, a packing material should be given in between such as rubber gaskets or rubber sheet or similar make etc. to protect the historic fabric from mechanical damage.
5. The temporary roofs / rain shelters are light weight structures which would need lateral stability and resistant to wind uplift. It is advisable to get the designs approved by a Structural engineer to ensure the structure is stable enough to withstand the high winds and rain.
6. Scaffolding can make buildings more vulnerable to intruders; ladders should be locked away at night and adequate security precautions is necessary.

[10] http://www.buildingconservation.com/articles/scaffold/scaffold.htm

7. Efforts should be made to ensure that the workforce recognizes value of the historic fabric and care is taken to prevent any material damage.

3.1.2 Retain elements of High Significance by preventive conservation measures on internal areas, vaulting and external surfaces

Before commencing any structural stabilization intervention and masonry repair it is necessary to protect the detached plasters with mural paintings and stucco mouldings of high value which may fall off.

a. Guidelines for Intervention

1. The sequence of work to be followed as per the instruction of the art conservator for emergency treatments on mural paintings and architectural decorative works[11] should interchange/alternate with the structural works depending on the treatments to be carried out.

2. Any intervention (structural and civil) should be carried out with the full knowledge and the consent of the Art Conservator so as to ensure that no damage occurs to these highly significant mural paintings and stucco work.

3. Lime-based grouts must fulfil the following parameters[12]:

    - good penetrability and fluidity with low-pressure injections;
    - long-time lasting sufficient penetrability;
    - minimum drying shrinkage coefficient;
    - good adhesion with the voids' surfaces to fill;
    - mechanical resistance and porosity similar to the original materials;
    - expansion coefficient as most as similar to the original ancient material;
    - must contain the lesser amount of soluble salts and other substances that could cause the formation of by-products or alter the ancient structure. (Ferragni et al. 1984: 110-116 & Peroni et al. 1982: 63-99).

4. Preparation of the surfactant and grout mixtures[13]:

The surfactant and grout mixtures should be prepared based on careful tests to determine the most suitable solution.

One possible grouting mixture is prepared by sifting the slaked lime with a graduated mesh sieve (180 - 200 mesh), measure one unity by volume, put the lime into a container, add the additives (neem glue) and slowly add the sieved pozzolan, add water if necessary for making it fluid but not liquid. Proportions of the grouting mixture can vary according to the type of separation, usually is 1 part in volume of slaked lime and 1 part of pozzolan. Jaggary (palm sugar) fluidifies the slaked lime so the addition of water can be reduced or even better, avoided. The grout, in some cases should be very thin but not liquid (for filling thin separations) or rather thick if the separation is quite large in order to create anchoring points for then filling the area. Carefully mix avoiding

[11] Lujan, Rodolfo Lunsford, report on "Recommendation on the Protection and Conservation of Mural Paintings and Architectural Decorative Works of 2162 Ananda-ok-Kyaung at Pagan". UNESCO October 2017

[12] Extracted from Section 4.2.3.2 Annexure IV - Report on "Recommendation on the Protection and Conservation of Mural Paintings and Architectural Decorative Works of 2162 Ananda-ok-Kyaung at Pagan",UNESCO October 2017 prepared by Rodolfo Luján-Lunsford.

[13] Ibid.

the formation of lumps until a homogeneous and fluid mixture is obtained, able to pass through a needle (180-200). It is important to keep the grouting mixture covered while not in use, can be contaminated by the fall of extraneous materials getting mixed with the grout that can obstruct the needle or the syringe while injecting.

5. Equipment & materials for fixing separated plasters and with deformation14

Equipment	
Buckets	Plastic containers with lid, various sizes
Soft plastic sponges	Plastic cups, small 150 cc content
Hand drill and drill bits 1, 2 & 3 mm diameter	Sieves 80 – 200 mesh
Syringes 20 & 50 cc capacity	Double headed iron spatulas
Stainless steel needles 180 – 200 diameter	Bowls for mixing mortars
Thin hypodermic needles	Rubber siphon
Graduated cylinder in cc	Dry cloth or wiper
Soft bristle brushes	Hand water-sprayers
Light planks, poles, string, sponge, foam, etc. for propping deformed plasters	

Materials (subject to confirmation and testing)	
Clean & distilled water	Hydrophilic cotton wool
Slaked lime	Surfactant: for instance, Benzalconium chloride
Pozzolan (from Mount Popa)	Alternative: denatured Ethyl alcohol
Surkhi (brick dust)	Tissue paper
Jaggary (palm sugar)	Micro Acryl Cv40
Electrostatic dry cleaning sponge (Wishab)	Nanometric colloidal silica
Micronised silica gel	Fume silica

6. Procedure for fixing separated or bulging preparatory layer (plasters and renderings) from 1 mm to 5 mm separation

- Previous any procedure for fixing plasters, the surface must be carefully inspected especially under raking light, so as to establish that the paint layer is sound enough to tolerate mechanical action such as abrasion, rubbing and knocking as well as the dissolving action of water. As a preventive measure, the paint layer must be fixed back to the substrate (if detached) and protected with a coating of a fixative.
- Find the most suitable point for injecting/grouting; this is done by gently tapping with the fingertips onto the surface. The reverberation of a dull sound will be produced that will change according to the type of separation. It is advisable to tap with one hand and gently put the other one nearby so as to physically feel the vibrations thence produced. Once the best point for injecting is found (care must be taken not to use vital points of the painting, e.g. faces, hands, important lines, etc.), drill a hole with equal diameter as the needle to be employed or, even better, employ cracks, borders of lacunae, etc.
- Eventual open borders and cracks of plasters must be filled with a similar mixture as the original and

[14] Ibid.

wait until it dries out. If the space is relatively narrow, as a thin crack, it can be filled with cotton wool aided with an iron spatula to fit into the interstices. These preliminary sealing operations are for avoiding the leakage of surfactant mixture or grouting over the surfaces beneath.

- The orifice produced by drilling or the best point(s) selected for injecting must be cleaned as well as the interior of the plaster from dust, as far as possible, with a rubber siphon.
- Inject with a syringe the surfactant solution and check if this flows from open areas. If this occurs, block/fill the area with suitable materials. Surfactant is a substance that decreases the surface tension of water so can wet the dusty interior of the separation. If grouting is done with slaked lime mixed with pozzolan, it is very important that the interior of the separation be completely wet and damp so the setting of the mixture during the hydraulic reaction takes place.
- Suck with a syringe the liquid grout, clean the squirt with water and insert the needle. Introduce the needle into the selected grouting point or orifice in the render and slowly inject the grout. In order to avoid side-leakage of the grout from the grouting point and the needle while injecting, it is recommended that a sort of washer with cotton wool be fastened around the needle and tightened against the injecting point in the plaster. Lime-based grouts have a pot-life of about 2 hours, therefore quantities must be prepared to employ during this time
- It is essential to have within reach a bucket filled with clean water, soft plastic sponges and a dry cloth so if the case is that the grouting mixture overflows from any unforeseen point (crack, void, etc.), the leaching area must be immediately sealed with cotton wool and, then proceed to wipe out the grout with a damp sponge taking care not to rub away the paint layer. If this occurs, it can be preferable to allow the grout to dry and remove the deposits with soft brushes or with an electrostatic dry cleaning sponge (Wishab).
- The fixing of large areas of detached plasters must be done gradually starting from lower sections, allowing the grout to set and dry so not too much wet weight is added at the interior of the structure that would result in its breakage. Once one section has set, the next one can be grouted and so forth, until conclusion. If the case is that one point of injection is used for grouting several times e.g. after the last journey's injection, it is recommended to clean the orifice by injecting water and put a sort of tap made with cotton wool.

7. Procedure of fixing plasters and renderings with deformation (from 5 mm to some centimetres separation): This procedure is similar as the one described above with few tips.

