GUIDANCE NOTE IN APPROACHES FOR CONSERVATION OF MURAL PAINTINGS AND ARCHITECTURAL DECORATIVE WORKS AT BAGAN

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within the framework of the UNESCO Projects
"Capacity building for safeguarding cultural heritage in Myanmar" funded by Italy
"Safeguarding Bagan within the World Heritage Framework" funded by NFUAJ

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Foreword

The objective in writing these guidance notes is for providing to all the international agencies that wish to implement a project in the site, a unitary approach for facing conservation problems and their resolution in the heterogeneous context of Bagan. However, comments, revisions, additions and contributions are well accepted if these are constructive given that this work is and will be in continuous development. Note that it was employed for the name of the site known nowadays as Bagan (meaning plate in Burmese but written with the same 'P' as in Pyu) the spelling is, according to G.H. Luce in his *'Old Burma, Early Pagan'*, Pagán and not, Pagan referred to paganism.

Introduction

The foundation of Bagan is attributed to the Pyu king Thamudrit in 107 AD 'would be that this date is entirely mythological' (Hudson 2002: 49) but according to other sources and to legend, the city was founded by king Pyinbya in 849 AD. However, 'the archaeological evidence indicates that a settlement was forming at Bagan during the last centuries of the first millennium AD. By the mid 11th century Bagan began to dominate Upper Burma, and the region began a transition from a system of largely autonomous city states to a centralised kingdom. Inscriptions from the 11th to the 13th centuries indicate that as the Bagan Empire expanded it subsumed the agricultural lands that had been developed by the Pyu' (Hudson 2004: 2). The historical evidence relatively supported by epigraphy, attests its existence during the reign of Anawratha (1044-77). Thus, it was the capital of the first Myanmar kingdom since then, after 1044 AD, until it ceased to be in 1297 as customarily has been explained; as a consequence of the Mongol invasions commanded by Kublai Khan in 1287 CE and to the decayed state in which, the monarchy had fallen. Though, the site was never since then, completely abandoned and other significant buildings were constructed during the following centuries until present times. The site of Bagan is located in the central dry region of Myanmar, called *Tatadessa*, this covers an extensive area of 16 square miles (about 41 ½ square kilometres) and includes 18 villages, agricultural fields containing many temples, stupas, monasteries, shrines, etc. that count over 2,800 monuments mainly built in brick masonry.

The walls of the temples, image houses or monasteries were plastered at the interior and many of them, were decorated with mural paintings, which amount to over 480, dating from the IX to the XX Centuries. The exterior of all the brick-built structures needed a protection against rainwater infiltration that would disintegrate the mud-based binding mortar, thence the need in plastering the exterior with water resistant materials. This was done with lime-based renders and it was a common practice to complete the work by ornamenting with stucco mouldings that certainly were polychrome. The external or internal decoration was furthermore enriched by the insertion of fragments of mirrors, glazed terracotta and sandstone plaques or simple terracotta illustrated plaques, etc. The assessment, documentation, research & monitoring; the preventive conservation, the execution of customary conservation works and treatments, the maintenance and keeping under control, by timely executing emergency interventions where deemed necessary, on such heritage, are actions of foremost importance to carry out, due to the number and uniqueness of the architectural and decorative features that characterise this important site.

I. Composition, behaviour and vulnerabilities of mural paintings and decorative works at Bagan

Mural paintings and stucco mouldings are the 'skin' of the ancient monuments that specifically define, characterise and differentiate each one from another therefore, are intimately linked with the architecture forming an indissoluble unity so cannot be treated separately but entirely and successively as a whole (unit). Their value is inherent to all of the ancient living monuments of Bagan since these correspond to a place of worship. The rarity and uniqueness of the mural paintings are of paramount importance in all of the South East of Asia and of the entire World.

1 Constitutive materials

The stratigraphy of the mural paintings and stucco mouldings is as follows:

- Support (wall, vault, ceiling, etc.) is the upholding structure made out of baked bricks, dressed stone, etc. bound with mud-based mortars.
- Preparatory layers (one or several layers of plasters, stucco mouldings or renderings) mixtures made out of lime or mud; with inorganic and organic aggregates such as sand, chaff, rice husks, crushed stone, etc. and additives such as jaggary, acacia glue, egg whites, cow dung, etc. that improved/changed the properties of the mixtures.
- Paint layer (the skin that defines the character & spatiality of the building with the environment) it is made out of a mixture of pigments and binders that is applied onto the polished and white plastered surfaces for enhancing the architecture with decorations of geometric, floral or faunal patterns/elements, depicting scenes and explaining stories.

1.1 The structures

The numerous monuments (temples, stupas (zedi), monasteries, libraries (pitatak), image house, etc.) that compose the skyline of Bagan are scattered all around the site with their characteristic decorative works (mural paintings, stucco mouldings, glazed plaques, sandstone elements, etc.) that are unique and comprehensively integrated in the architecture.

1.1.1 Walls & vaults

The constructed heritage of Bagan is made out of well baked bricks, of various sizes, bound with mud-based mortars. Detailed studies on the composition of these mortars are ongoing but it is suspected that were made out by a mixture of fine-grained sand, soil containing a high percentage of clay and saps extracted from plants and/or with the addition of animal glue. With the exception of two temples that are covered with a sandstone veneer (**1239** Nan-hpaya and **154** Kyauk-ku-umin) all of these structures were covered with lime-based plasters and eventually embellished with polychrome stucco mouldings.

There is evidence of old kiln-sites near Bagan but there was shortage of firewood so according to G.H. Luce, 'most likely some bricks were baked anywhere and brought by river from upstream; there was one (kiln-site) up the Chindwin opposite Amyint and one Ut-phuiw-rań, under Khamlhū in the northwest of Kyauksé.' (Luce 1969: 233). Although, according to P. Pichard the situation is different since in reality 'a few bricks stamped with names (usually the names of villages out of Bagan) have been found in some Bagan monuments, they represent an infinitesimal percentage of the number of bricks made during the Bagan period. By far, most of the bricks were unmarked and most probably made at Bagan, fired with wood coming down from the upstream forests of Upper Myanmar. Still today, huge wood rafts can be seen floating down the Ayeyawady River.

There is no more trace of brick kilns; as the kilns were made by the bricks to be fired. After firing, the kiln was dismantled and the bricks sent to the building sites.

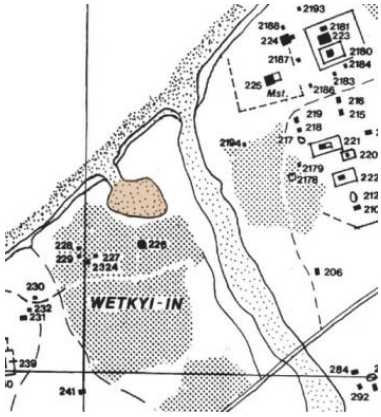
The clay was taken from the river bank, at least at three places were large depressions can be seen today, filled most of the time by the river:

1 At Wetkyi-in, where there bricks are still made today, near the mouth of Wetkyi-in chaung in the Ayeyawaddy River.

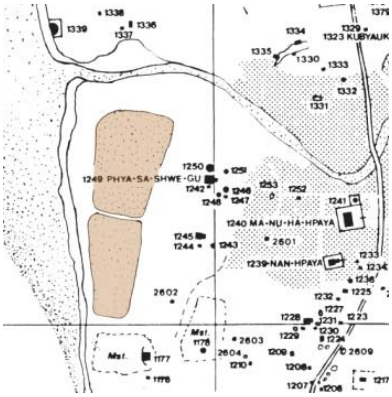
2 At Myinkaba, near the mouth of Myinkaba chaung.

3 At Thiripyitsaya, near the mouth of the Ye-o-zin chaung.

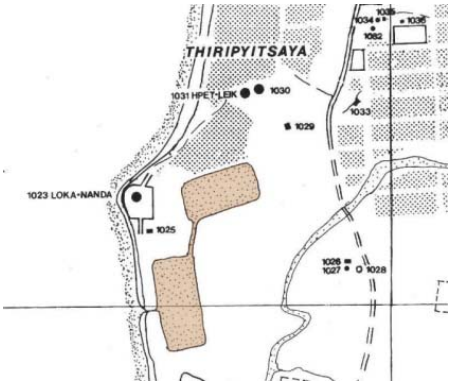
These large artificial depressions are the result of clay extraction during the whole Bagan period and possibly longer. The chaungs are intermittent streams, usually dry and sandy, still used by bullock carts to go inland from the river.' (Pichard, P., written communication 2017).



Map of Wetkyi-in chaung.



Map of Myinkaba chaung.



Map of Ye-o-zin chaung.

It must be stressed that the use of mud-based mortars for binding brickwork and the shallow foundations of the monuments of Bagan have been helpful inasmuch that probably have acted as buffers against strong vibrations or movements, e.g. earthquakes.

Other monuments that compose Bagan's heritage are subterranean temples and monasteries. These are composed by a mixture of masonry linked to sections excavated in the terrain or simply hewn in the subsoil taking profit of cliffs or the sides of hills. The typologies vary from half-underground to entirely subterranean temples but the majority are monasteries employed by the monks for meditation. The conservation of these structures must also rely on the expertise of a Geologist given that the sub-soil pattern in Bagan is a sandy formation susceptible to slides. Little research about has been produced and it should be the case to intensify studies.

1.2 The architectural decorative works

1.2.1 Stucco mouldings, plasters & renderings (internal & external)

The brick-mud constructions were always coated with a render or with several layers of lime-based plasters in order to avoid the penetration of rainwater that would wash away the constitutive mud-based mortar. The composition and the manufacture of the lime-based plasters & stucco is inscribed on a wall of temple N° 15 in Salé, (Aung Kyaing 1981: 123-124) but scientific research must be carried out in order to confirm if that recipe was strictly followed or there were deviations. However, according to U Aung Kyaing, during the 1960's, Temple **1825** in Bagan was selected for reproducing the above mentioned recipe. Additionally, other monuments have painted or stone inscriptions that list materials and their cost, such as **2162** Ananda-ok-kyaung Monastery dating to the Konbaung period. (See Annex A).

1825 TEMPLE, FROM NORTH-WEST. STUCCO MOULDINGS ACCORDING TO THE INSCRIPTION IN TEMPLE N° 15 IN SALÉ WERE APPLIED IN THE 1960'S.

1825 TEMPLE, DETAIL OF STUCCO MOULDINGS THAT SHOW TRACES OF DECAY WHERE RAIN STRIKES ON HORIZONTAL SURFACES.

Lime (most likely in the form of quicklime) was probably brought to Bagan from upstream, the Kyauksé Hill area. 'The eastern extremity of the Kyauksé Hill is formed of marble. The outcrop of the marble is divided into two by the Thindwe Canal.' 'This marble contains 43.44% $MgCO_3$ and 57.68% $CaCO_3$ so it is close to normal dolomite.' 'The local people still collect in a haphazard manner small quantities of the white marble chips and blocks in bullock carts from the only quarry of the locality.' 'It was stated on enquiry that the stone was used for lime making. The quarry looks old and not much used' 'This quarry may well be the very site from which marble was extracted for use as inscription stones during the Pinya and early-Ava periods of Burmese history' (Tha Hla & Ba Than 1961: 452-453, 466-467). It is not to exclude that similar quarries were used during the Bagan period. Probably the quicklime was slaked on site making lime putty that was mixed with several grain size sand (depending of the layer that was to be applied – from large to very small grain-size), and additives such as saps from plants and animal glues.

Generally the render/plaster layer(s) were spread homogeneously all over the masonry surfaces and eventually stucco mouldings were applied on the polished surface as in **1457** Maha-gu-gyi where the stucco mouldings, corresponding to the pilasters, have collapsed and the flat plastering can be noted.

Anchoring elements such as wooden pegs inserted into the plastering such as in **1812** Hti-lo-min-lo or **748** Sula-mani-gu-hpaya were employed for holding the stucco mouldings. Very rarely it is found that the surface on which the stucco was to be applied, was chipped so as to obtain a better adhesive rough surface. However, in later period monuments (**2162** Ananda-ok-kyaung) where the stucco reliefs are lost, remaining only the flat plastered surface, there are evident traces of scratched outlines, as sketches that suggested the shape of the reliefs. Would be of great scholarly investigation the research on the ancient colours employed as well as the identification of the techniques employed by the ancient masters for executing the intricate decoration in stucco.

2162 ANANDA-OK-KYAUNG MONASTERY, WEST WALL, RENDERING WAS APPLIED FROM TOP TO BOTTOM IN SUCCESSIVE HORIZONTAL AND VERTICAL SECTIONS FOLLOWING PROBABLY, THE HEIGHTS OF SCAFFOLD.

2162 ANANDA-OK-KYAUNG MONASTERY, AFTER THE APPLICATION OF A RENDERING LAYER, THE HORIZONTAL LOWER BORDER WAS COMPRESSED WITH A SLANTING ENDING SO AS TO APPLY BY OVERLAPPING THE SUBSEQUENT LAYER.

1457 MAHA-GU-GYI, VESTIBULE, WEST WALL, SOUTH SIDE. THE COLLAPSED PILASTER'S STUCCO PUT IN EVIDENCE THE FLAT FINISHING OF THE PLASTERING, THENCE NO PROPER ADHESION BETWEEN LAYERS.

2162 ANANDA-OK-KYAUNG MONASTERY, PLATFORM RETAINING WALL, EAST FACE, SOUTH SIDE. INCISED CONTOURS FOR THE APPLICATION OF STUCCO.

1812 HTI-LO-MIN-LO TEMPLE, EAST FACE, SOUTH SIDE. STUCCO MOULDINGS ANCHORED BY WOODEN PEGS INSERTED INTO THE RENDERING LAYER AND MASONRY.

1812 HTI-LO-MIN-LO TEMPLE, EAST FACE, SOUTH SIDE. WOODEN PEGS INSERTED INTO THE MASONRY AND RENDERING THAT SUPPORTED DISAPPEARED STUCCO MOULDINGS. NOTICE THE PAINTED BANDS THAT MIGHT HAVE FORMED PART OF A LOST DECORATIVE CYCLE.

1.2.2 Mural paintings

The mural paintings found inside the temples, monasteries, image houses, shrines, etc. of Bagan, belong to composite typologies given that two mineral binders in use since antiquity (mud and lime) were employed for manufacturing the plasters on which the paintings were executed. Therefore, different mixtures of these binders with aggregates and additives formed a variety of strata when applied. The interior of the monuments was plastered and customarily were painted enhancing only the architecture or, with a more elaborate ornamentation, completely decorating the surfaces with geometrical & vegetable elements, depictions of figures and scenes, etc. The combinations of plasters employed for the execution of mural paintings after drying, were mainly four:

Mud plaster & priming layer: the mud-based plaster was applied directly onto the wall at different thickness in order to render the architectural surface homogeneous, a white coating (as a primer) was spread all over on which the painting was executed.

Mud-lime plaster: the mud-based plaster was applied on the support (wall), covered with a thin lime-based plaster layer (1-2 mm thick), a priming layer was applied and the painting then, executed.

Lime-mud-lime plaster: an irregular roughing-in layer made out of lime putty was applied very liquid with brush, as a rendering, directly to the surface of the wall. Upon drying, the mud-based plaster was spread and compacted, then, covered by a very thin polished-compressed lime-based plaster (1-2.5 mm thick) on which a priming layer was spread by brush and, painted on top.

Lime plaster: lime-based plasters were mixed usually with sand and other aggregates and additives and, were applied internally and externally the monuments of Bagan, from one to several layers, usually up to 3, these were coated with a primer and painted.

Lime plaster & cloth: this was a not common practice but in order to avoid the formation of cracks while lime-based plasters were setting and drying, a thin textile or cloth was stuck on the surface and then spread on with the priming layer.

However, certain sections of the temples as for example; the porches, lower areas or upper floor storeys, were plastered with more resistant plasters that could bare abrasion and wear, such as those made out of lime and sand. The mud-based plasters (more sensitive to water) were employed in the deepness of the interior.

