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► **To cite this version:**

Thierry Joffroy. Moenjodaro UNESCO Emergency Mission Following Disastrous Rainfall in 2022 : Final report, May 2023. UNESCO; CRAterre. 2023, pp.101. hal-04449757

HAL Id: hal-04449757

<https://hal.science/hal-04449757>

Submitted on 9 Feb 2024

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Moenjodaro

UNESCO Emergency Missions Following Disastrous Rainfall in 2022



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Final Report

May 2023

Moenjodaro, Pakistan

UNESCO Emergency Missions Following Disastrous Rainfall in 2022

First mission: 21 - 29 October 2022
Second mission: 13 - 25 January 2023

Final Report

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May 2023

In August 2022, the Moenjodaro World Heritage Site received disastrous rainfall up to 779.5 mm that seriously affected the archaeological remains. The intensity of heavy rainfall caused severe structural damages, including collapse of walls, developing cavities and holes in structures due to loss of mud and bricks, erosion of slopes and mud *pushta*, weakened the foundations of walls and structures at Moenjodaro Site. Heavy rain also affected the drainage system and the main drain. The main drain around the Main Stupa area choked with silt and other wastes causing accumulation of water into the ruins up to the level of two feet inflicting further damages to the structure.

The site, already fragilized, has been set in a vulnerable condition and needs urgent intervention with damage assessment and stabilization work to protect these from further decay and future disasters. In the context of limited technical and financial capacity of the staff of the Directorate of Archaeology and Antiquities, Sindh, to handle such a huge disaster and major conservation and restoration work it is required to involve and seek guidance of international experts and technical support from UNESCO. Hence World Heritage Centre strongly encouraged the State Party to apply for International Assistance and mobilized the World Heritage Fund. Directorate of Archaeology and Antiquities, Sindh worked closely with UNESCO Islamabad office to prepare international request for immediate technical and financial support for immediate and long-term conservation of the site under the guidance of international experts and UNESCO.

The engagement of an international conservation expert was intended to ensure that the damage caused to Moenjodaro site by monsoon rainfall is stabilized, and to enhance the emergency response and preparedness capacity of the Directorate of Archaeology and Antiquities and the Government of Sindh, to prevent and mitigate the impact of future natural disasters. This was to be achieved through the following specific objectives:

1. A thorough damage assessment of the World Heritage Site, to establish findings and long-term recommendation.
2. Defining adapted measures and launching the stabilization, including immediate repair of damaged sections; training on emergency conservation best practices for site management staff.
3. Capacity building training for relevant staff to address emergency response and preparedness against future natural disasters.
4. Detailed strategy for long-term conservation of both sites, emergency response and preparedness against future natural disasters.
5. Identification of the potential of new knowledge that might result from some damage to be balanced with possible emergency needs including immediate repair and stabilization of affected sections of Moenjodaro as well as trainings and equipment required.

Cover pictures. Top: overall view of the Citadel (SD) area of Moenjodaro archaeological site / Bottom : January 2023 workshop participants' group picture.

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1. Summary and overall conclusions and recommendations

1.1. First UNESCO expert mission, October 2022

The first emergency international expert mission following the August 2022 heavy rains at Mohenjodaro World Heritage Site was organized from 21 till 28th October by UNESCO and the Directorate of Archaeology of the Government of Sindh. After a preparation phase and studying of the preliminary reports prepared by Mohenjodaro conservation office, the mission at the site comprised technical inspections of all site areas and technical meetings, while a final synthesis meeting was organized the last day of the mission with representatives of the Sindh government to discuss the first conclusions and orientations proposed.

Thanks to the good organization of the mission by the conservation team at Mohenjodaro, all areas of the site have been visited and examined which allowed to take stock of the level of destruction and first measures already implemented. A visit to the protective dykes and spurs was also organized, and additional reports and documents available in the office library were taken into account. The conservation laboratory was also visited with presentation of all testing procedures already in place.

The heavy rains that have occurred by the end of August 2022 have been challenging for the archaeological remains. Actually, the recorded level of rains represented twice the quantity ever measured for a full year (400 mm in 1994). In spite of all efforts made by the conservation team during the 10 days of rains (pumping of water in some of the rooms, verification of drainage canals, covering of the stupa with tarpaulin, etc.), there has been numerous destructions and there is hardly any structure which has not been affected in a way or another.

The site has been seriously affected however with a great variety of levels of destruction, including variations from area to area.

As a general appreciation, though, it also appeared clearly that the conservation works undertaken for several decades had been very useful. Still many built structures are in an acceptable state of conservation. The site remains impressive, more specifically as the conservation team has immediately engaged in cleaning works making already possible for visitors to access the main areas (SD & DK, VS¹).

1.2. Major findings of this first mission

a) State of the property and the causes of decay

Right from the beginning of this first mission, the intent was to observe carefully and share an understanding of what had happened at the site (circumstances and processes of decay) the the local team. This led to establish that:

. The great majority of the structural degradation are the result of an insufficient capacity of the walls capping to absorb water (as aimed at²) combined with the formation of large flows

¹ Areas have been named after the name of the archaeologist who excavated them (initials)

² See Conservation Manual – Treatment descriptions, p.13

of water against wall basis and, at some places, water stagnation, that weakened the basis of walls while there have also been infiltrations from the top of the walls with a majority of the destruction resulting of combined processes involving leaning of walls (base) and further infiltration between the wall and rooms floors (top and floors levels).

. There are 3 main causes, circumstances and processes of degradation, nothing really new, but with an increased level of the threats (higher rainfall than experienced earlier) to the site, resulting in more decays. Those are:

- superficial drainage,
- salts crystallization and hydration inside mortar and bricks, and
- pre-existing weaknesses in the walls structures;

. The specifications contained in the 1997 conservation manual are relevant. They have had some level of efficiency, while probably not implemented as often as what had been recommended.