- Apply propping if necessary, taking care that the painted surface is insulated, e.g. with plastic sheeting, and well protected with a buffer like soft plastic sponge from any eventual breakage from hard/stiff materials, such as planks, etc. The propping must be stable and independent of scaffolding, as no movements should occur.
- Find the most suitable point for injection (see point No. 1 in Procedure above). It is preferable to use upper areas or cracks: drill a hole only if strictly necessary. Clean the interior of the render, void, crack, etc., from dust using the rubber siphon as before. Once again, fill any point or area (cracks, borders, etc.) from which the grouting material could flow out.
- Inject the surfactant mixture and successively water, if grouting is done with slaked lime mixed with pozzolan, it is very important that the interior of the separation be completely wet and damp so the setting of the mixture during the hydraulic reaction takes place.

- Inject the grout. Grouting must be carried out at different stages from 12 to 24 hours so as not to overload the area to be fixed and allow the mixture to set properly between one application and the next. The grout must not be allowed to overflow, resulting in leakage onto the surface.
- It is very important to keep the grouting mixture covered while not in use. However, lime-based grouts have a pot-life of about 2 hours, therefore quantities must be prepared to employ within that arch of time.
- Remove the propping when the void is completely filled and dry. In some cases, the bulged plaster will change dimensions because it is 'pulled' or 'sucked' back to the wall by some millimetres/centimetres due to the shrinkage of the grout during setting.

8. The fixed plasters or renderings should make a hard sound when knocked similar to that made by adjacent firm plasters. It is not necessary to fill all the voids completely when fixing the preparatory layers, but a series of anchors should be produced at strategic points in order to fasten the plasters to the wall. Excessive grouting of every void could lead to mechanical stress within the original fabric or within the layers themselves, and this could result in their separation from the sound adjacent and untreated areas. Therefore, it is necessary to equalize as far as possible the distribution of the grouting

9. Fixing of Paint layer: The re-adhesion of the paint layer to the ground or preparatory layers must be carried out employing adhesives that can be easily dissolved and must not dissolve pigments making the paint layer.

Characteristics of adhesives and consolidants for paint layers and white-washes[15]

- a consolidant should penetrate well and impart structural strength;
- an adhesive should have good bonding and cohesive characteristics and not pull away parts of the object along the links while setting or during joint-failure;
- all materials should remain reversible and retreatable;
- no material should discolour or break down, giving off harmful by-products, while ageing;
- no material should be highly acidic or highly alkaline;
- no material should be used whose removal involves prolonged contact with water;
- no material should be used which requires the use of heat or produces heat while setting;
- no material should be used which would change the visual appearance of the object. (Snow et al. 1984: 142).

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[15] Extracted from Section 4.2.3.3 Annexure IV - Report on "Recommendation on the Protection and Conservation of Mural Paintings and Architectural Decorative Works of 2162 Ananda-ok-Kyaung at Pagan",UNESCO October 2017 prepared by Rodolfo Luján-Lunsford.

- no material should be highly acidic or highly alkaline;
- no material should be used whose removal involves prolonged contact with water;
- no material should be used which requires the use of heat or produces heat while setting;
- no material should be used which would change the visual appearance of the object. (Snow et al. 1984: 142).

Equipment & materials for fixing separated paint layer and lime-washes[16]

Equipment	
Buckets	Plastic containers with lid, various sizes
Soft plastic sponges	Dry cloth or wiper
Syringes 20 & 50 cc capacity	Hand water-sprayers
Thin hypodermic needles	Soft bristle brushes
Graduated cylinder in cc	Double headed iron spatulas
Materials (subject to confirmation and testing)	
Clean & distilled water	Hydrophilic cotton wool
Tissue paper	Surfactant: Benzalconium chloride, for instance
Micro Acryl Cv40	Alternative: denatured Ethyl alcohol IMS
Nanometric colloidal silica	Electrostatic dry cleaning sponge (Wishab)

Preparation of the surfactant and adhesive mixtures for paint layer and lime washes[17] :

The surfactant and adhesive mixtures should be prepared based on careful tests to determine the most suitable solution.

The adhesive solutions are prepared according to the behaviour of the overlaying coatings/varnishes that can be too hard to be swollen and flattened so the levelling of the paint layer will necessitate higher concentration of adhesive to be kept in position. Therefore, the percentage of the solutions of the adhesives/consolidants to employ can vary. Possible options range from 2% to 15 % in distilled water for the nanometric colloidal silica and from 3% to 10 % for the MicroAcrylCv40. Tests must be carried out beforehand so as to select the percentage that is the most appropriate.

10. Procedure of fixing separated paint layer or lime-washes: starting from the bottom to the top[18]

Previous any procedure for fixing micro-scaling/flaking, crest-shaped separation, bursting or pustule detachments of paint layer, the surface must be carefully inspected under raking light so as to define eventually their repositioning strategy. In addition, plasters should be sound or at least sound enough to tolerate weak pressure. Therefore, the paint layer must be repositioned and protected with tissue paper prior fixing the plasters and finally re-adhered to the surface as described here below.

Fold to a reasonable size tissue paper, wet (can be with the lips) the folding and tear along them, obtaining a

[16] Extracted from Section 4.2.3.3 Annexure IV - Report on "Recommendation on the Protection and Conservation of Mural Paintings and Architectural Decorative Works of 2162 Ananda-ok-Kyaung at Pagan", UNESCO October 2017 prepared by Rodolfo Luján-Lunsford.
[17] Ibid
[18] Ibid

fringed margin. Clean cuts made with scissors might mark the painted surfaces. Wet eventually the paper and allow drying so as to remove the sizing, becoming soft and malleable. Place the paper on the painted surface and with a hand-spray or a soft bristle brush apply water mixed with a surfactant until soaked and the flakes/scales, etc. are swollen, becoming more malleable. This mixture can help in the process of penetration of the adhesives under the layer.

Inject or spread with a brush or a hand water-sprayer a solution of a suitable adhesive.

Press back very carefully, flakes/scales employing a piece of soft plastic sponge dampened in water. While pressing, remove excess of adhesive and rinse the sponge thoroughly.

Continue to press with dampened cotton wool.

Remove tissue paper while damp taking care that it does not remove paint layer fragments. If there are some tiny fragments of paint adhered to the tissue paper, just put it back in the same position as it was and with a brush with the adhesive employed, apply on the paper and press back as explained above, when sure of having adhered the small fragments remove the paper and allow to dry.

The paint layer or lime-washes have regained homogeneity and are sound enough to tolerate the removal of eventual coatings with suitable solvents. The paint layer should make a sharp sound not dull but glittering when brushed with the fingernails using the upper side of the hand.

Protection of painted surfaces prior treatments

Removal of dust from, and protection (application of a waterproof coating) of the painted surface will be carried out on those areas that will be treated. Required properties of materials (consolidants) employed in consolidation of plasters, renderings, or paint layer/lime-washes lacking cohesions[19]:

- the chosen consolidant and the application method should not cause damage to the plaster or should not hinder further consolidation or make it impossible;
- the consolidated plaster must be strong enough but not too strong;
- The consolidant has to penetrate as deep and homogeneously as possible in order to avoid lamination effect which will cause stress between the weaker and the stronger layers. These stress points will cause damage in the plaster itself or loosening cohesion from the support,
- The chemical composition of the consolidant is as similar to the material to be consolidated. A new composite material has not to be formed by the consolidant;
- The consolidant has to behave similarly in ageing, thermal expansion and shrinking to the original material;
- It should not change the refractive index or cause discolouration or glossiness of the surfaces;
- a consolidant should not obstruct the porosity of the constitutive materials and allow water vapour exchange;
- the consolidant should not acidify by ageing. (Peterson 1982: 53-61)

[19] Extracted from Section 4.2.3.4 Annexure IV - Report on "Recommendation on the Protection and Conservation of Mural Paintings and Architectural Decorative Works of 2162 Ananda-ok-Kyaung at Pagan",UNESCO October 2017 prepared by Rodolfo Luján-Lunsford.