The technique of execution of the mural paintings followed a series of rules that are found almost everywhere in the World. Once the plasters have dried and the priming layer was applied, the surfaces (vaults & walls) were divided according to the decorative programme and layout the client had ordered to the painter(s) to carry out. The division of the sections to be painted with scenes or merely with decorative elements was done employing a cord soaked with paint, held at both extremities and then snapped on the surface so as to obtain, vertical, horizontal & diagonal lines, the best examples to be found are in **748** Sula-mani-gu-hpaya. In order to transpose a small scale drawing of a figure into a large one, a tracing grid made of vertical and horizontal lines snapped on the wall was used for maintaining the same proportions while drawing; a good example is found in **1244** Temple. Once the spaces were defined a preparatory drawing was done primarily by the painter master so the assistants & helpers would have filled with the respective colours and, final highlights and outlines were achieved usually by the master. The paintings were probably coated with a protective varnish made out of gums or resins.

474 TEMPLE. MUD-BASED PLASTER & WHITE PRIMING LAYER.

657 THAN-BU-DE-HPAYA. LIME RENDERING, MUD-BASED PLASTER, THIN LIME-BASED PLASTER.

1600 NAT-HLAUNG-KYAUNG. MUD-BASED PLASTER & LIME-BASED PLASTER.

1847 TEMPLE, HPAYA-NGA-ZU GROUP. LIME-BASED PLASTER – 3 LAYERS.

2119 TEMPLE. NOTICE THE ROUGH SPREADING OF THE LAYER OF LIME-BASED RENDERING, ON THIS, THE MUD PLASTER WAS APPLIED AND FINALLY COVERED BY THE THIN LIME-BASED PLASTER.

568 TEMPLE. LIME-BASED PLASTER & CLOTH ADHERED TO THE SURFACE WITH PRIMING LAYER.

748 SULA-MANI-GU-HPAYA. THE DRAWING OF THE PAINTING WAS CONSTRUCTED WITH SNAPPED CORD GUIDELINES.

748 SULA-MANI-GU HPAYA. DETAIL OF THE SNAPPED CORD GUIDELINES.

1.2.3 Glazed bricks, tiles and illustrated plaques (sandstone & terracotta)

The use of one-face-glazed bricks employed as veneer is rather exceptional in Bagan; certainly it was technically difficult to glaze the heavy bricks as well as their laying so as to obtain a uniform aspect. The upper section, dome and spire of **377** Sint-zedi were finished with glazed bricks while, the lower section of the stupa was covered with stucco mouldings that might have been completely polychrome. Another stupa of bulbous shape but fragmentary is **1603** Nga-kywe-na-daung in Old Bagan that was made out of one-face-glazed bricks on the long face.

Glazed terracotta tiles veneer, carved decorative elements and glazed illustrated plaques with Mara's army and Jataka stories, were combined in the rather unique architectural layout of **1439** Mingala-zedi. Other monuments contain glazed elements or, just simple glazed tiles, usually in turquoise, green, bluish-green and eventually combined with yellow as in **748** Sula-mani-gu-hpaya or **539** Tayok-pyi-hpaya-gyi. These elements were inserted into the architectural arrangement so as to complement the rich polychromy that certainly decorated the monuments of which, very few traces remain.

1145 SO-MIN-GYI-HPAYA. GLAZED TERRACOTTA PLAQUES WERE INSERTED INTO THE STUCCO DECORATION SO AS TO ENRICH THE VIVID POLYCHROMY.

1603 NGA-KYWE-NA-DAUNG, FROM SOUTH.

The illustrated plaques in terracotta and sandstone (this is of poor quality, it is quarried from the surroundings, given that the binding properties of the clayey component is weak so the material is subject to rapid pulverisation processes) were glazed because had to be protected against environmental

weathering given that these were inserted outdoors in the fabric, (Luce 1969: 241-242) their function was to be instructive texts, predominantly with Jataka stories as found in **1** Shwe-zigon or in **2171** Ananda-gu-hpaya-gyi. Elaborate carved decorative elements as 'horizontal bands of glazed elements with floral pattern and animal figures on each square terrace and corner figures' (Pichard 1995: 10) that might been complemented by a vivid polychromy, are found in **1145** So-min-gyi-hpaya. The illustrated plaques or the mere decorative elements were sculpted on sandstone or moulded on clay and then baked and glazed. The use of green, blue or related tonalities as a paint, was perhaps not suitable to be used outdoors so the glazed plaques succeeded in this task. In addition, few monuments contain sections of their original pavement made out of glazed stone or brick, such as **1192** Naga-yon-hpaya. Their study (as technique of execution) has been uncared and practically there are not available scientific publications. In particular, would be of great interest to find out the difference in the baking techniques of the glaze on sandstone and on terracotta, if any. This could be a beginning point of research if interest and funding are rendered available. In addition, the problem concerning the fragile glazed layer is to solve adequately.

1 SHWE-ZIGON. GLAZED SANDSTONE CARVING DEPICTING A JATAKA STORY, IT IS INTERESTING TO NOTE THE BANYAN TREE GROWING IN THE SAME PLACE OF A PALM.

748 SULA-MANI-GU-HPAYA. GLAZED SANDSTONE ELEMENT. THE GLAZING, HAS DETACHED DUE TO ENVIRONMENTAL FACTORS AND LACK OF MAINTENANCE.

1.2.4 Terracotta plaques

The terracotta plates 'originally placed anticlockwise' (Luce 1969: 264) on the walls of the vaulted circumambulatory corridors of both stupas **1030** Hpet-leik (east) & **1031** Hpet-leik (west) are rather unique in the Bagan context, these illustrate Jataka stories. In addition, other artefacts made out of terracotta are the votive plaques embedded in masonry that probably belong to former structures or were a propos inserted as dedication during the consecration of the building. There are apparently no reports that give details on conservation treatments probably carried out at the moment of discovery.

1.2.5 Sandstone elements (veneers, perforated stone window, pavements, etc.)

Temples **154** Kyauk-ku-umin and **1239** Nan-hpaya as said above, were constructed in brick bound with mud-based mortars (as main masonry component) along with were covered by a sandstone veneer made out of small blocks of stone bound with a lime-based mortar. The joints between the stone blocks are very thin, this in order to allow further carving in bas-relief of decorations or images, as those of Brahma in the **1239** Nan-hpaya. However, the flat surface of the wall was slightly chipped for receiving a coating of smooth plaster. The carvings were painted as per evident traces found in both temples.

Sandstone was employed also in masonry, as in **1** Shwe-zigon; as reinforcement of the architecture (large blocks inserted in corners, bases, walls, arches, vaults, etc.), as thresholds and floors, as door or

windows' panel sockets, as sockets for wooden pillars as also, for carving the perforated stone windows which can be monolithic (rare) or composed by assembled blocks of stone that upon laying, were carved. The local stone was also employed for carving statues and stone inscriptions that are movable.

154 KYAUK-KU-UMIN, NORTH PORCH, DETAIL OF CARVED EAST DOOR-JAMB BASE, FROM NORTH.

1239 NAN-HPAYA, SOUTHEAST PILLAR, FROM NORTH WEST. NOTICE THE REMAINS OF POLYCHROMY ON UPPER CORNICE.

2 Main causes of deterioration & related effects

The alterations found on mural paintings, stucco mouldings and decorative works are unique, pertaining to the composition of the object subject to the environmental factors that contribute to cause decay. Deterioration processes naturally occur on any material and develop in such a way that cannot be stopped but only and eventually by adopting the proper actions, to slow-them down.

The main cause of deterioration of works of art specifically of mural paintings and stucco mouldings is water in all of its forms and the human intervention. Other alterations due to chemical and/or physical causes, to inappropriate techniques employed while executing the decorative works and to obsolete conservation-restoration interventions are taken into consideration. However, the following factors of deterioration are not completely categorical but perhaps other, unknown or overlooked can exist in Bagan that must be added to this list.

2.1.Water and its movements: condensation, infiltration/percolation, capillarity

2.1.1 Physical action of water disaggregating constitutive mud mortars and causing breakage of stucco mouldings

The infiltration/percolation of rainwater through cracks, holes, loosened/open masonry joints, plaster's lacunae, etc. in roof(s) or walls is the main cause of disaggregation of mud-based mortars that disintegrate by the physical action of water. These are soaked, the binders are dissolved and washed away with the inert materials, depositing eventually in lower sections by water run-off. This is also applied to the mud-based plasters that decorate many walls of the temples of the early Bagan period.

697 HSIN-BYU-SHIN-HPAYA, SOUTH CORRIDOR, INNER WALL. WATER INFILTRATION FROM ROOF DISSOLVING CONSTITUTIVE MUD MORTAR AND PLASTERS. NOTICE THE STRIPES OF BARE MASONRY.

1605 PATHO-HTA-MYA, VESTIBULE, SOUTHEAST CORNER. RISING WATER DUE TO A POND-LIKE AROUND THE TEMPLE DURING THE RAINY SEASON. THE PROBLEM WOULD OBVIATE IF REMOVING SOME SOIL FROM THE ROAD AT THE NORTH WEST FOR WATER EVACUATION.

Moreover, the ancient stucco mouldings and renders decorating the exterior of temples and stupas have resisted to weathering due to their particular technique of execution in which durable materials (lime, sand & additives) were employed and because the central area of Myanmar in which these are located is, until recent times, arid and dry. On the other hand, the brittle surfaces of the stuccoes that conceal pulverised (lacking cohesion) stucco beneath, break due to direct rainwater droplets that hit the superficial hard crust producing small craters, in due time, these become larger and larger, until disintegration and natural loss occurs. Nevertheless, it is remarkable that most of the stucco mouldings protected by cornices or where there is no water run-off are in the majority of the cases perfectly preserved. Also lime-washes have had a role on protecting the stuccoes from deteriorating agents because acting simultaneously as a protective and sacrifice layer. Undoubtedly the stucco mouldings were polychrome with vivid colours that at present have almost completely disappeared, because the binding materials employed for painting, were sensitive to water (use of gums or resins soluble in water) so have been washed away. However, there are some monuments that show remains of polychromy and undoubtedly traces can be found and identified from protected areas. The polychrome layout might been complemented by the insertion of glazed plaques of greenish to bluish hues with yellow outlines, colours that perhaps were not possible to employ outdoors because susceptible to rapid decay. Would be an excellent point of research the systematic study and the identification of the materials employed for finishing the stucco mouldings with colour, similar to those as found at the interior of the temples.

1498 NYA-PYA-GU, NORTH PORCH, PEDIMENT. WATER PERCOLATION ON SURFACE HAS COMPLETELY ERODED THE ANCIENT STUCCO MOULDINGS.

2.1.2 Water in structures affects the mural decoration (evaporation and crystallisation of soluble salts)

Rainwater infiltration/percolation into a structure can be due to leakage through cracks in roofs and horizontal surfaces, by rising damp (capillary rise) from the sub-soil due to the rise of the water table or by stagnating water around the monument or, eventually, by driving rain entering open masonry joints in walls. Liquid moisture inside a porous structure sets into motion other related problems, e.g. movement of soluble salts; due to capillarity, water moves at the interior of the porous structure, both horizontally and vertically, transporting soluble salts in the deliquescent state (in solution), upon the evaporation of water, soluble salts re-crystallise somewhere else towards the surface. Soluble salts are naturally contained in constitutive materials or in the sub-soil. If the large pores are saturated by large amounts of dissolved salt these upon evaporation of water, re-crystallise gaining volume, and not having enough space while growing, break the walls of these pores causing the disaggregation and rupture of the adjacent material. If the concentrated salt formation occurs just beyond (under) the surface, is called sub-florescence whereas on the surface, efflorescence. (Torraca 1988: 32-33).

1323 KUBYAUK-GYI (MYINKABA), NORTH LATERAL FOREPART WITH WINDOW, WEST SIDE. ONGOING WATER INFILTRATION FROM UPPER PARTS GIVEN BY THE DARKER AREAS ON THE PLASTER, NOTICE THE DEVELOPMENT OF MICRO-ORGANISMS ON THE SURFACES.

1323 KUBYAUK-GYI (MYINKABA), NORTH LATERAL FOREPART WITH WINDOW, EAST SIDE, INDOORS. WATER INFILTRATING HAS OBLITERATED THE UPPER SECTION OF MURAL PAINTING. THE WHITE AREAS CORRESPOND TO DRY MASONRY WITH RE-CRYSTALLISED SALT.

2.1.3 Chemical action of water transforming insoluble salts (formation of crusts)

Clear rainwater mixed with Carbon dioxide contained in the air (forming acidic water) percolates over surfaces (plasters, glazed tiles, sandstone elements, etc.) transforming the Calcium carbonate contained in plasters and stucco mouldings into Calcium bicarbonate that mixes with other deposits found on the surfaces (such as dust or eventually, soot) these are inclosed, transported and fixed on the surroundings or, on another place. Upon water evaporation and reaction with Carbon dioxide contained in the air the reconstitution of the Calcium carbonate is accomplished forming a superficial yellow-brownish film. This phenomenon provides the characteristic coloured aspect of the surfaces of many glazed plaques, renderings and stucco mouldings of temples and stupas because of the dust trapped within.

539 TAYOK-PYI-HPAYA-GYI. GLAZED PLAQUE WITH DEPOSITION OF CALCIUM CARBONATE MIXED WITH DUST ON THE SURFACE, THIS IS THE YELLOWISH FILM ON THE GREEN GLAZE.

2162 Ananda-ok-kyaung Monastery. Yellow-brownish deposition on stuccoes as formation of a mixture of Calcium carbonate and dust.

'Carbon dioxide is always present in the atmosphere, its concentration being larger in polluted areas. It dissolves in water, forming carbonic acid a very weak acid. Carbonic acid solutions can affect mural paintings in which carbonated lime acts as binder of the pigment particles, i.e., fresco and lime techniques. As is well known Carbonic acid solutions can dissolve Calcium carbonate by converting it into water-soluble Calcium bicarbonate. Calcium bicarbonate in turn reverts to Calcium carbonate upon evaporation of the solution, but obviously Calcium carbonate is not re-precipitated in exactly the same position as it had before nor does exert the same binding action. (Torraca 1973: 170-171).

Pure water formed on surfaces due to condensation, can transform, mixed with the aid of Carbon dioxide (naturally contained in the air), Calcium carbonate into Calcium bicarbonate that runs over surfaces and depositing elsewhere reacting with Carbon dioxide again upon water evaporation.

2.1.4 Water vapour condensation on cold surfaces

'Direct condensation of water vapor takes place on a surface when the relative humidity of air in its vicinity reaches 100%. It can also happen that water droplets can be formed in the air, when humidity reaches 100%, and remain dispersed in the air;' (Torraca 1973: 170).

The condensation of warm-damp air on cold surfaces is due to differences in temperature, this rarely occurs within the context of Bagan, during the passage from the dry-cold to the dry-hot seasons. At early morning, walls are cold due to the drop of temperature during the night but as soon as the air is warmed-up by the sun, warm water vapour collides with the wall's plastered surfaces becoming liquid. If there are any hygroscopic soluble salts deposited on the surface, these will trap liquid moisture and become deliquescent recalling other soluble salts within the interior of the structure increasing their quantity, resulting in breakage of adjacent materials.

2.2 Bio-deterioration

2.2.1 Water supply for bio-deterioration

The major component indispensable for living organisms is water given that life cannot occur without it and therefore, the growth of inferior (moss, ferns, etc.) and superior plants (shrubs and trees) and even, the propagation of micro-organisms (bacteria, fungi, algae, lichens etc.) are due to this vital element.

Rainwater run-off on surfaces promote the growth and development of micro-organisms such as algae and lichens, as also the growth of moss especially on those areas that are protected from sunlight and

are particularly damp, as for example, the north side of the monuments and under the shade of trees. Nevertheless, microscopic algae need light for development and growth, whereas fungi can develop without it.

Superior plants growing on the roofs and upper sections of the monuments of Bagan are due to the deposition of seeds driven by the wind or from the droppings of birds and bats. During the rainy season seedling develop, introducing the roots into the masonry and if there is sufficient humidity, the plant will certainly develop and grow causing for example, the breakage of masonry.