. Thus some of the contents in the conservation guide need to be revised according to new potential threats (climate change with potential repetition of higher instant rainfalls). That mainly concerns the following conservation practices : drainage system and flooring method, bonding between old and new materials, quality of mortar and bricks at wall basis) that will be followed by proposals for the development of complementary research / experiments to be implemented for developing complementary solutions to those existing (or upgrading the properties of the building materials);

. As a result of the heavy rains and formation of gullies on some archaeological mounds, some structures have been revealed. Some structures appear to have specific interest (e.g. east side of the citadel) as a new archaeological corpus and it would also be important to analyze structures that may require preventive measures (avoiding degradations in case of new heavy rains).

b) Human resources

. The existing conservation team, in spite of its high motivation, faces difficulties to undertake all necessary maintenance and preventative works as indicated in the conservation manual. That will need to be discussed further with exploring potential for additional recruitments of workers with a variety of skills (masons, one carpenter, foremen, laborers) at Mohenjodaro (increase of regular budget);

. The team was impacted by the damaged state of the property but has remarkably addressed the situation during and after the rains. It has kept good moral and appears to be highly motivated for tackling the situation;

. Taking into account the extent of what is still to be done at all the areas of the site after the recent heavy rains (cleaning of debris, stacking of bricks, earth movements for drainage system), it was recommended that this team would be seriously reinforced, at least for a good period of time (minimum 4 months, but if possible up to next monsoon).

1.3. Proposed preliminary plan of action:

Disaster Risk Reduction at Moenjodaro, a required long term perspective

In the light of the extent of the conservation works to be implemented after the destructions resulting from the heavy rains and that such an important conservation project will require several years (probably 3 years), it was proposed to take this situation as an opportunity to

invest in an in-depth reflection for better preparation of Mohenjodaro archaeological site (and its conservation team) against the potential future impacts of climate change.

Such a project would include research and experimentation on a variety of aspects: selection of materials, improvement of mortar / bricks resistance; increased salt control/mitigation; major changes in drainage system and should end with a revision of the current conservation manual (25 years old) and also the Master plan (approved 50 years ago).

It was also raised that, if approved, what would then become an ambitious project would require specific funding, probably around 1.85 million USD (see updated estimate in appendix 3). The idea of such a project has already been judged relevant by Moenjodaro team and by the AA&C Department, Ministry of culture, Sindh province Government. But it still require time to be developed partly as its full description will be possible only when getting the results of the detailed condition survey (mapping and quoting) that was launched during the UNESCO expert mission. It will also require that national and international experts reflect on its extent and how each key issue identified should be addressed. Of course, time will also be needed to identify and secure the necessary funding sources.

Short term plan and needs for immediate Disaster Risk Reduction (to be implemented before 2023 monsoon)

Having in mind the relevance of adopting such a long term perspective, focus was also given to define how to address immediate conservation needs with the goal of minimizing the exposure of the site structures before the arrival of next monsoon (starting from July 2023).

To that end, it was suggested to urgently reinforce capacities of Mohenjodaro conservation team, during, at least, a first four month period to:

- . Make sure that the conservators / architects at Mohenjodaro can spend most of their time on the preparation and finalizing of the agreed maps and plans indicating state of conservation + bill of quantities for each area, and collecting of information (surveys, archaeological reports) for the most sensitive areas and preparing first technical proposals for undertaking the repairs with the guidance of international expert (actual works to be launched during its second mission);
- . Make proper communication system (including Internet coverage on site) available among experts (national and international) for smooth remote communication and data inputs, since there is no stable Internet facility on site. As a backup the local team can do the remote meetings in Larkana.
- . Make sure that the existing field team fully concentrate on the most urgent technical work using techniques already proven and mastered: underpinning, simultaneous repair of retaining walls and room drainage, creating water outlet systems where they are needed, starting from the citadel area, then DK, HR and VS.
- . Make an extra budget available (regular budget has been already allotted to take immediate measures during rains);
- . Make funds available for recruitment of 28 workers allowing the deployment of 4 independent teams that will be in charge of the works that do not need high skills like cleaning of debris, transporting and properly stacking bricks to be re-used, large movements of soil and debris (e.g. drainage of temple main room in HR area), removal of paths slabs, etc.;

- . Deploy (or redeploy) two additional assistant conservators for assisting in the condition surveys (elaboration of plans per theme) and the supervision of works at the site;
- . Confirm the task of the national expert to undertake a specific study on “Ancient drainage systems” as they appear in archaeological reports so that the year-old solutions can be given priority when taking conservation decisions;

For making this happen, it was recommended to urgently allot an amount of 70 000 USD (see appendix 2) to the Moenjodaro conservation team, with some items (deployment of assistant conservators for example) potentially being covered “in kind”, in order to complete the implementation of the emergency interventions (stabilization of structures at risk) and a first set of drainage improvements (priority to rooms that do not possess any water outlet system) while also ensuring that the whole regular yearly maintenance schedule be addressed at all the seven areas of the site.

Overall, this recommendation was followed that was made possible with funding provided by both by UNESCO under the Emergency Fund and the Sindh Government who actually did assume its responsibilities with not only providing funds for these conservation works as suggested to complement UNESCO support, but also to rehabilitate some of the buildings at the site (offices, staff housing) and for the provision of additional equipment.

Finally it was agreed that the second international mission of the UNESCO expert should be planned for January 2023, while regular Zoom meetings and email exchanges would be organized twice a month until then to follow-up on progress of both detailed condition survey and works at site. Internet communication remaining difficult in Moenjodaro, only three zoom meetings could be organised. Those occurred on:

- . November 16, 2022
- . December 14, 2022
- . January 4, 2023.