Equipment & materials for the consolidation of preparatory and paint layers lacking cohesion[20]

Equipment	
Plastic containers	Soft sable brushes
Syringes 20 & 50 cc capacity	Glass drip bottle ½ Lt cont.
Thin hypodermic needles	Hand water-sprayers
Soft plastic sponges	
Materials (subject to further confirmation and testing)	
Ethyl silicate Wacker OH	MicroAcrylCv40
Distilled water	Nanometric colloidal silica
Demineralised water	Ethyl alcohol

Preparation of the consolidating mixtures[21]:

The consolidating mixtures are prepared as established during the trial tests that determined the suitable percentage to employ. One option is to prepare these mixtures with the adhesive solutions described above with distilled water for the nanometric colloidal silica and demineralised water for MicroAcrylCv40. It is advisable that organic consolidants (e.g. Micro Acryl Cv40) should not be employed outdoors because can give rise to development of micro-organisms, therefore it is recommended the use of inorganic ones such as the Nanometric colloidal silica.

11. Procedure for edging the open borders of the lacunae[22]

Remove dust and clean the borders of the lacunae, wetting before the application of the plaster.

Prepare a mixture similar to the original material and fill the gap between the plaster or the rendering and the support using a small spatula. It is not necessary to cover the entire borders of the lacunae but must concentrate only on filling the gap, avoiding overlapping onto the original material. If the lacunae will not be filled, such edging (if compressed as a fillet) will be visually disturbing and will modify the natural aspect of the broken contours. The procedure must be done carefully, and the plaster must be applied while compressing it well to avoid any cracks.

If the edging is intended to seal joints and therefore to prevent the flow of grout, the area should be dry when grouting. Water can be injected to check if the sealing is effective. If it flows out, the gap must be resealed.

The appearance of the filled border must be as similar as possible to the original cracked/nervous borders, matching in colour and texture with the original, and not, as found in many monuments, looking like a fillet or band of compressed plaster that frames and divides the lacuna with the painted plasters, renderings, stuccoes, etc. This is optically distracting since it is seen even before the viewer looks at the original plaster, rendering, or

[20] Ibid
[21] Extracted from Section 4.2.3.4 Annexure IV - Report on "Recommendation on the Protection and Conservation of Mural Paintings and Architectural Decorative Works of 2162 Ananda-ok-Kyaung at Pagan",UNESCO October 2017 prepared by Rodolfo Luján-Lunsford.
[22] Extracted from Section 4.2.3.7.2 Annexure IV - Report on "Recommendation on the Protection and Conservation of Mural Paintings and Architectural Decorative Works of 2162 Ananda-ok-Kyaung at Pagan",UNESCO October 2017 prepared by Rodolfo Luján-Lunsford.

painting.

The reconstitution of the original stratigraphy must take into account the deformities of the surrounding plasters so as to match the ancient craftsmanship with the new one. Moreover, lacunae filled up to the paint layer level are subject to pictorial restoration and therefore their surfaces must be smooth but slightly rough (the roughness can be achieved by passing the fingertips with a rotating movement over the surface while setting) so as to allow the pigments to adhere. Avoid smearing the mixture onto adjacent areas in order to avoid white stains.

Filling of lacunae, cracks and grouting holes under the final layer level

The filling of lacunae under the paint layer level should be carried out only if this is necessary to enhance the pictorial text, avoiding deep contrasts of shadow and light in order to allow the visual appreciation of the paintings without abrupt interruptions.

Procedure of filling of lacunae, cracks and grouting holes under the final layer level

The procedure is explained above, filling lacunae at the paint or stucco moulding layer level. The exception is that the layer under the paint layer level should match the characteristics of the stratigraphy of the original preparatory layers. The filling should be applied without sloping towards the border of the lacuna, but should appear as if passing underneath it. The mixture of the plaster should be similar to the original, taking into account that texture and colour must exactly match.

The filling of lacunae in general is a technical operation that requires great sensitivity and sense of unity within a given architectural/pictorial context. The treatment reinforces the structure that supports the painted scenes and decoration, but it must not physically or visually overwhelm the pictorial or stucco mouldings text. In addition, the technical skill required to fill deeper voids and gaps within the pictorial/architectural context should aim to enhance perception, avoiding problems that can be created by contrasts of brightness and shade.

12. Filling of Lacunae, cracks and holes made for grouting[23] :

The losses of plasters in relation to the paint layer, stucco mouldings and renderings are filled according to the principles of aesthetic re-integration and presentation, which is the reconstitution of the potential unity of the work of art:

- at the paint or stucco moulding layer level: limited in surface area and capable of being ethically (according to a code of best practices) reconstructed;

- Under the final layer level according to stratigraphy: the plasters and renderings should match in colour and texture with the original that are not subject to total integration/reconstruction. The filling of lacunae under the final layer level involves a series of technical treatments that must be carried out with great sensitivity and skill, in that the appearance of the original and the new must be perfectly blended.

Filling of lacunae, cracks and grouting holes at the paint or stucco moulding layer level

[23] Extracted from Section 4.2.3.7.3 Annexure IV - Report on "Recommendation on the Protection and Conservation of Mural Paintings and Architectural Decorative Works of 2162 Ananda-ok-Kyaung at Pagan",UNESCO October 2017 prepared by Rodolfo Luján-Lunsford.

The lacunae that can and should be filled at the paint layer level are those that must be necessarily reconstructed according to a code of best practices for a better comprehension of the pictorial text by matching/jointing lines, etc., found in the composition. Important details such as figures, heads, hands, etc., or elements of which the exact outline is unknown must be avoided since these can be subject to artistic and subjective interpretation, falsifying the original artist's intentions.

Procedure of filling of lacunae, cracks and grouting holes at the paint or stucco moulding layer level

- Remove dust and other deposits from the surface to be filled.

- Prepare a mixture of similar materials and components as found in the preparatory layers to be filled, in order to restore the original stratigraphy. The thickness, granulometry and colour of each layer should match those of the surrounding renders.

Wet the area to be filled taking care that water does not run over the painting beneath.

Apply the mixture with a trowel or double-headed iron spatula depending on the size of the lacuna to be filled. It is recommended that the plaster be applied at the centre of the lacuna and then spread towards the border with the point of the spatula, paying attention not to go beyond that border. Care must be taken to press along the border between the lacuna and the original render so good adhesion is provided. It is essential not to cover/overlap on the adjacent areas of plasters, renderings, and painting.

The reconstitution of the original stratigraphy must take into account the deformities of the surrounding plasters so as to match the ancient craftsmanship with the new one. Moreover, lacunae filled up to the paint layer level are subject to pictorial restoration and therefore their surfaces must be smooth but slightly rough (the roughness can be achieved by passing the fingertips with a rotating movement over the surface while setting) so as to allow the pigments to adhere. Avoid smearing the mixture onto adjacent areas in order to avoid white stains.

Filling of lacunae, cracks and grouting holes under the final layer level

The filling of lacunae under the paint layer level should be carried out only if this is necessary to enhance the pictorial text, avoiding deep contrasts of shadow and light in order to allow the visual appreciation of the paintings without abrupt interruptions.

Procedure of filling of lacunae, cracks and grouting holes under the final layer level

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The filling of lacunae in general is a technical operation that requires great sensitivity and sense of unity within a given architectural/pictorial context. The treatment reinforces the structure that supports the painted scenes and decoration, but it must not physically or visually overwhelm the pictorial or stucco mouldings text. In addition, the technical skill required to fill deeper voids and gaps within the pictorial/architectural context should aim to enhance perception, avoiding problems that can be created by contrasts of brightness and shade.