2.2.2 Fauna participation to deterioration

Inferior species of animals such as insects (ants, termites, etc.) excavate tunnels under foundations or inside the buildings or, and especially, in mud-based plasters. Other species of insects, such as bees, wasps or hornets construct their honeycombs on any surface, as well as beetles from the Coleopteran family build their mud nests on the painted surfaces, being these very difficult to remove without causing damage, these species also burrow tunnels inside the mud plasters. Spiders build thick cobwebs on corners and paradoxically may help to support severely detached renders.

Another species of animals that fly, nest inside the protected and unprotected temples, as for instance feathered biped (Aves) such as pigeons (nest on horizontal surfaces) or swallows (build their nest hanging from vaults) stain the surfaces with heir acidic droppings. In addition, the bats, that are winged as well, belonging to the from the Mammalian class, during daytime sleep hanging from the vaults causing small detachments of plasters (with their fingernails while leaving the place), abrasion of surfaces with their wings while flying and stain the surfaces below with their droppings. These droppings are particularly difficult to remove given that form oxalates.

Lizards such as geckoes deposit their eggs on surfaces, nest in spaces between the plasters and the walls where they breed their children and cause eventually the collapse of sections of painted plasters as it happened in **657** Than-bu-de-hpaya due to a gecko living inside the gap between the wall and the plaster. It can be deducted that, what the 2016 earthquake did not do, a gecko managed to do.

2128 TEMPLE. TERMITE NESTS IN THE ORIGINAL SANDSTONE SLABS FLOORING.

1846 TEMPLE, HPAYA-NGA-ZU GROUP. COLEOPTERANS MUD NEST ON PAINTINGS, DIFFICULT TO SAFELY REMOVE.

263 TEMPLE. DEVELOPMENT OF MICRO-ORGANISMS AND GROWTH OF HIGHER PLANTS ON THE WALLS AND UPPER PARTS.

1499 MIN-NYEIN-KON. SWALLOWS' NESTS (UPPER LEFT SIDE OF PHOTOGRAPH) AND MUD RUN-OFF (RIGHT SIDE) DUE TO WATER INFILTRATION DISSOLVING CONSTITUTIVE MUD-BASED MORTAR AND DEPOSITING ELSEWHERE.

2.3 Other environmental factors of deterioration

2.3.1 Sunlight

'Sunlight, particularly ultraviolet radiation, acts on painting materials fading non-light-fast pigments and triggering oxidation and cross-linking reactions of the organic medium.' 'Strong variations of temperature favour the detachment of paint films from plasters because all organic substances have larger thermal expansion coefficients than inorganic ones. Heating and cooling of the surface of the paintings results, therefore, in setting up of mechanical stresses between the paint film and the support.' (Torraca 1973: 173).

The bleaching and discolouring properties of sunlight alter inorganic and organic pigments as well as organic binding media and eventual coatings/varnishes of mural paintings executed by the *secco* technique. Because of the above, binders tend to become dark and brittle so the detachment of paint layer occurs. In addition, inorganic pigments such as vermilion or cinnabar were extensively employed in Bagan that have discoloured into a black hue due to direct and/or reflected sunlight. 'Vermilion is darkened when exposed to direct sunlight that is merely by a physical change and it is thought to be caused by the formation of a metastable black modification of mercuric sulphide' (Gettens 1966: 172).

2.3.2 Thermal expansion

'Materials in buildings are subjected to daily and seasonal temperature cycles. Such cycles are important sources of stress because materials expand on heating and contract on cooling. Stresses arise even inside a homogeneous piece of material, between the surface, which is directly exposed to the environment and undergoes a greater temperature change, and the inner part, where the temperature variation is smaller. In building structures, thermal expansion movements are frequently important. If they are restricted, they cause stresses resulting in deformation or cracks. When joints open, they often do not close again completely on contraction, because debris can get into the crack. So the crack opens progressively more and more.' (Torraca 1988: 25-26).

An example of thermal expansion is the case of the **1323** Kubyauk-gyi temple that in 1991, the rendering of the external west wall was badly detached as a result of the heat from the sun which now

beats directly on it; the trees that formerly shaded and therefore protected the wall were cut down during the dry season, leaving it devoid of natural protection and altering its microclimate.

2.3.3 Thermic shock

Thermic shock happens to surfaces exposed under very high temperature (by insolation) with sudden lowering due to cold rain showers. This occurs at the end of the hot dry season and the beginning of the rainy season. This causes the formation of micro-cracks in stone, bricks, renders, plasters or stucco mouldings that can originate disaggregation of material.

2.3.4 Wind

Wind plays a double role in the destructive mechanisms of mural paintings. 'The first is a straightforward abrasion carried out by airborne sand particles that is a natural sandblasting process. In the second case, wind interferes with evaporation processes taking place from a wet porous surface; as the rate of evaporation of water increases with the speed of air circulation, when it is sufficiently high, evaporation and crystallisation of soluble salts takes place inside the pores and not any more on the surface of the material. So the destructive power of the crystallisation process is enhanced by the wind and it can result in a cavitation process (eolic corrosion) because the wind is channelled in the attacked areas, causing further activation of the process of evaporation and crystallisation.' (Torraca 1973: 173-174).

In addition, wind increases the circulation of air thus increasing water evaporation contained in walls where salts re-crystallise beneath the plasters and not on the surface, causing lack of adhesion (separation/detachment) (Mora 1984: 208)

Dense deposits of dust carried by wind are deposited on protruding sections of the painted surfaces or, on the stucco mouldings, rendering depictions or forms, partially or completely illegible. In some cases, dust is mixed with moisture or, even worse, with bats' urine forming hard crusts on the surface that are very difficult to remove.

2.3.5 Earthquakes/tremors

Earthquakes and tremors are natural events that by themselves do not cause harm and do not kill but can damage buildings that are weakened, not regularly maintained or were unsuitably constructed to tolerate such events. The key to avoid such dramatic results rely on safely constructed buildings and their systematic maintenance by employing intelligent actions. The effects caused by the 24th of August 2016 are well known in Bagan, as it was demonstrated that the junctions between ancient and new were not suitably carried out so the new damaged the old.

2.4 Human factors and interventions of deterioration

2.4.1 Incorrect use of monuments

Herdsman use to keep their beasts such as goats, cows, etc. in unguarded temples as well as sometimes they use the monument as shelter where to spend the night so sometimes they light fire inside to keep warm in cold evenings.

Children use the mural paintings or the stucco mouldings as blank to perfection their aim (pointing a weapon), so they compete by throwing stones to determinate targets.

2.4.2 Grime

Darkening, abrasion & loss of paint layer at hands' human height, caused on the pictorial surfaces due to devotees rubbing their hands across the surfaces depositing grease mixed with dust and, consequently, the paint layer is stripped away or obliterated by the dark smudged deposit.

2.4.3 Heat and smoke

Heat caused from a fire can change calcium carbonate into calcium oxide with an accompanying change in volume and cause moisture to be absorbed again. This will result in disaggregation of the lime-based plasters and alteration in tone of iron-based pigments such as yellow and green earths which become reds and browns by desiccation and oxidation. (Mora 1984: 208-209).

During World War II, many people took refuge inside the temples of Bagan so it was necessary to light cooking fires. The smoke produced deposited on the vaults and walls obliterating the depictions.

2.4.4 Vibration

The monuments of Bagan were constructed with shallow foundations in order that the buildings should slide back and forth during earthquakes. In spite of this, the ancient constructors did not calculate that Bagan would become a busy tourist destination with large buses full of visitors going all around the place, producing strong vibrations that alter the steadiness of the monuments causing cracks, separation of blocks of masonry and/or of renders, in particular to the small buildings.

2.4.5 Faulty technique of execution

The priming layer found between the preparatory and paint layers in Konbaung Period mural paintings, appears to be quite hygroscopic, this swells during the rainy season thus gaining volume and expanding, the opposite occurs during the dry-hot season that the layer shrinks and separate from the ground in the shape of scales or flakes. However, variations of temperature and relative humidity are responsible of the development of scaling and flaking paint layer.

2.4.6 Former obsolete interventions

With the intention in brightening and making clearer mural depictions, coatings of varnishes or fixatives such as, solutions of Polyvinyl acetate (PVAc) in Toluene or oil, were applied on unclean surfaces, at present difficult to remove. Moreover, the systematic coating of mural paintings obfuscated by smoke, especially with PVAc, was made with the purpose to improve the perception of the depictions.

The incomplete pictorial cycles with many abrasions and lacunae, with losses of painted plasters, were in some cases re-plastered and then the entire surface was whitewashed so as to render it homogeneous, such as in **85** Thein-mazi.

The idea that edging or filleting the borders of the lacunae will fix the separated plasters in place is completely erroneous. The edging materials have varied according to the time these were applied, from lime and surki to cement, surki and sand but have resulted more damaging than preserving. The edging has in some cases remained in place and the plasters have completely collapsed because not adhered to the support or, have been destroyed by wet-dry cycles upon soluble salts re-crystallisation.

The indiscriminate use of cement for edging the borders of stuccoes have helped to separate more rather than to keep them fastened to the masonry. This because when heated by sunlight expands differently due that the thermal expansion coefficient of cement is different from the one of brickwork, lime-based plasters and stuccoes.

2.4.7 Un-dexterous masonry repair and unsuitable conservation treatments

During the furious and extensive reconstruction of the monuments of Bagan in the decade of the 1990's and so on, many mounds or the remaining sections of buried and ruined monuments were unearthed and the lost (uncertain) sections were rebuilt. This is the case of **1160** a ruined temple, of which the lower sections of the monument were buried so the ground plan upon unearthing, was possible to complete. If consulting the *'Inventory of Monuments at Bagan'* by Prof P. Pichard, it can be found in page 37 of Volume five that the south forepart was still standing and retained the stucco decoration. These stuccoes no more exist because were destroyed during the inexpert reconstruction as

well as the pediment over the entrance. In addition, the debris around and inside the temple was removed up to a certain level (not at the original one) so the temple remained under the actual surrounding terrain level, to obviate this minimal deficiency, a retention wall and an apron were constructed all around. The base of the east side with very interesting extant stucco mouldings, was discovered at the time but at present show signs of heavy deterioration due to wet/dry cycles of stagnating water during the rainy season.

Another, as many other examples of transformation by uncontrolled reconstruction is **1810** Temple in which, the porch at the south face was completely destroyed and substituted by a plain wall that was easier to build rather than to preserve the ancient work.

1160 TEMPLE AS APPEARS IN VOLUME FIVE OF P. PICHARD *'INVENTORY OF MONUMENTS AT BAGAN'* BEFORE 1995.

1160 TEMPLE AS IN 2017. LARGE SECTIONS OF MASONRY & STUCCO MOULDINGS WERE DESTROYED; THE PROPORTIONS OF THE ELEMENTS WERE HEAVILY ADULTERATED AS WELL AS THE SHAPE OF THE PEDIMENT OVER THE FOREPART. THE TEMPLE IS INSIDE A POOL MADE BY THE RETENTIVE WALL CONSTRUCTED ALL AROUND WITHOUT AN OUTLET FOR WATER EVACUATION DURING THE RAINY SEASON.

1810 Temple at the southern side of **1812** Hti-lo-min-lo, south face as appears in 1995. (courtesy P. Pichard, 2017).

1810 Temple at the southern side of **1812** Hti-lo-min-lo, south face as appears in 2017. (courtesy P. Pichard, 2017).

3 State of preservation

Mural paintings, stucco carvings, stone veneers and sculptures, glazed terracotta plaques, etc. are intimately linked to the architecture and therefore cannot exist independently but compose a single unity. The bearing structure, i.e. temple or stupa, is the support of the external decoration, namely

stucco mouldings and renderings that have the main function to protect the core of walls and vaults from water penetration. Therefore, the safeguard of the building is of paramount importance for the protection of the mural décor by preventing dampness in all of its forms from water infiltration from roofs and upper parts, from capillary rise from the terrain or, from water vapour condensation on the cooler walls resulting for example, from the production of warm water vapour by high concentration of visitors. In addition, the structural solidity and stability owing to the soundness of the subsoil must be guaranteed. These are the main requisites prior the conservation of mural paintings and related decoration *in situ*.

Given the inconsiderate architectural reconstruction of the monuments carried out in the past decades, without coordinated planning, by adding considerable load to the ancient structures, not taking care that the junction between ancient and new had to be carefully done, using non-compatible/retreatable materials that had to be well-matched, etc. In addition, the introduction of damaging structures (reinforcements in iron as found in **65** Kyanzittha-umin, **154** Kyauk-ku-umin, **1239** Nan-hpaya, etc.) created the conditions for causing dangerous structural stresses resulting in damage and eventual collapse, were then established. The results are evident subsequent to the 24th of August 2016 earthquake.

The state of preservation of the architectural decorative works is determined by the environmental conditions that act undisturbed within the unprotected monuments of the site and open to the elements, very few monuments can lead that the safeguard is guaranteed. Particularly the mural decorations are threatened by liquid moisture in the state of spry or due to infiltration and percolation during the rainy season and to strong sunlight and heat exposure during the dry hot season with the resulting evident alterations produced, of which, very few are aware. Notwithstanding, that the entirety of matter contained in this World, is impermanent so unequivocally it is destined to be perishable because due to the progression of wear it is not destroyed, but only transformed in energy.

3.1 Main conservation problems encountered

The following list of conservation problems encountered in the monuments of Bagan involves as well the definition of the terminology employed. For a synthetic listing of damages or alterations correlated to the possible causes and the recommended treatments to undertake please refer to ANNEX C.

3.1.1 Lack of adhesion of preparatory layers (plasters, stuccoes & renderings)

It is the separation of interfaces between one material and another or amongst itself due to loss of binding properties. Three types of lack of adhesion have been identified so far in Bagan:

- Separation from the wall or amongst the layers: detachment up to 5 mm.
- Separation with deformation: bulging, from 6 mm onwards to some centimetres.
- Separation of layers from one material (lime-based) and another (mud-based): tunnels dug by insects.

The re-adhesion of separated/detached preparatory layers of mural paintings and stucco mouldings from the wall (support) has been the major conservation issue in Bagan. Unfortunately, despite the many times this issue was reported and stressed to the DoA, timely action was not taken and the consequences are well-known following the 2016 earthquake.

In order to detect the extent and types of detachments of the plasters, the surface must be carefully inspected, especially under raking light, in order to establish if the paint layer is sound enough to tolerate mechanical action such as rubbing and knocking. By gently tapping the surface with the fingertips, a dull sound will be produced that will change according to the type of separation. It is advisable to tap with one hand while gently putting the other nearby so as to physically feel the vibrations produced. Therefore, the identification of the plaster areas that are separated/detached must be carried out throughout all the surfaces that cannot be recognized with the naked eye.

1460 TEMPLE, SHRINE, NORTH WALL, WEST SIDE. DETACHMENT WITH DEFORMATION OF PAINTED PLASTER.

2162 ANANDA-OK-KYAUNG MONASTERY, NORTH FACE, SEPARATED RENDERING FROM THE WALL

1467 LOKA-OK-SHAUNG, UPPER STOREY, PORCH, SOUTHEAST CORNER. DEFORMED RENDERING DUE TO THERMAL EXPANSION & CONTRACTION.

698 MONASTERY, HSIN-BYU-SHIN MONASTIC COMPLEX, FOREPART, WEST FACE, NORTH SIDE. STUCCO MOULDINGS SEPARATED FROM SUPPORT WITH STRONG DEFORMATION (BULGING).

The re-composition and re-adhesion of broken glazed terracotta and sandstone elements into several fragments is an issue similar to the treatment of broken pottery so their treatment should follow those as employed for ceramics.

3.1.2 Lack of cohesion of preparatory layers (plasters, stuccoes & renderings)

It is the loss of bonding properties within the constitution of a given material resulting in powdering. This alteration is found in both, mud-based and lime-based plasters, stuccoes and renderings, as well as in brickwork bound with cement mortar, in terracotta and sandstone plaques.

2162 ANANDA-OK-KYAUNG MONASTERY, PLATFORM RETAINING WALL, NORTH FACE, EAST SIDE. PLASTER LACKING COHESION (POWDERY) AND THIN LAYER OF WHITEWASH LACKING ADHESION.