This later meeting has been the occasion to discuss the overall program the training workshop to be organized during the second mission, while the Ministry of Culture Sindh took the responsibility of the elaboration of the list of its participants.

Besides that, a visit to Paris on November 7, 2022, has been the occasion to organize a debriefing meeting at UNESCO Headquarters with the Director of WHC, Mr. Lazare Eloundou Assomo, the head of Asia-Pacific Desk, Ms Himalchuli Gurung and the Programme Specialist in charge of the follow-up of the mission, Ms, Nao Hayashi. The expert presented his conclusions and the proposed vision, that of envisioning a project for the long term while making sure the short term needs would also could also be tackled. That was discussed, resulting in a positive appreciation and an encouragement to continue in this direction.

1.4. Second UNESCO expert mission

The second international mission of the UNESCO expert was organized from 13 till the 25 January 2023. As a result of discussions held with the participants to the last zoom meeting, it was decided that the best format would be a longer workshop that what had been planned initially, with each day tackling one or two of the key issues identified and covered in the first mission report.

As already agreed during the first mission, the idea would not be to only have theoretical approaches / discussions, but also, when possible in the limited timeframe, to organize a series of demonstration works when adaptations to the existing specifications (existing conservation manual) would be agreed upon. While this was achieved, the idea to organize the short term program (emergency works before 2023 monsoon) with also keeping in mind long term perspectives was kept. To undertake that, every thematic session was concluded by a reflection for the long term, based on the thematic surveys (plans) that had been done by Moenjodaro team, at times recognizing the need to fine-tune them (for making more precise the levels of priority), but also quoting them, using the excel table system developed in a very interesting multidisciplinary approach by the staff of the administration of the site.

In that respect, each session was concluded with agreed upon:

- . Decisions on the evolution of the conservation techniques, at times simply more rigorous implementation of specifications already in the conservation manual;
- . Revision of some "Rate analysis" forms accordingly so as to insert them in the pivot table for estimating works;
- . Methodological approach to ensure that restoration works are never implemented before the causes have been identified (Risk mitigation);
- . Definition of priorities for the next 6 months (by area, sub area or specific structures);
- . Specific actions needed to prepare the information needed when time will have come to elaborate the proposed 3 to 4 year Sindh Govt. / UNESCO large project for better preparedness of Moenjodaro to new risks linked to Climate change.

A session of the workshop was more specifically organized to discuss the need to include in that long term project the preparation of a Management Plan for the site. The question being raised on the need for a specific Disaster Risk Reduction Plan, the expert recommended that rather than thinking of preparing two different plans, it would be more efficient to elaborate only one plan (The Management Plan). Actually, among the many other issues to be addressed, it would be easy to include that of Disaster Risk Reduction during the process which, anyway, would involve the participation of the same stakeholders (though of course a specific reflection may take place).

By the end of the second mission, a meeting was organized in Karachi with the Minister of Culture, Sindh province Government, and his Director General, Antiquities, Archives & Culture, Manzoor Ahmed Kanasro. This meeting was the occasion to share what had been possible to undertake during the training workshop and to present what was the proposed as the way forward.

Following the training workshop, additional exchanges with the Director of the site were held through WhatsApp (making possible to be more reactive) to discuss the relevance of acquiring ramming equipment and piezometer, and also some details for some very specific works to be implemented by the team in place. That covered the "No door" house, the proposed drainage pits, either new or to be installed in existing wells, and the reconstruction of the sacrificial mud brick masonry over the original remains of the stupa. The overall progress of the work could also be followed up in that way.

1.5. Results by the end of the UNESCO expert overall mission

Destruction at Moenjodaro in 2022 has been massive and the perspectives in a context of climate change are preoccupying. That situation calls for short term actions to be quickly implemented, but also a much longer term planning which has to adopt a strong reflective attitude and, to tackle some of the issues identified, some in-depth researches. And when taking into account the vastness of the site, the challenge appears to be even more difficult to address. Thus as an expert, it is important to quote the strong motivation of the conservation team in Moenjodaro and the support of the Sindh Government that were paramount in making possible the UNESCO expert to achieve the specific objectives that were set for his overall mission and probably to go beyond the expectations.

An important aspect that made this possible is the participatory approach adopted which was applied with enthusiasm and made possible to work together towards common understanding and the establishment of shared conclusions and perspectives. Today, the team in Moenjodaro, does not apply what the expert has suggested, but is applying what are the conclusions of what was commonly identified as key issues and that were further discussed both in terms of causes, circumstances and processes and potential responses.

Still some new approaches have been suggested and adopted with reflections not only oriented towards repair of damages, but making sure that the causes and the aggravating factors of decay would be well identified so that they could be mitigated before the intervention on the structure itself be implemented. A more holistic approach was also suggested with better integrating the quality of the raw and building materials used taking into account their whole life cycle, from the extraction site (quarries) to the possible decay processes going through all transformation and building processes. Another additional attention was also introduced to Moenjodaro staff, that of the potential of information that can be gathered from the ruined state, and also the observation of the collapsed structures / materials, including the possibility for re-using some of them after careful selection, at times because they have specific shapes (there are numerous original special bricks shape at the site). When thought already possible, new restoration techniques or revision of the specifications described in the 1997 conservation manual were made and demonstration of those have been implemented during the training workshop.

Besides that, a number of issues for which the need for further investigations, research and experimentation have been identified. They will need to be part of the longer term program proposed towards the potential definition of new practices with higher potential for more efficient and durable solutions to mitigate the new risks linked to the new levels of threats brought about by climate change, with, when possible, keeping maintenance needs to reasonable and affordable levels. All these observations and explorations made are described in detail in this final report.