3.2 Upgrading site conditions to improve the health of the building by preventing water infiltration and provision of appropriate water management at all levels

Efficient site drainage is critical for the structural health of any building. In the absence of effective drainage, surface water can potentially accumulate in low lying areas around the building or pool against the plinth wall or foundation. Infiltration of water results in rising damp through capillary action, which leads to pulverization of bricks, loss of historic mortar, and loss of plaster caused by mostly by efflorescence (lack of adhesion and lack of cohesion) and lastly growth of vegetation in and around the building. Altered ground levels which result in poor drainage could be due to erosion of the soil over time or alteration of the ground level by human intervention such as collection of debris, or dumping of soil.

a. Guidelines for intervention

1. The ground level to be carefully dressed in slopes to take the water away from the building.
2. No new building or structures should be allowed to be built around the drainage system
3. Temporary structures/shelters abutting the historic building edge should be relocated.
4. Re-assemblage of broken sandstone elements[24]

b. Recommendations

1. To protect the brick structures from water ingress and to enable drying action of the plinth walls as well as to prevent water collection, a soft treatment/ breathable surface i.e. plinth protection is proposed along the plinth walls after the levelling the ground to take water away from the structure. The 1000 mm wide plinth protection is recommended to be built around the base of the building with flat broken brick bats set in lime mortar (evidence can be found along the northern edge of the plinth). The debris and soil dumped along the southern side of the building should be removed and the drains(former intervention by DoA) created to drain the water away from the building to be dismantled

c. External Interventions

2. Correction of slopes and gradients: The ground on the external periphery of the monastery should be levelled and provided with proper slopes to drain the water away from the building.
3. Removal of vegetation growth: the vegetation at the base of the external face of plinth walls or in close proximity should be removed without causing any damage to the historic fabric to avoid water clogging at specific junctions.
4. Relocation of temporary shops: The temporary shop abutting the north –eastern edge of the monastery should be relocated.

[24] Extracted from Section 4.2.3.9 Annexure IV - Report on "Recommendation on the Protection and Conservation of Mural Paintings and Architectural Decorative Works of 2162 Ananda-ok-Kyaung at Pagan",UNESCO October 2017 prepared by Rodolfo Luján-Lunsford.

5. Prohibiting the storage along the plinth wall: The scaffoldings, pots, tin sheets, tiles stored along the western plinth wall should be removed and stored away from the building to avoid accumulation of water.

6. Management of the trees along the plinth: The tamarind trees along the eastern edge of the building require pruning to ensure that the branches do not sway / hit against the walls of the building; also the younger trees along the western edge to be transplanted to prevent adverse impact of the roots on the plinth wall.

7. Provide plinth protection in brick bats and lime mortar on the periphery of the plinth of the monastery.

d. Internal Intervention

8. Opening up Water Spouts: The rain water spouts on the plinth and upper level (terrace) require to be opened up for effective drainage of water and prevent infiltration of water. Stone water spouts following the original details are to be provided in areas where they are missing, to be laid in slope where the water spouts are broken, weathered or missing.

9. Removal of debris/stacked bricks: The stacked bricks on the western edge of the upper level must be removed to avoid water collection at the north western corner and also to remove extra load from the structure

10. Removal of later additions: The modern intervention of the layer of cement concrete flooring over a layer of bricks should be removed from flooring at plinth level and internal corridor to achieve the original level.

11. Trial trenches: is also recommended to do a shallow pits to investigate the historic floor level of the internal and external areas. The findings of the excavation should be recorded with photo documentation and drawings which will guide the process of next steps.

12. Providing conservation measures to prevent rising dampness and humidity in the building through minimally invasive innovative technology- 'Aquapol': As described on their website, "The Aquapol masonry dehydration system is a self-contained rising damp remedy system. The heart of the system is a small, lampshade-like device which is installed onto the ceiling. The device uses wireless technology to dry out the walls and it can be used for the dehydration of walls above and below ground level" .

3.3 Restoring the architectural integrity of the monument by reconstruction of lost features matching the original

The use of brick corbelling in the making of architectural details is a high value attribute of construction seen at Bagan. It is important to restore these architectural details, lending to improved readability of the architectural design. Restoration of brickwork is therefore recommended as an intervention of conservation, where loss is witnessed, towards recovering the architectural integrity of the monument.

1. As a norm, repair rather than reconstruction as a strategy is recommended to be employed. Where character-defining elements are severely deteriorated to conserve and where sufficient physical evidence exists via surviving prototypes, only then reconstruction is recommended to be undertaken. The intervention to match the forms, materials and detailing of authentic versions of the elements under consideration.
2. All interventions to be based on sound research of design, form, materials, and construction techniques (determined on the surviving elements in the building).
3. Where reconstruction of masonry is recommended to be necessary and still exhibits remains of high value plasterwork, the strategy for reconstruction is provided by the art conservator towards addressing the plasterwork.[25]
4. Areas where loss of masonry is witnessed- these are built features which are- by way of design, construction, location or other- intrinsically most vulnerable to damage – like the finials of a building. Strategies for reconstruction may thus need to include added attributes using recognized conservation methods, such as providing a sacrificial layer of plaster/ coping (informed by historic details), or adding reinforcement through anchoring etc. Impact of the interventions to be informed by non-destructive scientific studies such as computer modelling.
5. In continuing with the same principle, establishing post-repair preventative conservation strategies, such as periodic maintenance, are paramount to a sustainable conservation strategy.
6. Documentation of any intervention for future reference is necessary to record the history of repair in the building.
7. As a principle for reconstruction, the new work should be physically and visually compatible with, and possibly subordinate to and/or distinguishable from the historic fabric. For instance, repairs as a norm should be in matching physical and chemical compositions or in one 'softer' than the original, so any loss that occurs, occurs from the repair not in the original material.
8. Any new brickwork proposed on the roof/ terrace level- such as the reconstruction of the crenellations and dormer- is bound to increase the dead load on the building, and thus requires to be vetted by a structural engineer.

a. Recommendations

1. Reconstruction should follow the exact architectural design, materials and construction technique founded in understanding derived from areas in the building where the most authentic and intact representation of

[25] For details, see Annexure 4: *Recommendations on the Protection and Conservation of Mural Paintings and Architectural Decorative Works of 2162 Ananda-ok-kyaung at Pagán by By Rodolfo Luján-Lunsford (Paintings' Conservator-Restorer - UNESCO Consultant).*

the feature/s exist.

2. Before work is started, the surrounding masonry must be cleaned of all debris, accretions, and micro biological growth, weak materials (pulverised bricks or mortars) and appropriately raked to prepare the area/ surface for further work. This must be done carefully using least invasive techniques, such as with soft natural bristle/ nylon brushes. Precautions to be taken to prevent injuries due to falling pieces.

3. The dismantled loose historic material should be reused as far as possible.

4. Special care must be taken while working so that floor/base is not damaged. Scaffolding may be propped against the face of the building with suitably padded buffer. Piercing of walls for scaffolding supports shall not be permitted.

5. Reconstruction is to be undertaken in bricks and lime mortar matching the historic in both physical and chemical properties to ensure that the new brickwork is compatible with the historic- with respect to porosity, strength etc. avoiding any adverse reaction as has been witnessed by the use of incompatible materials in the past. Laboratory tests should be conducted to this end. Results of the laboratory tests will determine the following*:*

    - Physical and mechanical properties of historic materials, specifically relating to porosity, material composition, compression strength etc.

    - Establish a range under which the material properties of the bricks recommended to replace the incompatible intervention must fall under, to ensure the material integrity of the building is not compromised.

3.4 Deriving material authenticity – removal of incompatible interventions and undertaking interventions for consolidation in matching masonry, binders and finishes

Efficient site drainage is critical for the structural health of the building. In the absence of effective The use of compatible materials is paramount for conservation initiatives to be sustainable and to protect the authenticity and integrity of a building and its fabric.

Guided by a strategy of minimal and need-based intervention, reversal is proposed in areas only where the interventions have proved non-benevolent. Causes of decay and decay has been understood in two categories - Non- Benevolent (NB) – indicating high/active risk impact, and Benevolent (B) – indicating low /medium risk impact. 'NB' therefore indicates a cause of decay or decay which is dynamic in nature and seriously impacts the condition of the historic building and 'B' indicates a cause of decay that is not severely harmful or poses a threat to the property and user and also does not significantly impact the condition of the historic building.

3.4.1 Removal of modern bricks in lime/composite/cement mortar and rebuilding with masonry matching the original

a. Guidelines for intervention

For dismantling work:

1. The term 'dismantling' implies carefully separating the parts without damage to other elements. This may consist of dismantling one or more parts of the building as specified indicated on the conservation planning drawings.

2. All demolition shall be undertaken in a careful manner with minimum disturbance to prevent any damage to other parts or to the rest of the building.

3. Precautions: All materials obtained from dismantling or demolition shall be the property of the Government unless otherwise specified and shall be kept in safe custody until they are handed over to the Project Manager.