2162 ANANDA-OK-KYAUNG MONASTERY, UPPER STOREY, SOUTH FACE, PEDIMENT OF WESTERN DOOR. POWDERING STUCCO MOULDINGS DUE TO SALT RE-CRYSTALLISATION DUE TO WET-DRY CYCLES.

3.1.3 Cracks of preparatory layers

Cracks are a breakage/fracture within a structure. Three types of cracks are distinguished:

- Structural (masonry) cracks: cross throughout all the structure; paint and preparatory layers and the walls or vaulting.
- Mechanical cracks: caused by internal stress of the preparatory layer(s). Fracture or chink found in a given layer within the structure or that entirely crosses it.
- Drying cracks: due to contraction (shrinkage) of the binder while setting/drying, upon rapid loss of water or, to its excess of content in the mixture.

539 TAYOK-PYI-HPAYA-GYI, 1ST FLOOR, WEST PORCH, CROSSING CRACKS THROUGHOUT THE MASONRY.

1847 (HPAYA-NGA-ZU GROUP), CROSSING CRACKS ON PLASTER, PROBABLY FROM DISLODGED BRICKWORK BENEATH.

1249 PHYA-SA-SHWE-GU, CROSSING CRACK ALONG AND THROUGHOUT THE STRUCTURE.

698 MONASTERY, HSIN-BYU-SHIN MONASTIC COMPLEX, FOREPART, WEST FACE, SOUTH SIDE. DRYING CRACKS OF STUCCO MOULDINGS. THESE ARE ALWAYS DIVIDED IN THREE LINES, CHARACTERISTIC TO LIME-BASED PLASTERS WHEN SETTING/DRYING.

3.1.4 Lacunae in preparatory layers

Lacunae of preparatory layers are the interruptions or discontinuation of the visual and material fabric which asserts itself as an extraneous body, thus limiting the natural succession or unity of the surface.

- Superficial lacunae: loss of a portion of preparatory layer(s) at varying depths.
- In-depth lacunae: interruption of the unity of a plastered surface revealing the support.
- Vandalism: mechanical marks consciously caused or by misuse of tools.
- Erosion (mainly applicable to stuccoes and outdoors renderings): destruction and loss of constitutive material due to acidic water run-off the surface or to soluble salt sub-florescence and efflorescence.

1580 LOKA-HTEIK-PAN. SUPERFICIAL LACUNAE THAT INTERRUPT THE LEGIBILITY OF THE PICTORIAL TEXT.

433 PYWAN-TAN-HSA-HPAYA. LACUNAE OF PLASTER IN-DEPTH SHOWING THE BRICKWORK, COMBINED WITH SUPERFICIAL ONES THAT ARE THE REMAINING WHITE PLASTER.

2080 TEMPLE, INCISIONS CONSCIOUSLY CAUSED WITH A POINTED TOOL.

1152 TEMPLE. ERODED SURFACE DUE TO SLIGHTLY ACIDIC WATER RUN-OFF DISSOLVING CONSTITUTIVE MATERIALS.

3.1.5 Lack of adhesion of paint layer

It is the separation/detachment of the paint layer from the plaster or separation/detachment of glazing from terracotta or sandstone plaques.

- Bubble-shaped or sheet-shaped: thin separation of paint layer in the shape of semi-bubble or in the shape of a sheet-plate due to soluble salt sub-florescence or due to strong fixative/coating that have pulled-up upon rapid exsiccation, influenced by changes in temperature and relative humidity of the environment, the section of paint.
- Crest-shaped: similar to mountain creeks, it is a separation of paint layer that runs all along and corresponding to micro cracks in the preparatory layers.
- Scaling/flaking: separation of paint layer in the shape of scales or flakes due to the contraction of coatings/varnishes that have pulled-up upon rapid exsiccation, influenced by changes in temperature and relative humidity of the environment.

539 TAYOK-PYI-HPAYA-GYI. MICRO-SCALING OF PAINT LAYER, PERHAPS DUE TO THE SHRINKAGE OF A PREVIOUS FIXATIVE THAT WAS APPLIED.

482 THAMBULA-HPAYA. MICRO-SCALING OF PAINT LAYER DUE PERHAPS TO EXCESSIVE BINDING MEDIUM. HOWEVER, THIS OCCURS WHEN DIFFERENT BINDING MEDIA ARE EMPLOYED.

3.1.6 Lack of cohesion of paint layer

It is the loss of bonding properties within the constitution of the material (pigments and binder) resulting in disaggregated fine particles.

3.1.7 Cracks in paint layer

Cracks in paint layer are the breakage or fracture of the layer due to mechanic action (by changes of temperature and relative humidity) or to excessive exsiccation (drying) of the binder.

- Drying cracks or crazing: micro-cracks formed by contraction (shrinkage) upon the drying process of the binder.
-

2007 SHWE-KYAUNG-U-HPAYA. DRYING CRACKS FORMED ON THE PRIMING AND PAINT LAYERS. NOTICE THE DRIP OF LIME-WASH EMPLOYED FOR THE OUTSIDE.

539 TAYOK-PYI-HPAYA-GYI, UPPER STOREY TEMPLE, VESTIBULE, NORTH WALL. DETAIL OF PAINTING, PROBABLY A PURPLE LAKE, WITH EVIDENT CRAZING DUE TO EXCESSIVE WEATHERING.

3.1.8 Lacunae of paint layer

Lacunae of paint layer are the interruption or loss of the patina and paint layer at varying depth.

- Abrasion/scratches: wear or loss of minute scales of paint beneath, of which a part of the pigment layer or at least the original primer remains with traces of pigments (colour).
- In-depth lacunae: Complete loss of paint layer revealing entirely the preparatory layer.

2007 SHWE-KYAUNG-U-HPAYA. THE ABRASIONS OF PAINT LAYER LEAVE A SLIGHT TRACE OF PIGMENT ON THE SURFACE.

539 TAYOK-PYI-HPAYA-GYI, GROUND FLOOR, LACUNAE IN-DEPTH OF PAINT LAYER.

3.1.9 Alteration of pigments

The chromatic appearance and/or composition of pigments is transformed by chemical or physical action, usually these alterations are irreversible.

- Pictorial surface darkened by light: the binder or the original coatings of varnishes for protecting the murals have discoloured as a blackish/brownish layer.
- Pigments altered by heat/fire: iron-based pigments such as yellow ochre, turned red due to high temperature (300 °C at least) inside the temples.
- Pigments discoloured by light: organic and inorganic pigments susceptible to light discolouration by transforming into a black layer, such as vermilion or, have completely disappeared (fading) as indigo or lakes.

1323 KUBYAUK-GYI (MYINKABA), PASSAGE FROM VESTIBULE TO CORRIDOR, NORTH WALL. ALTERATION OF YELLOW OCHRE INTO RED OCHRE DUE TO HIGH TEMPERATURE ON UPPER PARTS.

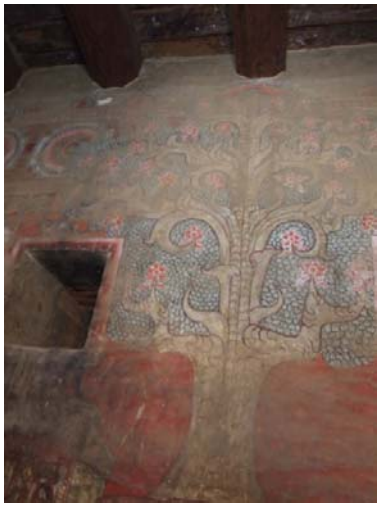
1336 TEMPLE, VESTIBULE VAULT. ALTERATION OF RED VERMILION INTO BLACK ON THOSE AREAS HIT BY REFLECTED SUNLIGHT WHEREAS, THE AREAS THAT ARE NOT UNDER THE SUNLIGHT REFLECTION ARE LESS ALTERED. WATER INFILTRATING HAS WASHED AWAY A GREAT DEAL OF PAINTING.

2162 ANANDA-OK-KYAUNG, DOORWAY SPLAY. THE ORGANIC PIGMENTS HAVE DISCOLOURED INTO A GREYISH FILM, WHEREAS THE INORGANIC PIGMENTS (RED, BLACK AND WHITE) HAVE REMAINED UNCHANGED UNDER THE REFLECTED SUNLIGHT.

539 TAYOK-PYI-HPAYA-GYI, UPPER STOREY TEMPLE, SOUTH WALL OF CENTRAL CORE. SOME ORGANIC PIGMENTS HAVE FADED BY SUNLIGHT BUT OTHERS SUCH AS THE PURPLE LAKE HAVE REMAINED.

3.1.10 Natural deposits on surfaces of mural paintings, stucco mouldings, plasters and renderings

- Calcium carbonate deposits: Calcium carbonate formation on the surface due to chemical processes with Carbon dioxide and water, occurring on glazed plaques, stucco mouldings and external plasters/renders.
- Dust: deposits on protruding rendered surfaces that can become very hard to remove if mixed with water or even worse, with bat's urine.
- Water run-off mud deposits/concretions: deposition of constitutive mud-based mortar from masonry washed away by water and run-off over the surfaces, leaving hard deposits.



2162 ANANDA-OK-KYAUNG MONASTERY, SHRINE, EAST WALL. MURAL PAINTINGS COVERED AT THE TOPMOST WITH A THICK LAYER OF DUST WHEREAS THE LOWER SECTION SHOWS HEAVY DEPOSITS OF SOOT.

1969 PITAKAT-HPAYA, DUST DEPOSITS ON PROTRUDING SURFACES AS WELL AS DEVELOPMENT OF MICRO-ORGANISMS PERHAPS DUE TO WATER INFILTRATION FROM THE ROOF (THE BLACKISH UPPER SECTIONS).

1145 SO-MIN-GYI-HPAYA, EAST SIDE. CALCIUM CARBONATE DEPOSITIONS ON GLAZED PLAQUES AS WELL AS BLACK DEPOSITS FROM ALGAE ON THE ROUGH SECTIONS WITHOUT GLAZING THAT DEVELOP DURING THE RAINY SEASON.

1457 MAHA-GU-GYI, VESTIBULE, SOUTH WALL MUD RUN-OFF THE SURFACE DUE TO INFILTRATION INTO THE MASONRY WASHING AWAY CONSTITUTIVE MUD-BASED MORTAR, AT THE LEFT GROWTH OF MICRO-ORGANISMS (ALGAE).

3.1.11 Bio-deteriogens on surfaces of mural paintings, stucco mouldings, plasters and renderings

Are caused by biological development and it is always associated to moisture.

- Micro-organisms: in association with moisture some species need light for growth (algae, lichens), others need a rich organic substrate such as bacteria or fungi, the latter can develop on an inorganic substrate without light. These micro-organisms cause staining and disintegration of materials as result of their metabolic functions. Microscopic algae develop outdoors or where there is illumination and corresponding to the surfaces wet by water run-off; these are identified by the blackish or greenish layer.
- Bat & bird droppings: products from the metabolic activity of animals that deposited on surfaces form insoluble oxalates (from bats) or acid guano (from birds). In addition, surfaces show signs of abrasion or loss of plaster caused by bats' wings and feet.
- Insect nests: termites, ants, beetles, etc. dig tunnels in the sub-soil or inside mud-based plasters. Other insects as bees, wasps, beetles, etc. construct their nests on any surface.
- Birds' nests: swallow nests under high and cool vaulting of temples that can be nearby the banks of the Aye Yar River. Nests of pigeons on horizontal quiet places of windows and niches are found as well in many of the temples given the
- Lizard (gecko) eggs: these reptiles select quiet and dark areas to deposit their eggs so the offspring will come out undisturbed.

1085 SEIN-NYET-AMA, VESTIBULE EXTERNAL NORTH WALL. MICRO-ORGANISMS (FUNGI, ALGAE, LICHENS) DEVELOP ON DAMPENED AREAS WHEREAS THE SECTIONS NOT REACHED BY WATER ARE IN RELATIVELY GOOD CONDITIONS.

2128 TEMPLE, VESTIBULE. PIGEON'S NEST ON STUCCO FLAME PEDIMENT.

1202 ABEYA-DA-NA, CELLA, VAULT. BAT DROPPINGS ON THE VAULTING SURFACE.

1323 KUBYAUK-GYI (MYINKABA), VESTIBULE, SOUTH WALL. INSECT EATER OF ACRYLIC RESINS EMPLOYED IN FORMER INTERVENTIONS, BURROW TUNNELS INTO THE MUD-BASED PLASTERS SEARCHING FOR THESE.

1219 KYA-ZIN-HPAYA, SWALLOW'S NESTS UNDER THE VAULTING OF THE SHRINE.

1487 TEMPLE, BIRD'S DROPPINGS ON MURAL PAINTINGS.

3.1.12 Former interventions on preparatory layers

- Red clayey fillings: mixed with other materials applied during former times (Ava period) in order to integrate the surface and over-paint with new depictions.
- Mud-based & lime-based fillings: built-in losses of plaster that were successively integrated with painting.
- Cement: mixtures of Portland cement and surki or sand, were used for filling lacunae, filleting borders of lacunae, re-pointing brickwork voids and for masonry repair.

- Hydrated lime: fillings with this material and sand or surki for masonry repair, for 'edging' borders of lacunae or for filling lacunae.
- Grouts and adhesives: injected with the aim in providing adhesion to detached plasters.

537 TAYOK-PYI-HPAYA-GYI, VESTIBULE, NORTH WALL. THE DARK BROWNISH AREA ABOVE THE ARCH IS A FORMER FILLING WITH MUD-BASED PLASTER AND THEN PAINTED FOR COMPLETING THE LOST DECORATION.

2007 SHWE-KYAUNG-U-HPAYA, WEST WALL, NORTH SIDE. DEFORMATION CAUSED TO THE ORIGINAL PLASTERS BY THE HARD FILLING IN CEMENT THAT DID NOT ALLOW ADJUSTMENT.

3.1.13 Former interventions on the painted and non surfaces and, due to human activity

- Grime: hands' grease mixed with dust and other materials rubbed on surfaces, especially painted, obliterate the depictions.
- Smoke: produced by igniting fire inside the temples, during 2nd World War when people looked for refuge.
- Coating/fixatives: synthetic and natural resins (PVAc, shellac, oil, etc.) applied in order to protect the surface.
- Whitewashes: applied for homogenising the surface after having filled lacunae of considerable dimensions.
- Over-painting: areas of original and perhaps damaged depiction were covered by subsequent painting by painters that did copies of the mural paintings.

1600 NAT-HLAUNG-KYAUNG. SMOKE DEPOSITS FIXED WITH PVAC COATING(S).

85 THEIN-MAZI. MURAL PAINTINGS BEING DISCOVERED UNDER WHITEWASH LAYERS OF LIME.

2162 ANANDA-OK-KYAUNG. GRIME AT HAND REACH AND FIXATIVES OBLITERATE THE PAINTED SURFACE AND CAUSED DETACHMENT OF PAINT (THE WHITE POINTS).

1404 SHWE-BON-THA. OVER-PAINTING IN LATER PERIODS WAS A COMMON PRACTICE, THIS MEANS THAT THE BUILDINGS WERE IN USE.

II. Do's and don'ts regarding assessment techniques, conservation-restoration techniques and materials

The international charters and guidelines for management, conservation and maintenance of sites and the monuments therein contained, have been produced by experienced professionals as theoretical and practical guidance. The guidelines these charters provide are useful to carry preservation works within determinate parameters so it is recommended to stick to their suggestions as this has not been the case of the site of Bagan. The main charters and guidelines referred to the conservation of mural paintings are: *ICOMOS Principles for the Preservation and Conservation-Restoration of Wall Paintings* (2003) and the *Guidelines and Recommendations for the Conservation and Maintenance of Mural Paintings in Subterranean Environments* (2015). Some of the charters referred to the conservation of monuments are: the *International Charter for the Conservation and Restoration of Monuments and Sites* (the Venice Charter 1964), the *ICOMOS Charter – Principles for the Analysis, Conservation and Structural Restoration of Architectural Heritage* (2003), the *Nara Document on Authenticity* (1994), *Principles for the Recording of Monuments, Groups of Buildings and Sites* (1996). In addition other charters can be useful for the preservation of the site, such as the *Charter for the Protection and Management of Archaeological Heritage* (1990) and the *International Cultural Tourism Charter* (1999).