Armed with these additional new knowledge and capacities, and with financial support by UNESCO under the World Heritage Fund, and an additional strong contribution by the Sindh Government, since the end of the training workshop organized during UNESCO expert mission 2, the Moenjodaro team has been able to immediately put in action the emergency plan that was prepared in common. With involving additional workers to the core team, progress has been well sustained over the last four months, making possible to implement

more works than what was included in the emergency plan prepared during the training workshop.

Concerning the long term objectives that had been set for UNESCO support to Pakistan and more specifically that of proposing a “*Detailed strategy for long-term conservation of both sites, emergency response and preparedness against future natural disasters*”, a specific aspect illustrating the success of the UNESCO expert mission is that the first mission report has been very much useful in the preparation of the “*STATE OF CONSERVATION REPORT*” prepared in February 2023 “*In compliance with the extended 45th session of World Heritage Committee, UNESCO, providing update on the site in order to raise international technical and financial support. A framework for the preservation in the coming years, including the strategy to cope with natural hazards and possible effects of Climate Change*”, document which has been ratified by M. Manzoor Ahmed Kanasro, Director General, AA&C Department, Ministry of culture, Sindh province Government. This, probably results from the very positive outputs of the meeting held with the Minister of culture on January 24, 2023 that concluded the second mission of UNESCO expert.

In that respect, it is to be quoted that the required “*detailed long term conservation plan for the long term to be further elaborated by the national authorities*” has been further elaborated during and in parallel to the workshop. Taking into account that it would be good to wait for the World Heritage Committee to deliberate positively (that will probably be the case, though possibly with a set of recommendations) on the relevance of launching a funding campaign for the proposed long term project for Moenjodaro, it is finally recommended that a new UNESCO expert mission be organized by the end of September 2023 that would allow to continue the work on the elaboration of this long term plan /project, with taking into account:

- . the world heritage committee recommendations;
- . the continuity of the conditions survey work (maps and plans) as planned during the workshop (the monsoon season will be a perfect time to undertake that);
- . a first evaluation of the behavior of the works implemented in the first half of 2023 using the new specifications proposed in preparedness to the monsoon season / and further the new levels of risks of destruction of the excavated structures of Moenjodaro archaeological site linked to climate change.

2. Activities carried out (Schedule and methodology)

2.1. Mission 1 programme

After discussion with UNESCO representatives, both in Pakistan and UNESCO Headquarters in Paris, as well as with Sindh Government, it was agreed that the first mission would be organised from 21 till 29 October 2022. The mission was prepared with primarily reading all documents made available by UNESCO Islamabad. It allowed to undertake the following:

Friday 21	Departure from Grenoble Travel to Karachi through Istanbul
Saturday 22	Arrival in Karachi Meeting with: . Dr. Abdul Fatah Shaikh, Director, Archaeology and antiquities, Sindh . Prof. Altaf Aseem, Archaeologist, Member of Mohenjodaro Technical consultative committee, National expert Travel to Moenjodaro by road Dinner / meeting with the Site manager, Dr. Syed Shakir Ali Shah
Sunday 23	Inspection of SD area, including discussions at site on specific situations and on-going works Elaboration of a program for the site visits of the week
Monday 24	<i>Morning</i> Inspection of DK Area Visit of laboratory and discussion on results of former lab activities <i>Afternoon:</i> Discussion on work plan to be established in view of defining a long term plan for the improvement of superficial drainage system
Tuesday 25	<i>Morning</i> Inspection of HR Area Demonstration of rammed techniques for floors treatment (and gullies) <i>Afternoon:</i> Discussion on issues related to the presence of salts (origin, effects, ways of mitigation)
Wednesday 26	<i>Morning</i> Visit of circular drain, dyke and spurs / Indus river Visit of Moneer and SV Areas <i>Afternoon:</i> Discussion on work plan to be established in view of defining a short term plan for mitigating structural risks (walls)
Thursday 27	<i>Morning</i> Conclusive meeting with Mohenjodaro team with discussions on tasks, responsibilities & plans for the future <i>Afternoon:</i> Trip back to Karachi

Friday 28 Preparation of summary report
Final debriefing meeting with:
. Dr. Nasim ul Ghani Sahito, Secretary to Gvt. Of Sindh, CTAAD
. Manzoor Ahmed Kanasro, Director General, AA&C Department,
Sindh
. Dr. Fateh Shaikh, Director, Archaeology and antiquities, Sindh
. Prof. Altaf Aseem, Archaeologist, Member of Moenjodaro Technical
consultative committee, National expert

Departure back to France

2.2. Intermediate zoom meetings

As suggested in the expert's ToR and further discussed during the first mission, a series of zoom meetings was organised. Those occurred on :

- . November 16, 2022
- . December 14, 2022
- . January 4, 2023

The aim of these meetings were to discuss progress made on the elaboration by Moenjodaro conservation team on the preparation of plans covering the following conservation issues :

- a) plans indicating existing drainage system : runoff paths and rooms without water outlet.
- b) plans showing the state of conservation of walls
- c) plans showing the state of the capping
- d) plans showing underpinning needs (minor ones)
- e) plans showing pathways and indicating the state of conservation and their potential negative impact (direct / indirect) on some of the structures.

Examples of the maps / plans produced are in appendix 3 of this report.

To be noted here is that during the first mission it has been agreed upon with Moenjodaro team that, in response to point 2.b of the Expert's Terms of reference, "... develop assessment tool / forms to undertake damage assessment", the best choice would be to use maps and plans with series developed for each area of the site and following the above mentioned topics. Such maps and plans would be easy to elaborate (skills available) and also very useful on the long term for decision on implementing works and progress follow-up.