4. The demolition shall always be well planned and shall generally be done in reverse order of the one in which the structure was constructed. The operations shall be got approved from the project manager before starting the work

5. All work on decorative surfaces shall be carried out by Art Conservators only or under their direct supervision. Precautions to safeguard the decorative surfaces/art works shall be carried out prior to commencement of civil dismantling or demolition works on the building.

6. Utmost care must be taken to ensure that the historic fabric of the building is not damaged in the course of demolition works as well as during conservation works. Special care must be taken to protect floor surfaces.

7. Necessary precautions shall be taken to keep noise and dust nuisance to the minimum.

8. All work needs to be done under the direction of project manager. Helmets, goggle, safety belts etc. should be used whenever required and as directed by the project manager.

9. The demolition work shall be proceeded within such a way that it causes the least damage and nuisance to the adjoining building and the public.

10. Any serviceable material, obtained during dismantling or demolition, shall be separated out and stacked properly as directed by the project manager within a lead of 50 meters. All unserviceable materials, rubbish etc. shall be disposed as directed by the project manager.

11. Screens shall be placed where necessary to prevent injuries due to falling pieces.

12. Water may be used to reduce dust while tearing down plaster from brick work.

13. Safety belts shall be used by workers while working at higher level to prevent falling from the structure. First-aid equipment shall be got available at all demolition works of any magnitude.

14. Any findings should be brought in to notice of the conservation architect. The constructions details will be reviewed on the basis of any new findings after/ during dismantling work. The process requires to be methodically photo documented.

b. Recommendations

For dismantling work

1. Necessary propping, shoring and or under pinning shall be provided to ensure safety of the adjoining work or property before dismantling and demolishing is taken up and the work shall be carried out in such a way that no damage is caused to the adjoining work or property. Wherever specified, temporary enclosures or partitions and necessary scaffolding with suitable double scaffolding and proper cloth covering shall also be provided, as directed by the project manager.

2. Dismantling shall be done in a systematic manner. All materials which are likely to be damaged by dropping from a height or by demolishing roofs, masonry etc. shall be carefully removed first. Chisels and cutters may be used carefully as directed. The dismantled articles shall be removed manually or otherwise, lowered to the ground (and not thrown) and then properly stacked as directed by the project manager. This requires expertise with skilled man power and mechanical machinery.

3.4.2 Removal of incompatible pointing from areas proposed to be plastered

a. Guidelines

1. Conservation planning for the monument is guided by a strategy of minimal and need-based intervention, reversal is proposed in areas only where the interventions have proved non-benevolent. In areas where plasterwork is considered not necessary or is in the category of 'desirable' (that is as, long term strategy), pointing must not be removed to avoid damaging the building further.

2. The reversal of the intervention is necessary as it is incompatible to the recommended surface finish. Due to the nature of the material, cement mortar or cement based mortars (like the composite mortar) used will have a tendency to retain moisture in the building thus accelerating decay.

b. Recommendations

1. A strategy for plastering- as necessary -has been proposed by the conservation architect's team towards protection of masonry as a sacrificial layer, specifically for the building elevations and external plinth elevations

2. Raking out joints undertaken in composite (lime and cement) or cement mortar from brick work and preparing the surface for re-pointing or plastering.

3. When raking is undertaken in joints of original masonry, great care is to be taken such that the edges and surfaces of the brick are not damaged with the chisel. When the cement pointing is hard and compact, a narrow/ fine chisel is to be used

4. The surface of the masonry must be cleaned of microbiological growth, efflorescence etc. before plasterwork is started.

5. Plastering the surface

3.4.3 Dismantling and re-laying of flooring in the internal areas

a. Guidelines

1. The process of dismantling/scraping of modern interventions to ensure no damage is done to the building during the process of work.

2. Due precautions have to be taken to support the internal vaults below (on the ground floor) in the building during work is in progress. Scaffolding and shoring/ propping to be designed and provided to ensure any adverse vibrations to the building are mitigated during dismantling work.

3. Any intervention, such as laying of lime/ cement concrete, which may add additional dead load onto the building, must be duly endorsed by the structural experts.

b. Recommendations

1. The plain cement concrete on the ground floor (lower level) must be carefully dismantled/ scraped using a hammer and chisel, with broken finer materials removed using nylon brushes.

2. All broken masonry and loose mortar must be consolidated and stabilized/ reconstructed before laying of the lime concrete.

3. Lime concreting is to be laid as a step towards consolidation of the terraces. Proportions to be determined by laboratory test of the materials and research on the details of historic flooring.

3.4.4 Repairing of cement concrete roof to protect for water seepage

a. Guidelines

1. Keeping in mind that the existing cement slurry is benevolent intervention and has prevented seepage of water into the built fabric, it is recommended that it be retained as removal will cause possible dislodging of the historic fabric. Additionally, where joints are loose on the terrace (where cement concrete has been

used), it is recommended to be pointed in lime: cement mortar (composite mortar/ if not successful with the matching mortar of the parent material) to close joints.

2. Precautions and preparatory work also requires the input from the specialist.

3. Due precautions have to be taken to support the internal vaults below in the building. Scaffolding and shoring/ propping to be designed and provided to ensure any adverse vibrations to the building are mitigated during dismantling and/or implementation of new work.

3.5 Cleaning surfaces and finishes to protect masonry (brickwork) and stonework

3.5.1 Cleaning of micro vegetation

a. Guidelines

1. Removal of micro vegetation must be done very carefully using non-abrasive tools, ensuring no damage is done to the surface of the material and historic architectural design and form is retained.

2. The source of the water ingress/ dampness requires to be identified and interventions towards water management need to addressed, towards a preventative conservation strategy.

3. All interventions to the surface are to be undertaken under the supervision of the Art Conservator.

b. Recommendations

1. Removal of micro vegetation from stone, plaster and brick surfaces:
   - Removal of micro vegetation from the surface [historic surfaces] must be done by dry brushing.
   - The process includes scrubbing off the loose algae with jute brush (or any non-ferrous tool) lightly in circular motions ensuring that the process does not result in any chipping or flaking of stone
   - Finally clean the surface with potable water by light sponging.
   - No chisel is to be used.
   - It must be ensured that work is done keeping intact the historic design, without damaging the historic fabric under the close supervision of an Art Conservator.

3.5.2 Cleaning of Efflorescence from the brick surfaces

a. Guidelines

1. Removal of efflorescence must be done very carefully using non-abrasive tools, ensuring no damage is done to the surface of the brick or stone

2. The source of the water ingress/ dampness requires to be identified and interventions towards water management need to be made, towards a preventative conservation strategy.

b. Recommendations

1. Removal of efflorescence to be undertaken by application of a poultice.

3.5.3 Plasterwork to protect the masonry, as a means of preventive conservation

a. Guidelines

1. Lime plasters, besides being a building embellishment, are fundamentally a sacrificial layer to protect the masonry from environmental factors and effects of water ingress.

2. Plastering is thus proposed as a necessary preventive conservation strategy to protect the masonry[26].

3. Brickwork on which plaster is to be done must be adequately conserved before plasterwork addressing issues of decay, specifically, loss of mortar, pulverization, dislodged masonry, vegetation, micro-vegetation and efflorescence.

b. Recommendations

1. Plastering work to be done with lime plaster of thickness and composition matching the historic plaster including preparation of mortar by traditional methods (by pressure mixing in mortar mill) in three courses of base coat and finished coat including tamping, beating, curing until all shrinkage cracks disappear. Each coat must be done after 3 days of the previous coat.

2. All surfaces which are to be plastered shall be thoroughly wet for 24 hours before commencing plasterwork and shall be kept appropriately damp, not wet. The surface must not be kept too wet, as the plaster is then likely to fall out. During the course of work, it is essential to maintain uniform suction of water by receiving surfaces, which shall be ensured by damping evenly all dry patches before applying plaster.

3. Surfaces to be plastered shall be thoroughly cleaned of all dust, grease, oil, and loose mortar. The entire surface shall then be thoroughly washed with nylon brush and clean water.