However, it would be of great utility if some of the main conservation principles for the preservation of historic monuments and their decoration be implemented so as to adhere to international standards:

- Reversibility states that it should be possible to undo what was applied and/or employed for conservation purposes without undue risks of the original material or excessive cost.

- Retreatability capable of being either removed or retreated without damaging any of the remaining material.
- Minimum intervention states that only necessary conservation work should be done not exceeding in transformations of the actual state of the object.
- Compatibility require that the composite formed by ancient and modern should behave in a favourable way in the expected environmental conditions.
    - Mechanical compatibility should insure that mechanical properties are properly matched and that it is unlikely for original parts to become over-stressed because of differential thermal expansion or other movements imposed by the environment
    - Physical compatibility involves the matching of such properties as porosity and water vapour permeability and the future behaviour of the composite when exposed to water
    - Chemical compatibility should provide insurance against the risk that by-products formed in setting reactions or decomposition products of the materials used might cause damage to the object under conservation
- The materials employed for conservation treatments should not cause an acceleration of the deterioration rate of the ancient fabric.
- The present intervention aims to slow-down decay because the constitutive materials of the ancient fabric are not everlasting and therefore the modern materials applied must 'sacrifice' for the longer duration of the ancient ones.
- Once the present conservation work is concluded regular inspection, eventual maintenance and timely repair must be done.

4 Pre-conservation-restoration actions

Prior any conservation-restoration treatment is carried out on the architectural decorative works, it is necessary to carry out a survey so as to establish their state of conservation followed by a thorough documentation (graphic and photographic). In addition, the study of their technique of execution is fundamental for establishing methods, techniques and materials to employ. Therefore, samples of constitutive materials, products of deterioration and materials employed in former treatments must be taken, analysed and the analytical results, interpreted by specialist so as to determine the proper methodology of intervention to adopt. Given that many materials employed for conservation are produced abroad and besides of their cost, also transportation is expensive, it is advisable to adapt materials locally found for the conservation of the ancient plasters, stucco mouldings and renderings. However, beforehand it is indispensable to carry out thorough research (samples, analyses, tests, etc.) so as to establish if the uses of determinate materials for the conservation of the architectural decorative works are suitable or not.

4.1 Assessment and recording

The purpose of rapidly assessing the conservation conditions and identifying the causes of decay of the monuments, namely the mural paintings and decorative works of the architecture, such as stucco mouldings, glazed plaques, pavements, etc. at Bagan is because of the vastity of the site and the large number of monuments that composes it. This in order to identify if there is ongoing damage or this has ceased and to establish the causes that provoked such state so as to act upon and then, draw up conservation strategies and planning interventions according to the rating of priorities given by the conditions in which the monument can be (precarious, good or negligible).

To this end, three survey forms were formatted. The **Rapid Condition Assessment Card for Decorative Works** (D-Card) following the UNESCO '*International Expert Workshop on Bagan Inventory*

System' (9 - 10 June 2014) and ICCROM's '*Pilot Study Workshop for Rapid Assessment Methods for Mural Paintings and Decorative Works'* (11 - 20 June 2014); the **Emergency Assessment Card** (E-Card) during the ICCROM intervention on post-earthquake activities, that is not but the D-Card compiled with the main recommendation under '**RECOMMENDATIONS FOR EMERGENCY STABILISATION & MAINTENANCE'** Need for Emergency Conservation; the **First Aid Treatment Card** for the timing/evaluation of treatments to carry out, (FAT-Card) during the UNESCO workshop *'Emergency and First Aid Treatments on the Mural Paintings and Architectural Decorative Works in the Monuments of Bagan subsequent the 24th of August 2016 Seism'* (21 November – 31 December 2016) for prioritising interventions in the monuments of Bagan (see Annex B).

4.1.1 Filling the survey cards

While filling the D-Card or E-Card all fields must be compiled, particularly the estimation of surfaces in m^2 (partial and total of the monument) so the estimate of percentages remaining can be easily calculated. This is useful also for calculating the surfaces to work on in relation to time so as to prepare more accurate work-plans and budgets as established in the FAT-Card.

The prioritisation of monuments for listing the order of first aid interventions can be altered if the situation of a given monument is aggravated and needs of urgent intervention rather that the previous one in list.

It is important to properly fill all the fields in the cards not leaving empty sections so as to have an overall view of the situation and the priority rating can be done easily. It is also important to clearly and carefully record on ground and reflected ceiling plans the identified damages and threats that is not to confound with graphic documentation which is something different.

4.1.2 Assessment techniques

Do not enter a temple that shows cracks or severe signs of structural damage, if not assessed before by an engineer and it is safe.

Wear safety gadgets (helmets, eye goggles, gloves, etc.) while carrying out surveys in endangered monuments and take the necessary precautions, do not speak at loud voice or produce noise, vibrations can accelerate the rapid induction of alternating tensile and compressive stresses in a very damaged structure.

There is a difference on how the structural and the architectural decorative works assessments are carried out. The structural assessment is macroscopic inasmuch that experienced visual expertise is needed to assess cracks, dislodged masonry, subsided sub-soil, etc. Obviously the survey is continued by installation of instrumentation and monitoring. Whereas, the architectural decorative works assessment, particularly on mural paintings, stucco mouldings and renderings, is practically a full contact of surveyor and the work of art, since every square centimetre of the surfaces is examined. The surveys are carried out, besides visual inspection, under different illumination angles (frontal and raking light) so as to identify any defect of the surfaces, under different exposures of lighting (IR & UV light), by tapping surfaces to categorize voids and separation between the plasters and the wall, etc. Therefore, it is necessary to remove barriers (if existing) and to use scaffolding accessible to all sections of the monument for assessing higher areas.

The survey must always start outdoors going clockwise around the monument starting at the east face, when surveying inside, repeat similarly as the outdoors survey, once this is concluded it is necessary to assess again the situation outdoors, checking if damages (especially cracks) match with those encountered at the interior. (see Annex B).

4.2 Documentation

The information collected regarding the various elements, alterations or actions carried out on mural paintings, stucco mouldings and architectural decorative works is one of the main issues concerning

their preservation. The collection of data or documentation that records a given present moment of the history of specific mural paintings and their architectural support is a complex procedure. This comprises the compilation of all available evidence regarding data such as reports, photographs, drawings, etc. complemented with further necessary investigation and recording.

4.2.1 Graphic documentation

Graphic documentation on the state of conservation of a monument consists of a detailed visual report, a mapping, in which are recorded all alterations, damages, actions found or produced on the decorated architectural surfaces marked on a drawing to-scale, whereas the rapid assessment records a given situation of the level and number of threats for establishing the present general state of a monument.

The documentation of mural paintings, stucco mouldings and architectural decorative works, in particular, comprises the assessment of the present state of preservation in which the monument is before any intervention takes place, the detection of former interventions, the identification of the technique of execution describing the techniques employed by the craftsmen and painters by the signs left on the surfaces and the record of the present intervention/treatments complemented with the mapping of monitoring areas or points of sampling for analyses. Therefore, a lexicon that defines the mural paintings terminology based on its stratigraphy as well as the main subjects regarding alterations and concepts or actions is produced so as to correlate this with the definition and representation of graphic key symbols to be used for mapping every heading so as to establish a common language between concept and image.

4.2.2 Photographic documentation

The photographic documentation is an aid to the graphic documentation employed for recording accurately significant details noted during the examination of the mural paintings, stucco mouldings and architectural decorative works. Special photography techniques (various types of lighting, shooting angles, UV, IR, etc.) are useful for documentation but cannot substitute drawings that are comprehensive and easy to understand. Nevertheless, photographs in black and white and colour of the entire walls and important details before, during (after cleaning the painted surface) and after conservation-restoration has taken place, are essential as evidence of the modifications the architectural decorative works underwent.

Photographs of buildings must be done with the sun at the back and never in front, best hours after dawn until 10:00 Hrs and before sunset from 15:30 - 16:00 Hrs.

Photographs of mural paintings must be taken perpendicularly to the surface and never oblique, this alters the proportions. It is better to employ lamps on stands rather than the flash. The camera must be still, preferably mounted on a tripod in line with the vertical planes that must be straight.

4.3 Scientific examination

4.3.1 Sampling and analyses

Taking of samples and their analyses are the main component of the scientific examination of mural paintings, stucco mouldings and architectural decorative works and are necessary for determining the component of materials and technique of execution employed, for identifying the eventual superimposed materials and for diagnosing the alterations and their causes. The value of the results of analytical examination of samples in the laboratory depends on the relevance of the samples that have been chosen and the comparison of the results with all the technological knowledge relative to the painting and the correct interpretation of this comparison.

The analytical process should start by analysing the components of the paint layer of the mural paintings with non-destructive analyses as for example, XRD analysis with a portable diffractometer. The proper conservation of historic and artistic works needs preliminary documentation and studies in-

depth with the aid of pertinent analyses that should be carried out beforehand. This for drawing methodologies and techniques of conservation as well as materials to be employed have to be adapted to every case encountered based on the analytical results.

The basic analyses recommended for undertaking conservation work can be synthesised as:

- Analyses of constitutive materials: plasters, stuccoes, pigments, binders, etc.
- Analyses of non-historic materials formerly employed for conservation purposes: coatings, former grouts, etc.
- Analyses of materials to employ in conservation: slaked lime putty and slaked lime (hydrated), pozzolan from Mount Popa, brick dust, natural resins and gums (neem, acacia glue) alone and in combination, e.g. grouts made out of slaked lime putty, pozzolan, jaggary, etc.
- Investigation on the use and application of protective coatings that must fulfil given international conservation parameters.

4.3.2 Trial tests

Based on the scientific investigations carried out, the selection of the most suitable materials to employ can have effect and consequently prepare mixtures for solving determinate conservation problems, e.g. grouts and glues for re-adhering mud-based plasters.

Identification of sources of possible reliable providers of materials (lime, pozzolan, etc.), selected under severe control of quality to employ and apply for conservation.

Tests for the fixing (grouting) of detached plasters (mud-based and lime-based) with materials of relatively low cost and available in Bagan, were carried out. The results are apparently good but it is necessary to carry out scientific testing and analyses for identifying any possible threat that can result from the use of these materials. Research must be carried out on those materials available in Myanmar that can be used for conservation; this must be encouraged and supported by the DoA along with the related faculties of the national universities.

The following are some of the mixtures with materials found on the spot on which research must be carried out:

- Lime-based grouts for re-adhering detached plasters, renders and stucco mouldings: establish suitable proportions.
- Mud-based grouts for re-adhering detached mud-based plasters and for filling the tunnels dug by insects. These grouts must contain an insect repellent so the burrowing is not done again.
- Mud-based mortars for masonry repair similar as the original.
- Lime/mud based mortars for re-pointing open joints in masonry: to establish colour, grain size, texture, etc.
- Lime-based plasters for filling lacunae in renderings, stucco mouldings and mural paintings.

Trial tests must be carried out on non-important areas with the materials selected for conservation treatments so as to verify their appropriateness and to eventually refine proportions and technique(s).

5 Conservation-restoration actions

Conservation treatments aim the stabilisation of vulnerable components of the mural paintings, stucco mouldings, renderings and architectural decorative works in feeble conditions. These involve the re-adhesion of detached/separated plasters to the support (wall), the fixing of separated paint layer and the consolidation of plasters and paint layer lacking cohesion and, the removal of detrimental materials applied during former interventions such as the cement fillings.

Conservation-restoration treatments comprise the removal of materials that however, distract the attention or obliterate the appreciation of the depictions of the mural paintings.

Restoration comprise treatments that purposely aim the reinforcement and/or removal of distractive gaps in the pictorial text so as to reconstitute the potential unity of the mural paintings' cycle without abrupt interruptions that include the filling of lacunae (re-pointing open brickwork joints in masonry, edging borders of lacunae with the scope of blocking the flow of grout while injecting and filling small lacunae under and at the paint layer level) the dampening of visual tonality and eventual adequate and punctual reconstruction of painted areas for major comprehension with an identifiable technique e.g. *tratteggio*. However, it is of primary importance that a report be always produced so as to keep track on the activities carried out.

The monuments with mural paintings and stucco mouldings must be stabilised beforehand, unless, if the case is, that the consolidation and fixing of plasters and stucco mouldings are needed before any masonry repair is carried out. Therefore, plasters must be treated with the safety precautions and subsequently the work on the structure should proceed.

The new materials employed for conservation in conformity with the new technologies, such as the production of nano-materials of which performance is superior to the former materials is to be encouraged. The use of these new materials adapted for conservation seems to render treatments more efficient with less consume of material.

5.1 Emergency conservation actions

For the-time-being the conservation work on the mural paintings, stucco mouldings and decorative works of the monuments of Bagan is a post-earthquake action, related to emergency fixing and consolidating separated/detached plasters by injecting grouts or adhesives and employing consolidants. Emergency works were systematically carried out during the implementation of the UNDP/UNESCO/ICCROM projects but this task Other conservation operations such as cleaning or pictorially integrating (retouching) mural paintings and carved stuccoes are not relevant for this particular case, that can be done subsequently. The partial or complete loss of the artistic/historical object (mural paintings, stucco mouldings, glazed plaques, pavements, etc.) deprive the monument from its complementary and enhancing components therefore it is important to preserve as possible all of the extant elements.

The emergency treatments on monuments and on the architectural decorative works must be carried out consequentially, ideally one operation subsequent to another, according to a work-plan previously prepared and depending on the type of treatments to be carried out so no overlapping or unnecessary work is carried out.

Do not erect scaffolding for working on the paintings if yet safety is not assured!

The operational sequence should be as follows:

1.- Assessment, recording, prioritisation, etc. As explained above, this is the departing point in which the priority grading for the monuments is listed and subsequent interventions take place.

2.- Retrieval of shattered architectural decorative fragments, cataloguing/registration, storage. The many fragments of mural paintings, stucco mouldings and glazed plaques that collapsed (due to lack of maintenance), were collected and kept in the basement of the museum of Bagan, will be sometime, recomposed and probably repositioned in the location from where the come from. Unfortunately this action in many of the cases will be possible to achieve with accuracy given that a complete inventory of the mural paintings and stucco mouldings does not exist in the DoA so photographic reference is non existent.

3.- Removal of debris & dismantling of fallen masonry by the technical personnel & labour. Erection of supporting scaffolding, propping, etc. for structural reinforcement and protection of personnel working below cracked vaults.

4.- Erection of scaffolding in bamboo or metallic with wheels for both teams; structural & mural. It is very important that the safety of the operators be guaranteed as well as working conditions is safe and steady.

5.- Temporary and/or permanent treatments & protection of unstable architectural decorative works by the mural conservation team. These are the emergency treatments to carry out on the mural decorations, such as adhering bandage for supporting temporarily endangered plasters or stuccoes about to collapse or to give extra support while injecting grouts or adhesives for fixing to the support and consolidating powdery preparatory and paint layers by injecting grouts, adhesives and consolidants.

6.- Provisional stabilisation of the monument by propping or using ties, belts, etc. at this stage both teams must work along for eventual protection of the mural and stucco decoration. This stage is very important given that the points of view of engineers and conservators are different. This is the case of **539** Tayok-pyi-hpaya-gyi in which, the previous steps were carried out one by one but at this point the engineers did not call the mural conservation team and installed the steel wire belts around the central core of the temple at the first floor, directly on the mural paintings with a rubber like buffer instead of the polystyrene layer and wooden pole as earlier discussed.

539 TAYOK-PYI-HPAYA-GYI. MODEL OF PROTECTION OF THE MURAL PAINTINGS OR STUCCO MOULDINGS WITH POLYSTYRENE SHEETING AND WOODEN PLANKS OR BEAMS BEFORE INSTALLING A STAINLESS STEEL BELT.