Besides that, another point of the Terms of reference had to be modified, that of the idea that the expert could produce "stabilisation report". Actually those could not be produced for two main reasons. First is that most of the work undertaken by Moenjodaro team after the first expert mission was cleaning of debris and stacking of reusable materials (burnt bricks mainly, with specific focus on special shapes/sizes). Second is that finances to undertake works (with including additional staff for it) came later than expected, making only possible before the second mission the launching of the preparation sundried bricks for the conservation works and starting some works on paths and, as such no reports could be submitted by Moenjodaro team on those within the limited time. Actually, this does not mean that no work was done on that, as long as all works done before the second mission was taken into account during the visits and of course technical discussions held during the training workshop. All new information and conclusions arisen from those are inserted all along the present report

Finally, it is also important to quote that the last zoom meeting included a discussion on the dates of the organisation of the second mission and the format and potential participation to the planned training workshop (see zoom meeting reports in UNESCO expert intermediate report)..

2.3. Mission 2 programme

As a result of discussions held by the end of the last intermediate zoom meeting held on January 4, 2023 (see above) an evolution of the initial training workshop concept (as proposed in the experts ToR) for the workshop (2 days) was discussed. The basic idea was to extend the workshop to almost the full duration of his mission. This was to allow maximizing interaction and make possible a more comprehensive development with combining lectures, discussions, field visits with observations and exercises, hands on works (demonstrations) and also participatory short and long term planning that would allow full understanding by the team in charge when having to implement the program.

The idea being well received by all participants to the zoom meeting was agreed upon. Thus a new program had been proposed, mostly based on the structure of the first expert mission report (see below), while the participants list was left to the national representatives with decision to be shared with Culture Tourism, Antiquities and Archives, Ministry of Culture, Sindh.

Friday 13	Departure from France
Saturday 14	Arrival in Karachi at 10.35 Meeting with Ministry of Culture representative . Departure to Moenjodaro
Sunday 15	Morning Overall discussion on first mission content / objectives Identification of specific key issues to be addressed / specific places at the site to be studied Preparation of a more detailed mission program / setting of responsibilities Afternoon: Beginning of workshop / introduction on objectives, methods and program Session 1 : Discussion on quality of raw materials and building materials
Monday 16	Session 2 : Drainage & canals
Tuesday 17	Session 3 : Capping
Wednesday 18	Session 4 : Underpinning
Thursday 19	Session 5: 5.1, Salt / 5.2, Paths
Friday 20	Rest
Saturday 21	Session 6: Study of places “at risk” + Stupa: discussions on works
Sunday 22	Session 7 : Overall planning / Works – Research- training - publications Closing meeting / ceremony

Monday 23	Transfer back to Karachi with on the way, visit to Chanhu-Daro
Tuesday 24	Final meeting with Ministry of Culture Sindh
Wednesday 25	Departure back to France (departure at 2.50 am)

2.4. Follow up exchanges

UNESCO expert has remained available for potential questions from Moenjodaro conservation team while implementing the works as planned during the training workshop. To make things more simple and dynamic – as zoom meetings required the team to move to the nearby town: Larkana – these exchanges were made through WhatsApp. More than 60 messages were exchanged with the director, Shakir Ali Shah that covered a variety of issues, technical questions, pictures to illustrate specific cases, advices for acquiring equipment's, and updates on the progress made at the site.

Besides that, both the intermediate and final reports were discussed with UNESCO Islamabad and WHC to fine tune content and make sure that those reports would respond to meet the ToRs and the best international standards

2.5. Overall approach adopted / methodology

Considering the specific and complex situation of Mohenjodaro, its world heritage status, its size (300 ha), its longstanding history of conservation efforts, and the extensive impacts of the recent heavy rains it quickly appeared that there was a need to adopt a very cautious attitude with first a strong focus on getting a maximum understanding of what occurred last August, how and possibly identifying the reasons, circumstances and processes of the variety of deterioration cases observed taking into account what had occurred and the measures taken since the site excavations.

The proposed stance was to give priority to consider the adversity that has occurred last August as opportunities, in order to increase knowledge about the site (from an archaeological point of view) and to deepen the understanding of the circumstances and processes of decay that have occurred so as ensure a maximum acquisition of knowledge and understanding before any conclusion and possible suggestions and recommendations be made.

The reflection was therefore nourished by studying:

- . Documents provided by UNESCO (reports and basic documents);
- . Reports on the situation at Mohenjodaro prepared by the Director for Antiquities and Archaeology, of the Culture, Tourism & Antiquities Dpt., Gov. of Sindh and by Director of the site (Archaeological museum).
- . Reports and documents provided by the team in charge, with a special attention given to the "Manual for the conservation and maintenance of Mohenjodaro, prepared in 1997 (CLT/CH/97/185 (UNDP FIT) and the Master Plan prepared in 1972.

Besides that, the first mission was organised in alternating sites inspections and formal meetings with the team in charge of the conservation of the site which proved to be both very motivated and very knowledgeable, thus calling co-reflection, and co-construction rather than providing expertise or orientations. Taking that into account, the site visits required to cover the entire site were conducted with the site supervisors, masons and labourers. The

numerous exchanges and discussions contributed to a good understanding of what was observed, starting from a variety of hypothesis that were evaluated taking into account the diversity of point of views, former experiences and observations, for some of the participants have been working more than 10 years for the site.