4. The joints should be raked 20 mm deep to provide for key to plaster. When raking is undertaken in joints of original masonry, great care

5. Piercing of walls for scaffolding supports shall not be permitted.

6. The thickness and composition of lime plaster must match the historic plaster.

7. Curing must be done for 21 days with help of water spray pump on the final plaster layer. Utmost care must be taken to prevent water logging that may take place at the time of curing the works. Any spill over of water must be avoided on the mural paintings in case the plaster work is being undertaken in internal areas of ground floor.

8. Work must be undertaken under the supervision and approval of the art conservator and conservation architect who will inspect and approve all work.

[26] For details, see Annexure IV: *Recommendations on the Protection and Conservation of Mural Paintings and Architectural Decorative Works of 2162 Ananda-ok-kyaung at Pagán by By Rodolfo Luján-Lunsford (Paintings' Conservator-Restorer - UNESCO Consultant).*

3.6 Repair, restoration and consolidation of damaged masonry

3.6.1 Repairs to areas with loss of mortar

a. Guidelines for intervention

Based on the ***intensity (in depth)*** and ***expanse (in surface area)*** loss of mortar in a particular area, the recommendations for repair will differ.

In areas where loss of mortar has caused extensive damage and is experienced alongside dislodging of bricks from their original profile, the masonry is proposed to be:

1. Carefully dismantling – Dismantling shall always be well planned before hand and shall generally be done in reverse order of the one in which the structure was constructed. The operations shall be got approved from the project manager before starting the work.

2. All materials removed shall be marked as they are removed, so as to clearly show where they have been removed from, and shall be kept on the site and protected from damage until they are inspected by the Conservation Architect. Marking of the historic material is essential. Each member/ material unit should be carefully removed, numbered and stacked carefully. A system should be adopted to number the members. The members will be numbered in the following manner: level no/ room no/ member no (to be numbered from north to south or east to west).

3. During/ before dismantling the dislodged brickwork, the area must be carefully and comprehensively supported using propping and shoring.

4. The original material of the damaged monument should be salvaged and used for reconstruction purposes as much as possible as good practice to avoid loss of original material and uphold material authenticity of the historic fabric. All historic bricks to be thus reused must be checked to ensure they are free of surface decay and deposition, such as microbiological growth, soot, dust, efflorescence and do not suffer from pulverization of more than 1/4th in depth- if this is the case then the brick must be replaced.

5. Rebuilding is to be done in the design, form, and system of construction matching the historic, re-using the historic bricks with fresh lime mortar. As good practice, historic materials must be reused as much as possible during conservation work.

6. The area must then be either pointed or plastered depending on the recommended strategy.

In areas where loss of mortar has caused minimal damage, the surface is proposed to be:

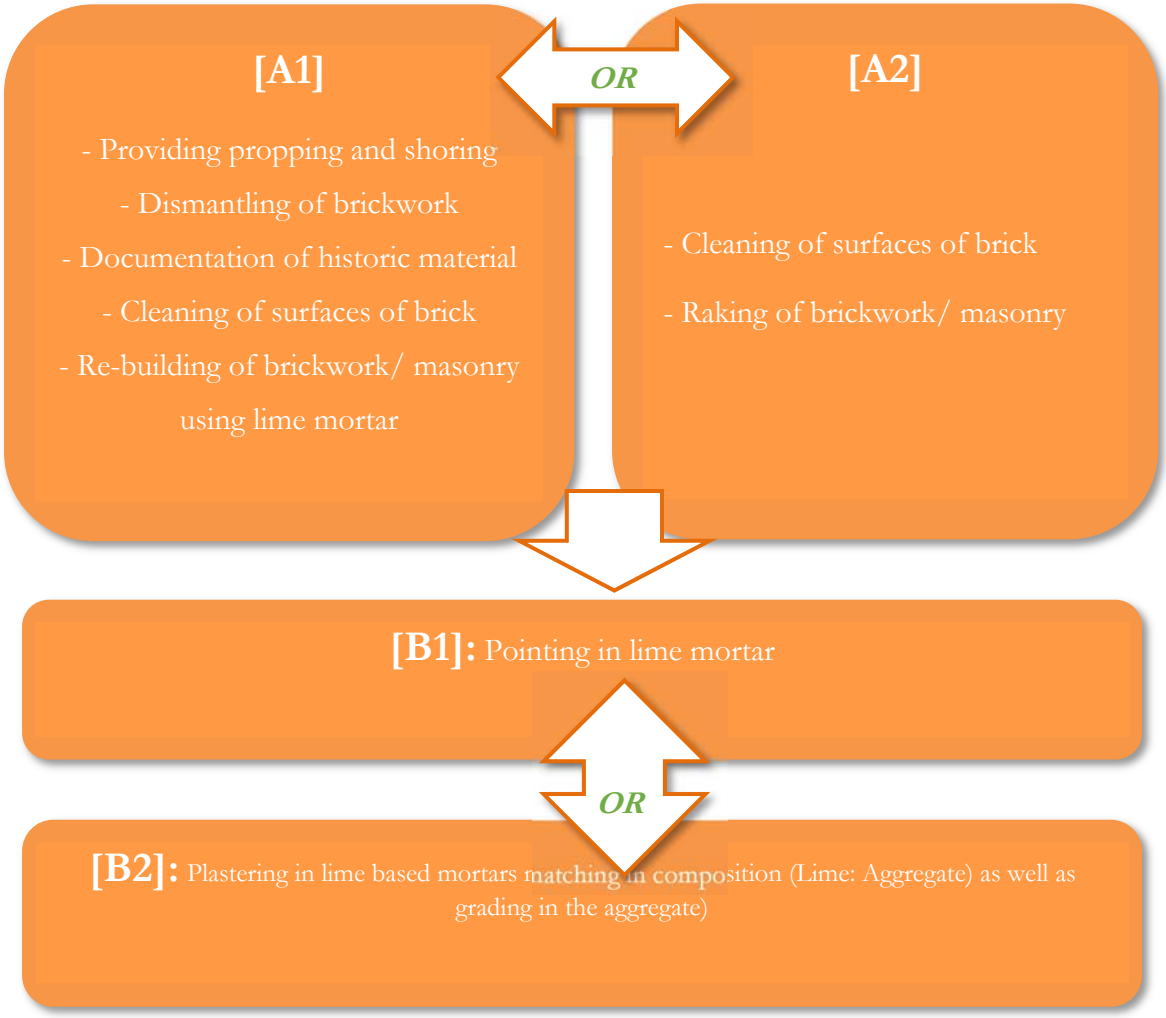
7. Raked and cleared of historic debris, followed by pointing or plaster to the surface.

8. The surface of brickwork must be thoroughly cleaned of any decay or deposits.

9. The process and proposal requires to be documented as good practice to record the history of repair in the building.

b. Recommendations

The following sequence and combination of steps is to be carried out to address the problem:



3.6.2 Reconstruction of bulging and dislodged brickwork of low-medium value at high risk

a. Guidelines

1. All dislodged and out of plumb brickwork which is observed on low to medium value attributes are considered high risk features and are recommended to be dismantled and rebuilt.

2. Where external stimuli, specifically vegetation growth, have contributed to the decay, these shall be appropriately removed or controlled.

    i. In case of vegetation as decay, interventions such as cutting of trees, killing trees through injecting chemicals, or selective pruning are undertaken. The action to be taken should be defined by kind of vegetation, current state of growth, impact of vegetation and significance of the component impacted
    ii. Fully grown plants can be controlled by cutting them down with sharp tools without damaging the fabric of historic structure.
    iii. For a small plant growth / initial stages, most effective method is physical uprooting of the plant.
    iv. Vegetation growth generally takes place when there is a crack, loose masonry, missing masonry or open joints. After removal of plants, cracks/loose masonry/open joints should be repaired to prevent any further growth.
    v. Regular care of the monument can prevent growing of trees.
    vi. Water being necessary for plant growth in the monument, it is most important to prevent water seepage //infiltration into the masonry of the structure.