539 TAYOK-PYI-HPAYA-GYI, UPPER STOREY, SHRINE, SOUTH EAST CORNER OF CENTRAL CORE. THE STAINLESS STEEL BELT WAS INSTALLED ON A THIN BLACK RUBBER SHEET DIRECTLY SET ON THE PAINTINGS. THIS WILL CAUSE DAMAGE TO THE PAINTED PLASTER AT THE CORNER.

7.- Further strengthening and protection of decorative works after the structure has been stabilised. This is current conservation work on areas that were not treated before because relatively out of danger but in need of fixing or consolidation.

8.- DEFINITIVE STRUCTURAL INTERVENTION OF THE MONUMENT BY THE ENGINEERING/STRUCTURAL TEAMS.

997 KYAUNG-GYI-NIMA (AMA), WEST PORCH, NORTH. THE BUTTRESS FOR SUPPORTING THE PORCH WAS BUILT WITH STRONG CEMENT DIRECTLY ON THE STUCCO MOULDINGS WITHOUT ANY PROTECTION OR BUFFER. **ATTENTION TO STRUCTURAL WORKS BE AWARE!!!**

997 KYAUNG-GYI-NIMA (AMA). SHRINE, SOUTH WALL. THE WHITE LEAKAGE OF GROUT CORRESPOND TO A FORMER LEAKAGE OF MUD MORTAR. THE MASONRY REPAIR TEAM WAS UNAWARE OF THE PROBLEM SO NOT UNDERTOOK THE NECESSARY MEASURES TO PUT REMEDY.

9.- Eventual removal of buffering materials and conservation-restoration interventions on the decorative works. (Please see below conservation-restoration treatments).

The dangerously detached/separated painted plasters from vaulting must be propped before any attempt to fix is done by injecting grouts, but before, the paint layer must be fixed and protected with a coating if necessary. It is very important to use buffers (plastic sponges, polystyrene sheets, etc.) between the rigid and friable plasters/stuccoes and the planking employed for propping.

539 TAYOK-PYI-HPAYA-GYI, TEMPLE AT UPPER STOREY, VAULT OF PASSAGE TO SHRINE, SOUTH SIDE. MURAL PAINTINGS SEPARATED FROM THE VAULT ARE PROPPED BEFORE GROUTING.

539 TAYOK-PYI-HPAYA-GYI, TEMPLE AT UPPER STOREY, SOUTH SIDE OF VAULT OF PASSAGE. GROUTING IS DONE THROUGH AN OPEN SIDE OF THE PLASTER.

The painted plasters, stucco mouldings and renderings must be consolidated and fixed to the walls or vaults in case that any eventual vibration during repair works is produced, these will not collapse.

The painted and the stucco surfaces that are in vicinity of crossing (structural) cracks that will be grouted during masonry repair, must be fixed to the wall (if separated) and the crack filled as deep as possible so as to prevent leakage of grouting material onto the mural painting surface.

5.1.1 Permanent interventions

The so-called permanent interventions of detached plasters and scaling/flaking paint layer should relatively last for some time. The fixing back of plasters and paint layer has been the main conservation

issue in Bagan but little attention has been given by the DoA so given that other issues have been prioritised such as cleaning the paintings for such or such patron.

Given that first aid work is just to secure the decorative works, it is not important the aesthetic presentation. The main conservation issue is therefore, the re-adhesion and the consolidation of plasters and stuccoes in precarious state, separated or detached from the support. This type of intervention is to last quite long, for sometime thus, can be called permanent, whereas the temporary treatments consist of facing completely the area or sticking bands of textile for holding for providing support dangerously separated plasters from the wall.

5.1.2 Temporary treatments

Other less permanent interventions are done by providing support, with bandage made out of cotton gauze strips pasted with highly reversible resins in solution, to areas near bulging plasters or renders in extreme dangerous conditions so as to prevent their collapse as a preventive measure during treatment or, while awaiting a longer-lasting treatment such as, grouting. Facing of separated areas with cotton gauze cloth and reversible adhesives, is another transitory protective measure that can prevent the collapse of larger areas of plasters or renderings.

1471 THEIN-MAZI, VESTIBULE, NORTH WALL PROVISORY BANDAGE ADHERED SECURING THE SEVERELY DETACHED MURAL PAINTINGS.

539 TAYOK-PYI-HPAYA-GYI, TEMPLE UPPER STOREY, NORTH FACE, EAST SIDE OF PORCH. SECTION OF RENDERING FACED WITH COTTON GAUZE AND HIGHLY REVERSIBLE GLUE.

5.2 Regular conservation-restoration actions

There are and have been projects implemented in Bagan that have had as main objective the conservation of the monument, its mural paintings, stucco mouldings, renderings, glazed plaques, etc. In many cases the materials employed met with given conservation standards but in other, the use of obsolete materials was a routine. Therefore, and given the importance of the architectural decorative works, particularly the mural paintings in Bagan, it is of primary advice that the use of materials be in line with the international charters of conservation as also with the state-of-the-art scientific research on new materials and methodologies, more apt to current conservation issues.

Some conservation projects have employed imported materials not found in Myanmar so their cost is high including transportation therefore, it is not realistic the provision of large quantities for use in such vast site as Bagan is, in reality it is needed a selection of sustainable materials (compatible, similar and retreatable) and technologies available on site and at low-cost.

The main conservation-restoration works of architectural decorative surfaces comprise:

5.2.1 Fixing preparatory layers lacking adhesion

Is the re-adhesion of separated/detached interfaces of plasters amongst themselves or with the support (wall or vault). Fixing can be carried out by grouting liquid mortars or by injecting compatible and retreatable adhesives.

The systematic fixing and consolidation of separated plasters in the monuments of Bagan has been recommended since the distant past phases of conservation work (1988) but attention was not given and many fragments of paintings collapsed during the 24th of August 2016 earthquake that now fill countless shelves in the depots of the museum.

The re-adhesion of detached preparatory layers from the wall or amongst their interfaces as well as between the plaster and the paint layer has been an issue of not easy and satisfactory solution. The mechanical behaviour of the ancient constitutive materials usually is not the same as for the new ones employed in conservation and therefore, these must be modified and adapted to every case. The use of similar and compatible materials with the original fabric is one of the main requisites for a reliable conservation practice, whereas, reversibility is no more considered as a requisite because, the material that was injected remains at the interior of the structure and cannot be removed.

The main priority in Bagan has been the fixing and consolidation of mural paintings, stucco mouldings and plasters separated/detached with, or without deformation from the walls. The fixed idea that edging the borders of surviving plasters and stucco with lime putty and brick dust or with cement, might fix them, is ineffective. There are many examples that show the plaster fallen and the edging standing. The fixing of plasters must be carried out by employing similar materials to the original but this has not been done in Bagan. Tests with compatible, similar and retreatable materials have been done but there has been no follow-up on this action. Even in recent times, it is still employed something similar to Poly-vinyl-acetate in aqueous emulsion (white carpenter's glue) alike to Primal and other synthetic resins employed in the 1980's but **not** now in 2017. The use of synthetic resins for fixing plasters is not advisable because in the long-term, cause damage becoming brittle ad fragile.

1580 LOKA-HTEIK-PAN, PORCH, EAST WALL. DURING A GROUTING TEST WITH MATERIALS LOCALLY FOUND SUCH AS SLAKED LIME PUTTY, POZZOLAN, JAGGARY.

539 TAYOK-PYI-HPAYA-GYI, FIRST STOREY TEMPLE, SOUTHEAST CORNER OF CENTRAL CORE IN SHRINE. GROUTING MATERIAL RUN-OFF OVER THE SURFACE THAT WAS NOT REMOVED SO THIS WILL SHOW FOREVER A WHITE INDELIBLE STAIN. IT IS IMPORTANT TO BE ATTENTIVE.

Regrettably, this ha been the case in Bagan when there is not the supervision of the UNESCO consultants that have suggested to use other similar materials to the original plasters such as lime, pozzolan, sieved soil and neem or acacia glue, etc. compatible, retreatable and similar in composition with the original materials. The problem is that the use of the latter materials requires more work for their preparation and their application need dexterity and time.

It is important that the paint layer be sound before injecting or grouting plasters or renderings as well as to begin from the bottom to the top.

5.2.2 Consolidation of preparatory layers lacking cohesion

It is the strengthening of materials lacking cohesion. This is carried out by injecting, spraying, percolating compatible/similar materials (consolidants) to the original binder aiming that the linkage between aggregates and powdery binder is reinforced.

5.2.3 Fixing paint layer lacking adhesion

It is the re-adhesion of separated/detached paint layer from the preparatory layer. Scaling/flaking or crest-like paint is fixed through impregnation through tissue paper of thin/liquid adhesive. It is compulsory that the fixing of the paint layer begins from the bottom to the top as to avoid damage if fixatives run-off down on the surface, it is safer to remove from a fixed surface rather than from a non treated one.

5.2.4 Consolidation of paint layer lacking cohesion

It is the strengthening of incoherent particles of paint layer that lost bonding. This is done by spraying, injecting or percolating compatible/similar consolidant(s) into the powdery layer.

5.2.5 Removal of obsolete materials

The elimination, usually by mechanical means, of damaging or outdated materials employed for filling lacunae, edgings or re-pointing masonry e.g. Portland cement, dating to former interventions.

Cement is incompatible with the original materials and it is unsuitable for conservation of ancient fabrics due to the following reasons:

- cement is too strong (high compressive strength and high modulus) in case of differential movement, stress will be transmitted to the older sections which will fail;
- has large thermal expansion coefficient which will result in stress and damage of the 'weak' old masonry;
- forms soluble salts while setting and their leaching takes place even long time after setting when comes in contact with water;
- has a low porosity consisting in very small pores hindering moisture movement in masonry not allowing evaporation beneath the cement layers.

Coatings of PVAc (Poly-vinyl acetate), shellac, oil, etc. formerly applied on the painted surfaces have discoloured, hardened and have became brittle, have rendered the surfaces impermeable and their removal implies the use of strong and harmful solvents for the operator. During the rainy season, these resins (especially PVAc) absorb humidity and expand whereas during the dry-hot season the film contracts and pulls away the thin, fragile paint layer, causing its detachment.

Analyses of the paint layers composition (resistance to the action of determinate solvents) as well as to establish the parameters of solubility of the synthetic coatings formerly applied in order to select the most appropriate solvents for their removal is essential. Testing on a non important area would be the next step to carry out so as to establish the length of application through compresses (tissue paper, cotton wool, etc.) for the swelling and safe removal of the coatings.

5.2.6 Filling of lacunae, cracks and losses

The lost constitutive sections in which this treatment is needed are filled with similar and compatible materials; therefore if the plaster layer is made out of mud, the filling must be mud-based plaster and **not** another material, e.g. plaster of Paris, as used by some unscrupulous persons.

- Re-pointing masonry is the re-sealing of open joints of masonry with similar material to the original mortar.
- Edging (filleting) borders of lacunae is a treatment that employs similar material to the original on borders of lacunae for sealing these before grouting, as reinforcement or as filler of gaps. This treatment has been extensively carried out in Bagan with the (ineffective) aim of supporting separated plasters or renderings and has caused the most endangering source of deterioration of mural paintings, stucco mouldings and brickwork.
- Treatments of lacunae: the losses of renders and paint layer are filled with similar and compatible materials to the original accordingly to the stratigraphy and with the principles established regarding the problem of re-integration.
  - under the paint layer level renders should match in colour and texture with the original not subject to pictorial integration must appear flat as the original underlying plaster.
  - at the paint layer level limited in surface area and capable in being ethically reconstructed.

The treatment of lacunae or losses of the preparatory layers is carried out depending if the paint layer is subject to pictorial reconstruction or not. The lacunae that are filled to the paint layer level are meant to be reconstructed employing a discernible method such as *tratteggio*. Whereas the lacunae that are filled below the paint layer level must appear alike the other, never handled as the intact ones.

The lacunae that can and must be filled at the paint layer level are those that ethically can be reconstructed and deemed necessary for a better comprehension of the pictorial text; only and because the information is provided by similar elements, by matching/jointing of lines, and, etc. which are 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 can be subject to artistic and subjective interpretation, falsifying the original artist's intention.

1600 NAT-HLAUNG-KYAUNG, EXTERNAL WEST WALL OF CIRCUMAMBULATORY CORRIDOR. THE LACUNAE WERE FORMERLY EDGED WITH STRONG CEMENT PLASTER BUT THE PLASTERS WERE NOT FIXED/CONSOLIDATED. THE CEMENT WAS REMOVED AND THE SMALL LACUNAE FILLED WITH SIMILAR COMPATIBLE MATERIAL AS THE ORIGINAL AT THE SAME LEVEL AS PER THE ORIGINAL STRATIGRAPHY. IT IS PENDING THE REMOVAL OF THE PVAC AND SMOKE LAYERS FROM THE SURFACE THEN, EVERYTHING WILL BLEND WITH THE CLEANED PAINTED SURFACE.

2171 ANANDA-GU-HPAYA-GYI, ENTRANCE PASSAGEWAY. THE APPROACH FOR THE TREATMENT OF LACUNAE AS WELL AS FOR THE ORIGINAL PLASTERS IS INCORRECT. THE PLASTERS MUST BE FIXED/CONSOLIDATED, THE LACUNAE CLEANED AND FILLED WITH SIMILAR MATERIALS TO THE ORIGINAL, NOT CHOPPING OUT THE LOOSENED SECTIONS AND FILLING WITH NON-SIMILAR MATERIALS. THE WATER INFILTRATION PROBLEMS HAVE NOT BEEN SOLVED, NOTICE THE DARKER AREAS THAT CORRESPOND TO WET PLASTER.

The edging or sealing open borders of lacunae is a treatment that is carried out before fixing separated renders, as reinforcement or as a filler of gaps. Edging borders of lacunae as a filleting continuous slope was a conservation practice that aimed to provide support to separated renders from the wall and degenerated into a widespread technique for protecting borders without a proven positive result.

Edging must be very carefully done, in a way that blends with the present situation of the paintings because, on the contrary, extra bands, as tapeworms, are shaped within a ruined state causing a notorious disgusting visual impact. These treatments and the re-pointing open masonry joints must be done employing similar materials as the original retaining the authentic initial characteristics and aspect.

5.2.7 Cleaning

Is the removal of extraneous deposits from the surfaces, revealing the present state of the original materials. The selection of materials and methods depends upon the nature of the substances to be removed and the resistance to abrasion and solvents of the underlying layers composing the mural painting.

The removal of undesirable deposits (coatings such as PVAc and oil, lime-washes, bat and bird droppings, insect nests, hardened dust, smoke, etc.) from the surface to reveal the state of the paint layer is carried out by wet and dry cleaning.

- Dry cleaning is the removal of solids covering the surface is carried out by mechanical means, without employing chemicals or reagents but only with instruments and tools capable in causing their breakage, separation and disintegration and/or manipulating the mechanical properties of water.
- Wet cleaning is the use of chemical cleaning agents (bases and acids) that break by reaction the primary bonds of the solids covering the surface or by exchanging ions allowing their removal.

Before cleaning a mural painting it is necessary to know about the technique employed by the painters, the material composition of the paint layer as well as the coatings or deposits on the surface. Samples must be taken and analyses carried out for exactly understand the mechanics to implement while safely removing undesirable deposits from the painted surfaces. Unfortunately, this is not the case in Bagan cleaning has been carried out without the scientific support and very restricted usage of solvents have been employed without taking the given precautions and causing irreversible damage such as, abrasion or washout of the paint layer. The cleaning of mural paintings particularly those of Bagan that are very sensitive and fragile is a very delicate operation that must not be carried by inexpert or arrogant operators.

The mural paintings must not be cleaned before any structural intervention takes place, this must be, along with filling lacunae and the pictorial presentation, the final operations to carry out during an overall conservation-restoration of a monument. The cleaning of paintings in general is an irreversible operation because once, even a slight portion of paint is removed from the surface, cannot be put again. As stated above, voluntary or uncontrolled damage caused by the technician to the fragile paint layer means an irreversible damage caused. Therefore, it is an enormous responsibility of the specialist to carry out correct treatments on the mural paintings, especially when cleaning the surfaces being a permanent action. The cleaning of mural paintings requires, likewise the technician to be capacitated with extreme high skill, the use of appropriate techniques (dry or wet cleaning), comfortable and safe scaffolding and excellent illumination. While cleaning surfaces it is important to start from the top (upper parts) and then continue downwards without dripping the cleaning solutions on the surfaces below so no lines or other strange over-cleaning issues become.