Taking into account the good level of the existing capacities at the site also led to suggest a very participative format for the organisation of the training workshop during the second mission. That resulted in the organisation of each session with mixed, as a basic framework:

- . in the morning an introduction based on UNESCO expert mission report followed by a theoretical discussion and then, field visits / inspections;
- . in the afternoon, after the preparation by the expert of a proposed synthesis, a discussion of what should be the guiding principles to tackle the specific conservation issues studied in the morning and priorities towards the elaboration of a draft 3 year project schedule.

A specific mention is here to be revealed, that of the very good capacity of the administration team at Moenjodaro to prepare tables for preparing estimates for works to be undertaken. In addition to the capacity to map specific situations / issues / conditions on autocad plans, that comprises a series of "Rate Analysis" forms linked to an excel pivot table that allow for quick elaboration of costs estimates. Those have been very useful tools that have been much used during (and between) the expert mission to adjust some of those to new observations / specifications proposed and according to priorities set.

3. Basic information on the property (WHC web site)

Outstanding Universal Value: brief synthesis

The Archaeological Ruins at Moenjodaro are the best preserved urban settlement in South Asia dating back to the beginning of the 3rd millennium BC, and exercised a considerable influence on the subsequent development of urbanization. The archaeological ruins are located on the right bank of the Indus River, 510 km north-east from Karachi, and 28 km from Larkana city, Larkana District in Pakistan's Sindh Province. The property represents the metropolis of Indus civilization, which flourished between 2,500-1,500 BC in the Indus valley and is one of the world's three great ancient civilizations.

The discovery of Moenjodaro in 1922 revealed evidence of the customs, art, religion and administrative abilities of its inhabitants. The well planned city mostly built with baked bricks and having public baths; a college of priests; an elaborate drainage system; wells, soak pits for disposal of sewage, and a large granary, bears testimony that it was a metropolis of great importance, enjoying a well-organized civic, economic, social and cultural system.

Moenjodaro comprises two sectors: a citadel area in the west where the Buddhist stupa was constructed with unbaked brick over the ruins of Moenjodaro in the 2nd century AD, and to the east, the lower city ruins spread out along the banks of the Indus. Here buildings are laid out along streets intersecting each other at right angles, in a highly orderly form of city planning that also incorporated systems of sanitation and drainage.

Criterion (ii): *The Archaeological Ruins at Moenjodaro comprise the most ancient planned city on the Indian subcontinent, and exerted great influence on the subsequent urbanization of human settlement in the Indian peninsular.*

Criterion (iii): *As the most ancient and best preserved urban ruin in the Indus Valley dating back to the 3rd millennium BC, Moenjodaro bears exceptional testimony to the Indus civilization.*

Integrity

The Archaeological Ruins at Moenjodaro comprise burnt brick structures covering 240 ha, of which only about one third has been excavated since 1922. All attributes of the property are within the boundaries established for proper preservation and protection. All significant attributes are still present and properly maintained. However the foundations of the property are threatened by saline action due to a rise of the water table of the Indus River. This was the subject of a UNESCO international campaign in the 1970s, which partially mitigated the attack on the mud brick buildings.

Authenticity

The Archaeological Ruins at Moenjodaro comprise the first great urban center of the Indus civilization built 5000 years ago with burnt brick structures. The property continues to express its Outstanding Universal Value through its planning, form and design, materials and location. The setting of the property is vulnerable to the impact of development in its vicinity.

Protection and management requirements

The Archaeological Ruins at Moenjodaro are being protected by National and Regional laws including the Antiquities Act 1975 from the threats of damage, pillage and pilferage and of new developments in and around the boundaries of the property. There is a management system to administer the property, protect and conserve the attributes that carry Outstanding Universal Value, and address the threats to and vulnerabilities of the property as outlined above. A comprehensive Master Plan has been prepared by the Department of Archaeology and Museums, Government of Pakistan to identify the actual extent of the archaeological area of Moenjodaro. However during the process of approval of the Master Plan, the archaeological area of Moenjodaro has been transferred from the Federal Department of Archaeology to the Culture Department, Government of Sindh. Under the Constitution Act 2010 (18th Amendment), the Culture Department, Government of Sindh is now responsible for the proper up-keep and maintenance of the property.

In order to tackle the potential weaknesses as mentioned in the statements of authenticity and integrity there is a site office supported by a scientific laboratory to deal with the issues of conservation and other problems in a scientific way with traditional methods. The problems of salt action, thermal stress and rain are dealt with through a holistic approach involving application of mud slurry, mud capping, re-pointing and other consolidation works such as under-pinning in order to retain the authenticity and integrity of the property. Besides the above threats there is the danger of flood which was mitigated to some extent by constructing embankments and spurs. However, a breach of the dam upstream would cause catastrophic damage. The Department is therefore undertaking regular monitoring of the dam and is seeking secure funding from the Government, NGOs and other donor countries in order to strengthen it.



Moenjodaro, drone picture of DKG area, April 2021© MCO - Arch. N. A. Sangha

4. Overall assessment of the situation after the 2022 rains

The overall assessment in this final report is based on the initial assessment made during mission one but has also been enriched by some few new findings made during the numerous site visits organised during the training workshop of mission 2.

4.1. The 2022 torrential rains and their impact

On the 2nd of September 2022, a brief report was sent by Ihsan Ali Abbasi, Curator and Naveed Ahmed Sangah, Architect to the Director, DAMS, Antiquities and Archaeology, Culture, Tourism & Antiquities, Govt. of Sindh in Karachi which included the following words:

“We received torrential rains particularly at Archaeological Ruins of Mohenjodaro. In August we received record heights level rain i.e 779.5 mm started from, 16/08/2022 to 26/08/2022, and in July 2022 211 mm, which play havoc role for the exposed structures of this site, unfortunately we witnessed the mass destruction at the site.”