3. Eradication of Infesting Plants

<u>Choice of methods of control:</u>

- location of the species to be controlled, as security distances, which can vary from species to species, between plants and archaeological structures should be established;
- the age of plants, related with their different patterns development;
- the eventual naturalist value, in view of environmental and landscape protection;
- the social-religious importance of some species, as for example the Ficus religiosa, which has often being planted near temples and venerated places and should therefore eliminated in cases of real need.

This information can be only obtained through a survey on site, which can map the necessary data.

As stated above, on the basis of obtained data methods and idoneous products will be indicated and should be suitable for the specific causes identified (e.g. age and varying distances of plants, etc.). However priority will be given to the problems posted by Ficus religiosa, Ficus rumphii, Capparis flavicans and Capparis horrida, which furthermore are those which cause most damage and are also the most difficult to eliminate.

The elimination of these species with standard mechanical methods really becomes very difficult. At first we are talking about species with a high capacity of proliferation of their primary and secondary meristemae; which allow them to react to the cutting of portions emerging from the ground and from their own roots, through

the re-emission of new suckers. The total removal of roots is extremely problematic both for the extension and ramification of these radical organs, and for the practical non-feasibility of such a procedure, especially when their growth concerns wall or paved surfaces which will be irretrievably damaged. The possibility of the procedure resulting ineffective is therefore due to the previously described fact, since a residual presence of unremoved growing portions can easily result in the further emission of suckers; with the consequence, the opposite to that intended, that the fragmentation of the vegetative structures will result in a method of propagation rather than control of the infesting species.

Regarding the above mentioned considerations, it is necessary to resort to control with chemical methods employing suitable weed killers for this field of application. Such requirements for biocide products employed in archaeological areas are:

- effectiveness of the product against the species to eliminate,
- suitable toxic characteristics for the safety of the applicator and the environment,
- product interference with the substrata.' (Vero Barcellona 1991:17-22).

Equipment & materials for the eradication of infesting plants growing on the monuments

Equipment:

Bristle brushes of various sizes	Soft plastic sponges
Buckets	Hand drill & drill bits
Hand water-sprayers	Plastic containers
Plastic syringes 50 cc content	Graduated cylinder in cc
Stainless steel surgical scalpels	Knifes, machetes, etc.

Materials:

Clear water	PVAc resin of tar
Biocide: imazapyr, Arsenal formulate Cyanamid	Mastic
Biocide: Paraquat dichloride	Commercial paint thinner

Procedures of application of biocides

1 In case of weeds or young suckers:

- spray of biocide solutions dissolved in water (1-2%) up to complete wetting of the leaves.

2 In case of trees or shrubs of a certain size:

- cut down stumps to the root heads,
- drilling holes into the external portions of the emerging roots (e.g. such is the case of the Ficus religiosa primary roots) in order to facilitate the injection of the product,
- injection of biocide solutions carefully calculated (10 – 20 % dilutions),
- brushing waterproof mastic over the exposed treated stumps.

3 In case of roots emerging from renderings:

- brushing over biocide solutions (10 % dilution) after removing the external bark.

Doses to be employed vary depending on the plant bio-mass but can be approximately calculated to around 20 30 cc of biocide product (in its commercial form and not in its natural state) up to a maximum of 50 cc in the case of stumps of large dimensions (diameter 40 cm) with thick emerging roots.

Finally, it must be noted that in the case of tree like plant roots, which are deeply rooted inside walls, the simple elimination of their external portion is insufficient. In fact, with water infiltrations in such hot and humid climates, they become rotten and their ligneous portions begin to disintegrate. In the case of seriously deteriorated walls, this could provoke their collapse; in such cases, the walls should be dismantled partially to remove roots and then reassembled.

Period of treatment

The climatic characteristics of the zone are characterised by fairly high temperatures throughout the year, with minimum readings during the period December - February and maximum from March to June and by heavy rain, but concentrated during the period from May to October.

In such a tropical climate, seasons vary mostly in the rainfall regime and vegetation does not have much rest in any period of the year. Despite this, the optimum period of treatment is during the months of March and April, before the rainy season starts. Treatment should be carried out during dry days in order to avoid dispersion of the product. Windy days should be avoided as well as the hottest hours of the day.

In case the first treatment carried out in spring is insufficient that is if a new growth of suckers at the base of the cut stumps is apparent, the treatment must be repeated immediately after the rainy season, in November.'

'A more precise description of the interventions should be specified, in order to prepare a botanical and maintenance plan of the area. This is possible only through a first-hand survey on site using suitable methodologies of vegetational analysis and a mapping out of the vegetation.

In such a phase, it should be possible to identify the vegetable associations present and their evolution pattern and the safety distances between different species planted and the buildings themselves.

Such information, that must be collected and studied by specialists in the field, taking into account the existing archaeological reality, is fundamental in order that interventions can be carried out that take into consideration the lead to protect the environmental heritage and to plan future interventions within the entire archaeological complex.' (Vero Barcellona 1991:17-22).

b. Recommendations

1. In areas where vegetation growth is present, generally there are two kinds of methods adopted for removal of plants/trees from the historic structure:

    i. Physical: In this method, the plants are removed by uprooting them in their initial stages of development. Fully grown plants could also by removed by physical method, by cutting them down using the cutting tools without any damage to the historic structure.
    ii. Chemical: In this method certain chemicals are used which are able to kill plants in time of few weeks. These chemicals are usually biocide which are responsible for killing of plants by either stopping the photosynthesis activity or by killing the cells and tissues responsible for plant growth hence killing the plant in few weeks[27].

[27] Known practices by DoA to be considered in selecting the biocide

iii. Manual uprooting of the grass/ plants in the masonry of the structure which are in its earlier growing stage. Clearing and grubbing including uprooting rank vegetation, grass, bushes, shrubs, saplings and trees girth up to 300 mm, removal of stumps of trees cut earlier and removal and disposal of top organic soil not exceeding 150 mm in thickness.
iv. Carefully felling trees of the girth (measured at a height of 1 m above ground level), at all levels, including cutting of trunks and branches removing the roots, ensuring that the historic masonry is not damaged; Girth up to 1800 mm
v. Careful pruning of the trees / cutting of branches, ensuring that the historic masonry is not damaged.

3.6.3 Pulverisation of brick

a. Guidelines and Recommendations

Based on the ***intensity (in depth)*** and ***expanse (in surface area)*** of pulverisation in a particular area, the recommendations for repair will differ.

1. In areas where pulverisation has affected less than 1/4th the depth of the brick and is **not** recommended to be plastered, no intervention is necessary.

2. In areas where pulverisation has affected less than 1/4th the depth of the brick and is recommended to be plastered
    i. The surface is to be built up by applying multiple layers of lime mortar mixed with coarse aggregate (brick pieces) in layers.
    ii. The surface is then to be plastered.
3. Areas where there is high intensity pulverisation is witnessed, i.e., greater than 1/4th the depth of the brick work: The top layer of brickwork showing signs of high intensity pulverization is to be carefully dismantled and replaced with matching brick and mortar to rebuild the brickwork up to the historic surface.

4. This shall be followed by plasterwork or pointing in lime as recommended.

5. Pulverisation is a symptom of a larger risk/ decay being experienced by the building. As described in the section on condition, this could be due to continued water ingress or due to incompatible material interventions and others. Tasks to actively address the underlying cause of decay would be urgently required to mitigate further distress, which has been done and explained in supporting sections of this chapter.

6. The process and proposal requires to be documented as good practice to record the history of repair in the building.

3.6.4 Weathering of brick

a. Guidelines

The extent of weathering noted in the building is not cause for concern structurally, though it does contribute in a benevolent manner to the loss of architectural detailing and thus readability of the building, by faintly subduing the form of some of the character defining elements of the building. Since the decay is seen as benevolent, the strategy for conservation is one focused on preventative conservation measures.

3.7 Detailed guidelines for materials

3.7.1 Bricks

- Bricks shall be sufficiently wet before lying to prevent absorption of water from mortar. The wet bricks shall be kept on a clean wooden platform to avoid earth being smeared on them. Every brick shall be carefully fit to the adjacent masonry so as to form neat and close joints. All brickwork shall be maintained wet for a minimum period of 10 days.