For example, in **534** Sa-pwe-tin Temple, the mural paintings were 'restored' inasmuch that some painted areas were over-cleaning at a point in which the paint layer appears abraded by the solvents employed and other areas, were not properly cleaned revealing dirty/obscure areas. It was said that someone working on the restoration of the murals in this temple did a mixture of the available solvents such as water, butylamine, acetone, ammonium carbonate, salt of EDTA, and etc. that probably neutralised each one the action of the other and, did no harm at all but could have caused also the contrary as well as could have produced a health hazard threat to the operators that employed it. The use of tissue paper cut into squares or rectangles as support/poultice for the solvents while cleaning the

mural paintings can be useful as well as hazardous because can leave indelible marks. The borders must be cut by tear and not with scissors so as to fringe the perimeter.

It is important when wet cleaning is done through tissue paper that this must be done the most homogeneously as possible so no joints' marks are produced between one sheet of paper and another. It is better to apply the tissue paper on a complete area within a given perimeter, as for example; a complete figure, or a head, a decorated area and so forth. Thus, it is recommended that the tissue paper be applied to circumscribed areas or scenes so the cleaning becomes homogeneous.

Therefore, if the wet cleaning of a mural painting is difficult even upon scientific research, it is necessary to be humble enough to admit that this operation will be done in a later stage when the most appropriate and suitable materials and techniques for carrying out this operation in the safest possible way are accessible.

However, the majority of the mural paintings in Bagan have deposits of dust that must be removed with very soft brushes upon verification of the state of the paint layer in order to carry out eventual fixing. Other deposits found on the mural paintings are mud deposits, coatings (shellac, oil, PVAc, Paraloid B72) previously applied, smoke, birds and bat droppings, etc. that should be removed according to good conservation practice and not as it has been done until present, unscrupulously employing any or only one substance (solutions of Ammonium carbonate and bicarbonate in water) without a proper technique. In most of the cases dry cleaning with brushes and electrostatic dry cleaning sponges is enough, and if localised areas need wet cleaning, this is done by stabilising the paint layer around with the aim in preventing water stains (if used) and then employing the most suitable solvent for removing the deposit.

1668 SHWE-THI-HSAUNG, VESTIBULE, NORTH SIDE OF ARCH. CLEANING TEST WITH HEAVY DRIPPING BELOW. IT IS DIFFICULT TO GET RID OF THE LINES PRODUCED SINCE SOME ARE STILL DIRTY AND OTHERS OVER-CLEANED THUS, AN UNEVEN SURFACE IS CREATED.

534 SA-PWE-TIN, CIRCUMAMBULATORY CORRIDOR. HEAVY OVER-CLEANING IN WHICH, THE PREPARATORY DRAWING OF THE CENTRAL FIGURE WAS REVEALED HAVING DELETED FOREVER THE PAINTING.

1846 TEMPLE, PENATHA-GU GROUP, PORCH, NORTH WALL. THE PAINTINGS WERE CLEANED AT A POINT THAT FINAL OUTLINES AND DETAILS WERE REMOVED BY USING INAPPROPRIATE TECHNIQUES AND MATERIALS (NOT SUITABLE STRONG SOLVENTS). THE EXTANT NOT CLEANED AREA WITH THE RECTANGLE, IS PRACTICALLY INTACT, IT WAS NECESSARY TO ONLY REMOVE DUST BY DRY CLEANING.

534 SA-PWE-TIN, CENTRAL CORE, SOUTH WALL, EAST SIDE. IRREVERSIBLE DAMAGE TO PAINTINGS DUE TO NON HOMOGENEOUS CLEANING, NOTICE THE LINES MARKED BY THE TISSUE PAPER JUNCTIONS. THE SOLVENTS EMPLOYED ARE UNKNOWN.

571 TEMPLE, SOUTH VESTIBULE, VAULT. THE CLEANING OF THE PAINTED SURFACE SHOWS NON HOMOGENEOUS APPLICATION OF SOLVENTS AND PERHAPS WITH DIFFERENT TIMING. DARK AND LIGHT PATCHES RENDER THE APPRECIATION DIFFICULT.

534 SA-PWE-TIN, CIRCUMAMBULATORY CORRIDOR. THIS MUST NEVER BE DONE, IT IS A BRILLIANT DEMONSTRATION OF INCAPACITY.

5.2.8 Pictorial presentation

It is the minimisation of the disturbance caused by losses of the pictorial text restoring the image to the maximum presence possible while respecting its authenticity as a creation and as an historical document. The potential unity which is characteristic to mural paintings is that it is a whole and not a sum of parts and therefore directs the interpretation of losses and the way to treat them.

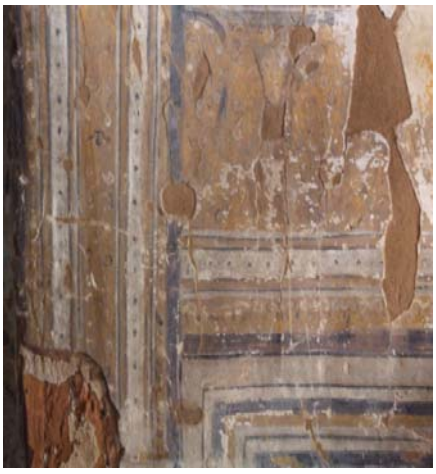
- **dampening of the wear of patina and paint layer** that consists in reducing the pale tonality of abrasions and paint layer by darkening those lighter areas so as to integrate them with the surrounding extant paint.
- **dampening of visual tonality of losses of paint layer and plasters not subject to reconstruction** which consist in darkening the lacunae so as to drive them backwards forming part of the rear and allowing the re-emergence of the pictorial fabric as a figure.
- **reconstruction of the paint layer with *tratteggio*** that consists of thin, parallel, vertical lines which adequately recompose the pictorial fabric from afar, still keeping the *tratteggio* easily identifiable as an abstract instrument aimed solely at restoring the potential unity of the work of art.

Aesthetic or pictorial presentation is the minimisation of the disturbance caused by losses in the pictorial text, restoring the image to the maximum presence possible while respecting its authenticity as a human creation and as a historical document. This operation completes the cleaning of mural paintings providing order, especially when facing the problem to re-establish unity to a fragmentary context. The potential unity which is characteristic to mural paintings is that it is a whole and not a sum of parts and therefore, directs the interpretation of losses and the way to treat them.

The wear of patina and paint layer such as abrasions, are dampened by darkening lighter areas integrating the visual tonality and providing continuity to the pictorial text. The losses of paint layer besides altering the state of the surface alter the perception of the image that appears in recess of the original plane of perception. Therefore, it is necessary to visually make diminish the disturbing light losses, by toning-down with glazes of colour slightly lighter and cooler than the original so as to distinguish the original from the intervention, giving the impression of being a trace of the original colour. As illegibility caused by wear or losses disappears, the forms recover their continuity and by improving the precision of the image, it can be properly judged the treatment of the remaining losses and to decide, if necessary, the reconstruction of limited losses in order to provide major comprehensibility of the depiction.

Dampening of visual tonality of lacunae, is the toning-down of losses of paint layer and plasters that are not subject to reconstruction, this consists in darkening the lacunae so as to send them ideally backwards in the plane of perception and forming part of the rear and therefore, allowing the re-emergence of the pictorial fabric as a figure.

262 SHWE-LEIK-PYI, VESTIBULE, NORTH WALL. AREA OF PAINTING BEFORE INTEGRATION WITH WATERCOLOUR GLAZES. NOTICE THE WHITE LOSSES ON UPPER SECTION.



262 SHWE-LEIK-PYI, VESTIBULE, NORTH WALL. AREA OF PAINTING AFTER TONING DOWN THE WHITE LOSSES OF UPPER SECTION WITH WATERCOLOUR GLAZES.

'The reconstruction of the paint layer with *tratteggio* that consists in transposing the modelling and drawing of a painting by a system of hatching based on the principle of division of tones by thin, parallel, vertical lines which adequately recompose the pictorial fabric from afar, still keeping the *tratteggio* easily identifiable as an abstract instrument aimed solely at restoring the potential unity. This method should be only utilised for reconstruction of missing parts as providing better perception of the image without conjectural interpretation but only based on evidence provided by the surrounding painting. This operation must stop where hypothesis begins.' (Mora 1984: 301-312).

5.2.9 Protective coatings

Once the conservation and restoration treatments are concluded it is advisable that a coating of a protective layer on the mural paintings be applied, this for homogenising the visual appreciation of the paintings as also their protection from unforeseen agents.

2171 ANANDA-GU-HPAYA-GYI. THE MURAL PAINTINGS WERE CLEARED FROM WHITEWASHES, THE LACUNAE FILLED WITH PLASTER OF PARIS AND PICTORIALLY INTEGRATED. A COATING OF NON SUITABLE PVAC WAS APPLIED AS A PROTECTIVE COATING.

571 TEMPLE. DURING THE RESTORATION WORKS OF THE MURAL PAINTINGS, A COATING WITH NEEM GLUE WAS DONE ALL OVER THE SURFACE WITH THE EXCEPTION OF THE DARKER SQUARE AREA THAT WAS COATED WITH AN ACRYLIC RESIN (PARALOID B72).

6 Post-conservation-restoration intervention actions

Regular inspections and monitoring of the monuments in Bagan are the best preventive measures to undertake, because any potential damaging issue, if identified on time, can be immediately treated. The case of Bagan is difficult due to the reduced number of personnel that should watch out for the hundreds of monuments. Notwithstanding, that even with the monuments that are under the care of trustees, damage appears but they do not pay attention to the early condition until they realise that the situation cannot be kept under control with partial or if not, total destruction incurring into high expense for repair. Preventive conservation and maintenance are two concepts that must be kept in mind because, as for example, once conservation work is concluded; there is the notion that it will last forever but this concept is invalid because can happen that something can go wrong.

6.1 Preventive conservation and maintenance

Preventive conservation treatments comprise those actions that preclude and/or minimise beforehand the development and related consequences or further exasperation of damaging causes. Numerous activities fall within this concept such as, the assessment of the potential damaging causes, the monitoring of possible factors so as to understand their behaviour through attentive analysis and the implementation of measures that eliminate or in any case, that reduce these damaging factors.

The maintenance programme must prevent the current intervention to fail in the short-term. It must be reminded that conservation work only slows-down deterioration processes and never stops them; in addition, minimal intervention ensures the original materials to perform without too much interference.

ANNEX A

The three lines of the poem in ink inscription on the east wall of Temple N° 15 at Salé

Taken from: Minbu Aung Kyaing, ***'Architectures of Bagan Period'***, Rangoon, 1981. Burmese text, pp. 123-124 translated into English by U Aung Kyaing during the *'Field Working Session and Training Workshop on Conservation Planning for Post-Earthquake Rehabilitation'*, 11-19/5/2017.

1. Yumkabar man boiled the hide of buffalo mixed with the white lime and sour water carefully. Then after the mixture is boiled, he scraped out from the big bowl for the mortar.
2. Then the bark of ohn-don tree is peeled out and boiled them to be sticky and put them into the above mentioned mixture with oil into the big bowl. Afterwards the mixture of buffalo hide, white lime, molasses, sticky ohn-don bark was stirred by pounding several times to be the powder.
3. Then the mixture has to stay in the sun to be dry, to be hard just like the hardness of stone.

Proportions of materials: *
toddy pots of buffalo hide.....10
toddy pots of ohn-don tree bark.....2
toddy pots of molasses.....3
toddy pots of the bark of lacquer....5
Total..10 + 10
+ toddy pots of lime (putty).....20
toddy pots of sand.....20
Total 20 + 40 = 60 toddy pots of stucco/plaster.

* measured by volume in pots for containing toddy sugar from palm trees.

The composition of traditional lime-based plasters

According to U Aung Kyaing the following proportions were employed for manufacturing traditional lime-based plasters (the source is unknown):

Seven times of the bark of the ohn-don tree to be boiled

Nine times of the buffalo hide to be boiled

Two times of molasses

More times of bael fruit jelly than molasses

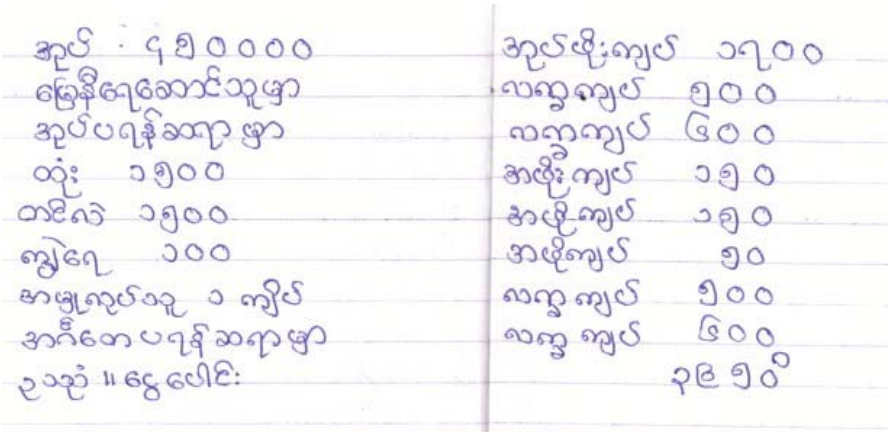
One fistful of cotton or silk cotton

Half pound of oil.

The 2162 Ananda-ok-kyaung inscription

The dedication inscription in **2162** Ananda-ok-kyaung Monastery contains a list of some of the materials employed for construction and decoration and, their cost. This was a common practice ensued by the Buddhist donors since the Bagan period, to list properties donated as well as the materials employed, etc. but especially the expenses incurred so as to gain merits.

2162 ANANDA-OK-KYAUNG, NORTH CIRCUMAMBULATORY CORRIDOR AROUND CELLA, INNER WALL, WEST SIDE. DETAIL OF INSCRIPTION MENTIONING MATERIALS AND COSTS INCURRED FOR THE CONSTRUCTION OF THE MONASTERY.



Copy of a section of the dedicatory inscription in which are mentioned some of the materials and costs for the construction of the monastery.

The translation of the above inscription is roughly:

Number of bricks employed	450,000	1,700 Kyats
Cost of construction		500 Kyats
Cost of brick mason		600 Kyats
Lime	1,500	150 Kyats
Molasses	1,500	150 Kyats
Buffalo hide glue	100	50 Kyats
Labour		500 Kyats
Mason labour		600 Kyats
		3,950 Kyats

There is a scene on the lower sector of the east section of the north inner wall of the circumambulatory corridor around the central cella on which, the monastery is depicted with its measurements. In addition, below the scene there is an inscription that mentions the name of the merit maker builder (Ottanayazan), the builders' names (Shwe Ya, Shwe O & Shwe Pan), the name of the monk abbot (Shinthudhamalankrara) living in the monastery, total cost of painting charges 7,250 Kyats, date of construction 1,143 to 1,147, the date of consecration Buddhist year 2,319 = Myanmar Era 1,137 = A.D. 1775. (Data kindly provided by U Aung Kyaing).