Actually, the level of rainfalls quoted for these last days of August 2022 (not taking into account the July figures) represents twice what has ever been recorded for a full year in Mohenjodaro. The situation has not been unprecedented. Most of the past reports include references to heavy rains, but rather short in duration. The “Conservation Manual” prepared in 1997 clearly refers to such rains and provides indications for mitigating measures, including clear guidelines / specifications for the superficial drainage as well as for wall capping.

However, what appeared to have been sufficient in terms of monsoon preparedness until this year was unfortunately only partially efficient under such exceptional rainfall. Very concerned by the situation, the Antiquities staffs were mobilized to do their best to protect what could be, even if their own houses were being flooded by that time. It is an effort important to acknowledge. That included setting of tarpaulin on the top of the stupa, pumping water (even at night) in flooded rooms, repair of drainage canals, etc.



Pictures by Arch. N. A. Sangha: Left, installing tarpaulin on top of the stupa; Right, the Great bath when flooded

Work at the site never stopped and the team worked hard to ensure that the site could be visited by the public with full security, starting with the most visited area: the citadel. The team’s hard work in protecting the site was emphasized during the September 8, 2022 visit of the UN Secretary General Antonio Guterres accompanied by Foreign Minister Bilawal Bhutto Zardari, Sindh Chief Minister Murad Ali Shah, Sindh Provincial Minister for Culture and Education Syed Sardar Ali Shah, and UNESCO Director Youssef Filali-Meknassi.

At this occasion the UNSG had declared³ “*It is not a matter of generosity, but a matter of justice,*” and reiterated the United Nations’ commitment, strong support and solidarity with the flood-affected populace of Pakistan: “*The UN absolutely supported the Pakistani nation and requested the well-resourced nations to support the country massively, so that it could face the future challenges of climatic changes and save its nation*”.



FM Bilawal briefed Guterres on the damages conceded by Mohenjo Daro due to historic rains and floods.
PHOTOS: EXPRES

The goal set by UNSG was clear and thus the UNESCO expert mission would therefore not only be oriented towards an assessment of the damages that had occurred, but also identify the potential variety of levels of destruction and the remaining risks at the various areas that the site comprises (7), to set priorities of intervention, suggest evolution of the specifications of conservation measures to adapt against the new levels of risks identified and ultimately plan for capacities reinforcement towards an increased local resilience in preserving the site.

4.2. Overall assessment

To undertake that priority has been given to observe, describe and moreover understand what had happened at the site that led to concentrate much on the identification of the circumstances and processes of all types of decay that could be observed. These observations allowed to learn as much as possible so as to ensure that it would then be possible to make relevant suggestions not only for stabilization and further restoration.

This process also allowed to launch a participatory reflective process on how the site and its conservation team could be better prepared to the fact that, due to climate change, such heavy and long-lasting rains could happen again, possibly on more and more regular basis. This also led to identifying the expectations and needs in terms of “capacity-building programs for national experts and heritage professionals to cope with disaster risk reduction/preparedness and overall site management”⁴ that would have to be developed during the training workshop that was organized during the 2nd mission of the UNESCO expert (see intermediate report).

³ Express tribune : <https://tribune.com.pk/story/2375944/unsg-visits-mohenjo-daro-assures-support-for-conservation>

⁴ UNESCO- WHC web site : <https://whc.unesco.org/en/news/2484>



Pictures by Arch. N. A. Sangha: Cleaning of debris in SD (Citadel) area immediately after rains

In spite of the vastness of the site (240 hectares) thanks to the good organization of the missions by the conservation team at Mohenjodaro, almost all areas of the site were visited and examined, allowing to take stock of the level of destruction and of the measures that the team had already been able to implement. Visits were also organized at the protective dykes and spurs was also organized while more attention was given during mission 2 at the circular drainage canal.

Numerous efforts were also done to collect additional reports and documents to those available in the Office library so that the information that they contain could be taken into account. That said, it has become clear that further efforts would need to be done for that in the future, so as to make sure that all documentation can be available at the site and well organized for facilitating both research and proper understanding and documentation of conservation works. The conservation laboratory was also visited with presentation of all testing procedures.



SD Area, the best preserved



Moneer area, in a preoccupying state of conservation

As a general appreciation, it has appeared clear that the conservation works that had been undertaken for several decades⁵ have proved their appropriateness. Thanks to their implementation on (more or less) regular basis, many built structures are still in an

⁵ There has been a series of large campaigns of restoration organized by UNESCO and UNDP by the last three decades of the 20th century, resulting in a well restored site, established facilities and a conservation manual (1997) giving guidelines for the regular maintenance and repairs, being still the reference for the conservation team at Moenjodaro.

acceptable state of conservation. The site remains impressive, more specifically as the conservation team immediately engaged in cleaning works after the heavy rains' destructions towards making as quickly as possible access to the main areas (SD & DK, VS in progress⁶) for the potential visitors.

What should be noted though is that the state of conservation varies quite tremendously area by area. The SD area being the best preserved while the Moneer area, that probably received less attention in the past, is in a preoccupying state of conservation (see pictures above). In addition, some areas south of DK for example A, B and C seem to have been almost abandoned, probably due to lack of resources (staff and funds) and lesser visibility and also potential for attracting visitors.

As far as what happened in August 2022, during first mission, just few weeks after the disaster, it has quickly become clear that the great majority of the structural degradation resulted from an insufficient capacity of the walls capping to absorb water combined with the formation of large flows of water against wall basis and, at some places, water stagnation. That weakened the basis of walls while there have also been infiltrations from the top with a majority of the destructions resulting of combined processes, involving leaning of walls (base) and further infiltration between the wall and rooms floors (top and floors levels).