- To ensure the new and historic brickwork is stitched together well, the joints shall be staggered to avoid vertical cracks.

3.7.2 Lime

- This specification lays down the general characteristics of lime to be used for the conservation work. No readymade mortar mixes or dry hydrate limes is to be used for any of the work. The classification of lime to be used for various purposes is as follows:

  Lime for concrete terracing: Class A lime: Hydraulic Lime[28]

  Lime for making lime mortar: Class B lime: Feebly hydraulic lime

  Lime for making lime plaster: Class C lime: Fat lime[29]

- Supply and Storage: The lime to be used for concreting of terrace or Class A lime is to be supplied as hydraulic lime only. The class B and class C shall be supplied as quick lime. Lime supplied as quick lime or lump lime at the site should be in a sealed condition and subsequently stacked in a store or any other place which is dry and under cover well protected from rain. Rejection of Lime: The lump or quick lime having stone pieces, impurities and powdery shall be rejected. The contractor at his own expense shall remove lime, which has been rejected by the conservation architect, from the site of work within 3 days.

- Lime slaking in tank: A tank lined with stone or brick and finished with cement large enough to permit, stirring and hoeing shall be prepared (generally tanks suitable for 5 quintals or 10 quintals of quick lime are used in practice). The tank shall be filled to half its depth with water. Quick lime shall be gradually added till it fills the entire bottom to about half the depth of water. Never add water to lime. While quick lime is being added it shall be constantly stirred and hoed so as to break up the lumps. No part of the lime shall be allowed to expose above water level. As the lime slakes as an exothermic reaction temperature begins to rise and more

[28] Lime containing small quantities of silica and alumina and/or iron oxide which are in chemical combination with some of the calcium oxide content, giving a putty or mortar which has the property of setting and hardening under water.
[29] The lime, which has high calcium oxide content. It is dependent for setting and hardening solely on the absorption of carbon dioxide from the atmosphere. It is used mainly for finishing coat in plastering, white washing and with suitable admixture, such as pozzolonic material to produce artificial hydraulic lime.

water may be added the material may need to be stirred till lime has slaked in entirety, the stirring and hoeing shall be continued during the above process and for some period even after the slaking is apparently over. This whole act has to be done with utmost precaution to the body by covering the eyes with glass goggles and wearing rubber boots.

- Maturing: After the lime has cooled, more water shall be added if required and it shall be left undisturbed for not more than 14 days. The putty shall be allowed to mature but not allowed to dry out till it is used. Therefore the tank will need to be filled with water to allow the slaked lime to be constantly in submerged in water.

3.7.3 Brick dust/ Surkhi

- Surkhi is the powdered burnt bricks, brickbats and is used as an admixture to lime both for making lime mortar and lime plaster. It shall always be obtained from fully burnt or slightly under burnt, but never from over brunt bricks. Surkhi obtained from burnt loam shall not contain any un-burnt soil. Surkhi shall be perfectly clean, free from an admixture or any foreign. Surkhi shall not contain soluble sulphate more than 0.5% for exposed work and work in damp situations and not more than 1.0% when used for works in dry and internal situations.

- Stacking: Surkhi shall be stacked on masonry or wooden platform in regular stacks as of size 2.0M x 2.0M x 0.6M at the places as directed by the conservation architect and shall be protected from dust, rains and dampness and shall be kept under adequate coverings provided by the contractor.

3.7.4 Sand

- Sand used in the making of mortar should be coarse grained, perfectly clean and sharp and preferably of a yellow and variegated colour, physically and chemically matching the sand found in the historic lime mortar. It is recommended that the sand be obtained locally, obtained from local pits or river bed. It is absolutely essential that it should possess the above mentioned qualities in order that a successful result may be obtained for the lime mortar. Fine grained, dusty or dirty sand must not be allowed, and each fresh consignment should be carefully inspected in order to see that it corresponds with the sample approved in the first case. Many sands which would otherwise be of good quality contain lumps of foreign matter, or a quantity of dusty particles. Such sand may with the engineer or conservation architect's consent, be used after it has been thoroughly washed, sifted and without organic materials.

3.7.5 Pozollanas

- Volcanic Ash- As a traditional/ historic practice pozzolanas have been added to lime mortars to augment the strength and setting of lime. It is used in the making of lime mortar along with sand and surkhi. This is specifically for mortars to be used in masonry and concrete. These are not detrimental for the mortar unless fine mortar is needed. Volcanic ash is richly available

around Bagan, especially near Mount Popa, near the Pegu range which could be used as a pozollana.

- Another alternative is lime ash, which is available from the lime kiln and is produced in the process of burning of limestone for the production of lump lime. The ash as obtained from the kiln also contains over burnt pieces of stone or coal and this should not be removed from the ash.

3.7.6 Water

- For all mortars, water used shall be free from mud, clay, and acidic, basic or organic impurities and shall be potable.

3.7.7 Lime mortar

- Proportion[30]: Lime A, B and C class shall be used in the preparation of mortar and shall conform to the specification for lime mortar determined by the laboratory analysis of the mortar in both composition and texture (of the aggregate)

- Preparation of mortar: Mortar mill mixing: It is recommended that the mortar is produced with pressure mixing. This allows for improved strength of the mortar as compared to hand mixing. The traditional technology for preparation of mortars in Bagan is described to be undertaken in large size mortar and pestle while in countries like India mortar mills were built in the earth and large size stone wheels were used to pressure mix.
- In the case of pressure mixing in the mortar mill slaked lime in the required quantity and fine aggregates in proportions and are put along with water in the mill spreading uniformly all along its circumference and ground with a stone mill till a mortar of uniform colour and desired consistency is obtained. As grinding is done the mixture shall be continuously raked and turned over and over specially from corners and sides. Mortar is to be ground to the required consistency depending on the mode of grinding i.e. bullock or tractor for 3 hrs. and 1 and 1/2 hour (at least) respectively. The prepared output has to be then removed to a rectangular pit that would be used for storing of the mortar with enough space to allow the mortar to be mixed well for a short duration using feet (with boots on) before delivering it for application. Volcanic/lime ash must not be added to make mortars for plasters.

i. Sand, *Surkhi* as well as lime putty must be sieved before mixing for the preparation of the mortar for plaster. It must be assured that the mortar does not contain any pieces/ small lumps of lime, it may be found that in many cases small pieces of over burnt lime does not slake and pieces of lime are later found in small lumps in the plasters and mortar. In case the lime has this behaviour, it is mandatory that the lime putty be sieved before it is used in the making of

[30] The composition of the lime mortar and plaster can vary based on the result of the laboratory tests carried out on the actual lime plaster and mortar in the historic building. In conservation work the lime plaster and mortar should match with the original material and composition.

the mortar**.**

ii. Addition of *Surkhi*, or other pozzolonas in the making of mortars gives the mortars the properties of hydraulic mortars i.e. quick setting properties and should be treated like Class A and Class B lime mortars, depending upon the hydraulicity.

- Strengthening of the mortar: The prepared lime mortar can be added with the admixture of soaked fenugreek + beetle nut + jaggery water which should be added only after being filtered properly. The filtered admixture will be thoroughly mixed with the lime mortar and then added with mastic gum (plant sap) for extra strengthening of the mortar in the final knocking of the mortar (before its use). Additives will be added only if they have been found in the historic mortars.
- Storage of Mortar: Lime mortars prepared shall be used up as soon as possible after mixing 2 days for Class B limes from the time of making putty or first grinding. Mortars from Class C limes can be used for periods longer than 3 days after the making of mortar provided they are protected from drying out. The mortar left over at the end of the working hour should be properly covered with moistened jute bags. When the mortar is used after a gap of 2 days it should be sprinkled with limewater and mixed well using feet covered with gumboot.
- Rejection of Mortar: Mortar not found in accordance with the specifications above and unsuitable according to field and laboratory tests of lime mortar shall be rejected. The rejected mortar shall be removed from the site of work within 3 days.

3.7.8 Lime concrete

As a preventive conservation strategy, coping in lime concrete is to be provided over the turrets as a sacrificial layer to protect the built feature. The process to include consolidation, finishing and tampering.

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