ANNEX B

The survey cards

FIRST AID TREATMENT CARD (FAT-Card)

THE REPUBLIC OF THE UNION OF MYANMAR – UNESCO/DoA THE SITE OF BAGAN			MONUMENT NUMBER: NAME:
PRIORITY LEVEL ☐ HIGH ☐ MEDIUM ☐ LOW	**GRADE LEVEL:** GRADE I ☐ GRADE II ☐ GRADE III ☐ NO GRADE ☐	**INITIAL DATE OF INTERVENTION:** ☐ Continuous ☐ Divided into Phases	**PREVIEWED DATE OF INTERVENTION CONCLUSION:** ☐ Phase I ☐ Phase II ☐ Phase III

OPERATORS (total N° of workers and names)
Conservators (specialised level): ☐☐
Other (specify qualification): ☐☐

NEEDED TIME FOR EXECUTION OF WORK	Temporary Intervention	Permanent Intervention	Total days
☐ Phase I (short term - days):			
☐ Phase II (medium term - weeks):			
☐ Phase III (long term -months):			
		TOTAL NEEDED TIME FOR EXECUTION OF WORK	

REQUIREMENTS	**AMOUNT**	**RATE**	**COST**
TOTAL COST FOR COMPLETION OF WORK (as per cost by work expressed in sq m)			
TOTAL COST MATERIALS (as per enclosed Attachment A)			
TOTAL COST EQUIPMENT (as per enclosed Attachment B)			
TOTAL COST INFRASTRUCTURES (scaffolding, water & light supplies)			
TOTAL COST TRANSPORTATION OF EQUIPMENT AND MATERIALS			
		SUB-TOTAL 1 REQUIREMENTS	
OTHER/UNFORESEEN COSTS (10% of sub-total 1)			
		GRAND TOTAL	

INTERVENTION

CONSTITUTIVE MATERIALS/ELEMENTS	**DAMAGE/ALTERATION**	**m² / m**	**TYPE OF TREATMENT**
☐ Mud plaster & priming layer (1)	☐ Detachment/separation		☐ Grouting
☐ Mud-lime plaster (2)	☐ Bulging		☐ Injection fixatives/consolidants
☐ Lime-mud-lime plaster (3)	☐ Scaling/flaking		☐ Consolidation
☐ Lime plaster (N° of layers) – (4)	☐ Powdering		☐ Filling voids
☐ Lime plaster &cloth (5)	☐ Detachment & powdering		**Temporary/Provisory**
☐ Priming & paint layers (6)	☐ Bulging & powdering		☐ Facing/bandage
☐ Stucco carvings (indoors) – (7)	☐ Cracks		☐ Covering/total protection
☐ Stucco carvings (outdoors) – (8)	☐ Lacunae & open borders		☐ Propping
Additional Decorative Elements			
☐ Glazed plaques	☐ Detachment/flaking		☐ Fixing
☐ Terracotta plaques	☐ Powdering		☐ Consolidation
☐ Mirror mosaic	☐ Cracks		☐ Filling voids
☐ Stone carvings	☐ Lacunae		☐
☐ Other	☐		☐
NOTES			

MURAL PAINTINGS & DECORATED ARCHITECTURAL SURFACES RAPID ASSESSMENT CARD BAGAN, REPUBLIC OF THE UNION OF MYANMAR	Monument Number/Name:

SURVEY DETAILS

Survey person(s):	Institution:	Survey date:

Type of inspection:			Type of monument:			
☐ regular	☐ emergency	☐ other:	☐ Temple	☐ Stupa	☐ Monastery	☐ Underground structure
			☐ Archaeological element	☐ Other		

GPS co-ordinate(s) & height above sea level:

LEVEL OF PRIORITY AND RECOMMENDED ACTIONS

Overall Severity Magnitude of Observed Degradation:			Overall condition rating (current):				
☐ High	☐ Medium	☐ Low	☐ Very bad	☐ Bad	☐ Poor	☐ Fair	☐ Good

Significance of monument:				Significance of decorations:				
☐ Grade I	☐ Grade II	☐ Grade III	☐ No Grade	☐ Excellent	☐ High	☐ Medium	☐ Good	☐ Low

Priority for detailed condition assessment of decorations:				Safety concerns (danger for visitors):	
☐ Urgent	☐ High	☐ Medium	☐ Low	☐ Yes - specify:	☐ No

Recommended actions and further investigation needed:

☐ Emergency conservation intervention	☐ Structural assessment	☐ Address safety concerns ☐ Other
☐ Detailed decorations' assessment	☐ Liquid water run-off/drainage	☐ Other

TYPE OF DECORATION — **Estimate of surface area (m² or % remaining)**

	Original (m²)	**1992*** (%)	**Current** (%)
Mural paintings on mud plaster ☐ on lime plaster ☐			
Stucco (exterior) ☐			
Stucco - polychromed (interior) ☐			
Plaster ☐			
Stone carving ☐			
Sculpture ☐			
Glazed plaques (terracotta ☐ sandstone ☐) ☐			
Flooring (brick ☐ stone ☐) ☐			
Other:			

OBSERVED DAMAGES	Severity high med low	Area (m²)	DEGRADATION FACTORS	SEVERITY high med low
STRUCTURAL INSTABILITY (SUPPORT) **New ☐ Ongoing ☐**			**ENVIRONMENT & BIODETERIORATION**	
Unstable masonry	☐ ☐ ☐		Water infiltration (major leaks)	☐ ☐ ☐

Cracks	□ □ □		Poor drainage	□ □ □	
Other:	□ □ □		Light exposure	□ □ □	
	□ □ □		Micro organisms	□ □ □	
PLASTER LAYERS/RENDERS **New** □□□□□□□ **Ongoing** □			Plants	□ □ □	
			Animal excreta (bats □ birds □**)**	□ □ □	
Lack of adhesion (risk of collapse/loss)	□ □ □		Insects	□ □ □	
Lack of cohesion (risk of collapse/loss)	□ □ □		Threat from visitors	□ □ □	
Cracks	□ □ □		Other:	□ □ □	
Other:	□ □ □			□ □ □	
PAINT LAYERS & GROUNDS **New** □□□□□□ **Ongoing** □			**RECOMMENDATIONS FOR EMERGENCY STABILISATION & MAINTENANCE**		
Lack of adhesion	□ □ □				
Lack of cohesion	□ □ □				
Other:	□ □ □				
	□ □ □				

SITE INFORMATION

Access to building open □ locked □	Electricity supply available yes □ □ no □	Water supply available yes □ □□□□ no □	Existing scaffolding yes □ □□□□ no □	Lighting system in place yes □□□□□ no □

MURAL PAINTINGS & DECORATED ARCHITECTURAL SURFACES **RAPID ASSESSMENT CARD BAGAN, REPUBLIC OF THE UNION OF MYANMAR**	**Monument Number/Name:**

GROUND PLAN / CEILING PLAN OF THE MONUMENT INSERT GROUND PLAN (with scale bar and compass) + GRID HERE. If there is more than one ground plan (e.g. multiple stories) – or it is necessary to divide the ground plan in parts (e.g. large and complex building) INSERT ADDITIONAL PAGES and number accordingly (i.e. page 2a; 2b etc.)

LEGEND

LEVEL OF SEVERITY HIGH (RED) MEDIUM (YELLOW) LOW (GREEN)

MURAL PAINTINGS & DECORATED ARCHITECTURAL SURFACES RAPID ASSESSMENT CARD BAGAN, REPUBLIC OF THE UNION OF MYANMAR	Monument Number/Name:
SURVEY DETAILS	
Survey date:	Survey persons:

External or Internal	Architectural element	Decorative element	Grid ref. (ground plan)	Height above ground (m)	Description	Severity of damage (H/M/L)	Size of damage (m x m)	Photo number

EMERGENCY CARD FOR DECORATIVE WORKS (E-Card) compiled as an example

MURAL PAINTINGS & DECORATED ARCHITECTURAL SURFACES RAPID ASSESSMENT CARD BAGAN, REPUBLIC OF THE UNION OF MYANMAR	Monument Number/Name: 43

SURVEY DETAILS

Survey person(s): Daw Ohn Mar and her team	Institution: DOA	Survey date: 27-09-2016

Type of inspection:			Type of monument:			
☐☐ regular	☐☐ emergency	☐☐ other:	☐☐ Temple	☐☐ Stupa	☐☐ Monastery	☐ Underground structure
			☐ Archaeological element	☐☐ Other		

GPS co-ordinate(s) & height above sea level:

LEVEL OF PRIORITY AND RECOMMENDED ACTIONS

Overall Severity Magnitude of Observed Degradation:			Overall condition rating (current):				
☐ High	☐☐ Medium	☐☐ Low	☐ Very bad	☐☐ Bad	☐☐ Poor	☐☐ Fair	☐☐ Good

Significance of monument:				Significance of decorations:				
☐ Grade I	☐ Grade II	☐ Grade III	☐ No Grade	☐ Excellent	☐ High	☐ Medium	☐ Good	☐ Low

Priority for detailed condition assessment of decorations:				Safety concerns (danger for visitors):	
☐☐ Urgent	☐☐ High	☐☐ Medium	☐☐ Low	☐☐ Yes - specify:	☐☐ No

Recommended actions and further investigation needed:

☐ Emergency conservation intervention	☐ Structural assessment	☐ Address safety concerns	☐ Other
☐ Detailed decorations' assessment	☐ Liquid water runoff /drainage	☐ Other	

TYPE OF DECORATION — **Estimate of surface area** (m² or % remaining)

	Original (m²)	1992* (%)	Current (%)
Mural paintings on mud plaster ☐☐ on lime plaster ☐			
Stucco (exterior) ☐			
Stucco - polychromed (interior) ☐			
Plaster ☐			
Stone carving ☐			
Sculpture ☐			
Glazed plaques (terracotta ☐ sandstone ☐) ☐			
Flooring (brick ☐ stone ☐) ☐			
Other:			

OBSERVED DAMAGES	Severity high med low	Area (m²)	DEGRADATION FACTORS	SEVERITY high med low
STRUCTURAL INSTABILITY (SUPPORT) **New** ☐☐☐ **Ongoing** ☐			**ENVIRONMENT & BIODETERIORATION**	

Unstable masonry	□ □ □		Water infiltration (major leaks)	□ □ □
Cracks	□ □ □		Poor drainage	□ □ □
Other:	□ □ □		Light exposure	□ □ □
	□ □ □		Micro organisms	□ □ □
PLASTER LAYERS/RENDERS **New** □□□ **Ongoing** □			Plants	□ □ □
			Animal excreta (bats □ birds □**)**	□ □ □
Lack of adhesion (risk of collapse/loss)	□ □ □		Insects	□ □ □
Lack of cohesion (risk of collapse/loss)	□ □ □		Threat from visitors	□ □ □
Cracks	□ □ □		Other:	□ □ □
Other:	□ □ □			□ □ □
PAINT LAYERS & GROUNDS **New** □□□ **Ongoing** □			**RECOMMENDATIONS FOR EMERGENCY STABILISATION & MAINTENANCE**	
Lack of adhesion	□ □ □		No door. Situated in a village. Need for Emergency Conservation.	
Lack of cohesion	□ □ □			
Other:	□ □ □			

SITE INFORMATION				
Access to building open □ locked □	Electricity supply available yes □ no □	Water supply available yes □ □□□ no □	Existing scaffolding yes □□ □□□ no □	Lighting system in place yes □□ no □

ANNEX C

Synoptic Table: Damage/alteration – Cause(s) – Recommended Treatment(s)

Damage/alteration	Cause(s)	Recommended Treatment(s)
Lack of adhesion of preparatory layers (detachment with no deformation) up to 5 mm	Rising damp and/or water infiltration, later evaporation and sub-florescence of soluble salts Earthquakes, vibration Thermic shock (outdoors) Thermal expansion (outdoors) Roots of plants	Fixing by grouting or injecting suitable adhesives. Start from bottom to top, avoid leakage of materials. Do not fix plasters if the paint layer lacks adhesion, fix first and then grout/fix plasters.
Lack of adhesion of preparatory layers (detachment/bulging with large deformation) from 6 mm to several centimetres	Rising damp and/or water infiltration, later evaporation and sub-florescence of soluble salts Earthquakes, vibration Roots of plants Thermal expansion (outdoors) Thermic shock (outdoors)	Propping independently from the scaffolding on which work is ongoing to avoid movements, use of buffer materials & fix by grouting. Grouts must be injected at different stages so as not to overload the void(s), leave to dry between one injection and another. Plant suitable trees on side most exposed to sun heat.
Lack of adhesion of preparatory layers (delamination & burrowed tunnels)	Tunnels burrowed by insects in the mud-based layer Separation between layers	Mud-based grouting for filling tunnels. Injections of suitable adhesive.
Lack of cohesion of preparatory layers (powdering)	Rising damp and/or water infiltration, later evaporation and crystallisation of soluble salts Thermic shock	Consolidation by spraying, injection or percolation of compatible consolidant(s). Provide protection during the change of climate.
Crossing cracks in masonry (from side to side)	Roots of plants Sub-soil subsidence Earthquakes, tremors, vibrations	Usage of weed killers. Engineering work (insertion of micro-poles). Engineering work.
Mechanical cracks in preparatory layers	Thermal expansion (outdoors) Water percolation (outdoors) Earthquakes/tremors	Provide suitable protection. Plant suitable trees on side most exposed to sun heat.
Drying cracks in preparatory layers	Shrinkage due to excess of water in the mixture or to rapid evaporation of water	Nothing to do. Eventual consolidation and micro-filling.

Damage/alteration	Cause(s)	Recommended Treatment(s)
Lacunae in preparatory layers	Erosion due to water infiltration and salt re-crystallisation. Failure of detached plasters. Breakage by mechanical action (throwing of stones, conscious removal for inserting tie beams, etc.).	Protect from dampness. Consolidate existing lacunae (if necessary). Fill gaps according to established code of ethics.
Lack of adhesion of paint layer (scaling/flaking, bubble-shaped, crest-shaped detachment)	Rising damp and/or water infiltration, evaporation and sub-florescence of soluble salts. Shrinkage of coatings or fixatives.	Re-adhesion through tissue paper, pressing & fixing. Begin from lower sections, if material drips down it is easy to clean.
Lack of cohesion of paint layer (powdering)	Water evaporation and crystallisation of soluble salts.	Consolidation by spraying, injection or percolation of compatible consolidant(s).
Cracks in paint layer	Drying & shrinkage of binding medium. Exsiccation of coatings that pull out the paint.	Nothing to do. Remove obsolete coating.
Lacunae of paint layer	Coatings that have pulled away paint sections. Mechanical abrasion by people rubbing the surface	Fix detached areas and remove dangerous coatings by previous study of paint layer and coatings (sampling, analyses and interpretation of results) for applying the most suitable techniques and solvents.
Alteration of pigments	Sunlight Excessive heat/fire (irreversible damage)	Install screens & anti UV/IR glass.
Calcium carbonate & dust deposits	Acidic water percolation on surfaces, dissolution and deposition elsewhere	Protect upper sections from water run-off.
Dust deposits	Wind Large tourist buses & vehicles on unpaved roads	Wind barriers, remove dust regularly with soft brushes taking care not to abrade the paint layer.
Water run-off mud deposits or concretions	Water infiltration into masonry dissolving constitutive mud mortar, depositing elsewhere on surfaces	Find source & repair upper parts.
Bio-deteriogens on surfaces (micro-organisms: algae, lichens, fungi)	Water percolation & run-off on unprotected surfaces (outdoors)	Deviate/stop water percolating running-off over surfaces, once no water on the surface, clean, not before (it is useless).
Bio-deteriogens inside structures (superior plants, bushes, trees)	Water stagnation/infiltration	Weed killers, repair upper parts.

Damage/alteration	Cause(s)	Recommended Treatment(s)
Droppings from different animals on surfaces	Faunal activity (birds & bats)	Install ultrasound inhibitors, nets on openings.
Abrasion of surfaces	Faunal activity (bats)	
Insect or reptile nests on surfaces	Faunal activity (beetles, geckoes, etc.)	Regular monitoring and persuasion to nest in temples.
Breakage of plasters and masonry due to water evaporation and crystallisation of soluble salts.	Obsolete former interventions (use of Portland cement)	Removal of cement and eventual substitution with similar material to the original.
Whitewashes Over-painting	Human activity	Cautious removal of whitewash if ancient painting is underneath. To discuss with historian if remove or not. However it is better to keep as part of history and because underneath, maybe little original painting is left.
Grime Smoke Obsolete varnishes/coatings	Human activity	To remove/clean by previous study of paint layer and deposits (sampling, analyses and interpretation of results) for employing the most suitable techniques and materials (solvents). Areas at hand reach protected with self-standing plexiglass or glass panels and not with wire mesh screens.

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