Typical wall deformation with crack at DK Area



Gully type of erosion of drainage system at DK area

While undertaking the first overall assessment, the main circumstances and processes of decay were studied. Overall, three main causes of decay have been identified:

- . superficial drainage;
- . salts crystallization and hydration inside mortar and bricks, and;
- . pre-existing weaknesses in the wall structures.

A specific additional point is the visitor's pathways which at some places were seriously affected by the flows of water. Many of the pipes installed to cross water runoffs superficial gullies have proven to be under-equipped for the heavy flows. At some places (I and HR more specifically), the paths have been undermined and have partially collapsed, to a point that during mission 2, it was recommended that some of them be clearly closed to public access.

Besides these considerations, some paths have slopes leaning towards archaeological remains or tend to block water flows, situations that have already led to weakening the walls' basis that do need to be revised (see following pictures).

⁶ Areas have been named after the name of the archaeologist who excavated them (initials); SD for A.D. Siddiqui, VS for M. S. Vats, DK for K. N. Dikshit and HR for H. R. Hargreaves.



Damaged pathway between SD and L areas



Slopes of pathway led to self and wall damages (L area)

Finally, an important issue has also been observed, representing an additional opportunity for scientific research. As a result of the heavy rains, erosion gullies have developed deeply on some of the many untouched archaeological mounds. This has resulted in revealing some unknown archaeological assets (see pictures hereunder). Some of those appear to have specific interest (e.g. east side of the citadel) as a new archaeological corpus. It will also be important to analyze some situations that may require preventive measures (avoiding degradations in case of new heavy rains).



Probably a portion of city wall (near HR area)



At the east side of the citadel: traces of a staircase?



City wall / bastion east of SD area, have been revealed



Traces of drainage canal above an ancient dyke (DKG)

5. Main factors, circumstances and processes of decay

Similarly to the overall assessment presented in chapter 4, the elements in this chapter are built on what was in the first mission, enriched with additional observations, continued reflection and new findings during mission 2.

5.1. Superficial drainage

The heavy rains that have affected Mohenjodaro by the end of August 2022 have resulted in numerous and sometimes large flows of rainwater, a situation that had not been taken into account by previous studies, most of them dating back from the last century. Major difference with what had been observed in the past is that with both the repetition and intensity of the rains for 10 days, the absorption capacity of both wall capping and floors has been reduced or even eliminated due to their level of saturation.

In the Conservation Manual (Treatment descriptions – 13), the wall capping is presented as: *“The aim of the wall capping is to provide a protective covering over the wall that will minimize the flow of rainwater into the wall from the top. Wall caps have been used for more than 30 years and have proven effective at providing important protection against penetrating rain which would ultimately destabilize the walls. ...”* This is absolutely right, but what is also the effect of these caps is absorption of a good part of rain water. But when the cap is saturated the water then flows down the wall and continues on the ground / floor.

Concerning the floors, there are several sub-chapters (treatment descriptions – 15, 16 & 17) including sloping, levelling and reinforcement of gullies, all described as ways of keeping reasonable run-off and transporting it to safe discharge areas. It is also indicated that in some cases, terracing, ponding and shallow trenching could be good solutions in case of little collection surfaces. The use of drainage pipes is not so much encouraged: *“The installation of pipes through the walls should only be carried it as a last resort for reducing serious problems of run-off accumulation in closed areas. Very careful consideration should be given before disturbing ancient walls, and all alternatives should be explored. ...”* The manual also suggest the use of drains, as being “important character-defining features at Moenjodaro” (Treatment descriptions – 22), and further recommends the preparation of comprehensive drainage plan (Maintenance – 4).

Though these recommendations took into account what had been considered at that time as being the worst rainy season at Moenjodaro (298 mm between July and September 1994) this was far from what was experienced last August (779.5 mm in 10 days). As a result, the capacity of the drainage system in place, even if actually very well mastered (very high know-how on that, with very fine work observed) has been seriously challenged leading to most of the major damages observed.



Failure of flooring-drainage at SD area © N.A.Sangha Temple at HR area, with traces of high water level

The very huge amount of water brought by rains has resulted in either water to stagnate inside some of the rooms (some of them have no water outlet system and had required pumping of large amounts of water), either to the formation of huge flows of water at the basis of some walls and also floor/ground erosions (gullies) that, at some points, have led to damage walls. Gaps in the backfilling under some room's floors have also led to the formation of depressions with, at times, the formation of underground flows of water.



Undermining of wall by run-off, SD area © N. A. Sangha Ancient drainage systems damaged, south of SD area

One should note that the system used at Moenjodaro for the treatment of the floors (sundried mud bricks laid on a layer of sand) though giving satisfaction for draining water flows placed a negative impact when run-off developed large gullies which manage to fully erode the surface bricks, with very little resistance of the sand layer and acceleration of the erosion process.



Gaps left by eroded sand under mud brick floor SV area Pushta protection affected by water infiltration HR area

Besides that, this system is allowing water infiltration through the bricks and then through the layer of sand down to the original fabric. The resulting issue is that this humidity is like trapped under this layer of sand with the only potential of being evaporated through wall structures, at times above ground level, but also when structures are forming terraces (more specifically the case of the stupa zone, but not only), and as such, increasing the potential of crystallisation of salts on their surfaces (see next chapter).



Traces of high humidity content under floor SD area

Traces of high humidity on retaining wall. SD area

At a larger scale, it was noted that the overall drainage system sometimes involves collection of rainwater from large areas and instead of driving the run-off far from the archaeological remains, drives it inside narrow streets. This is what has been happening at the drainage canal from the pool at SD area (see pages 39 & 40). But the most problematic case is at DK area where the large street at the eastern side drives water towards south but as it is blocked by archaeological debris mounds turns right inside the old city fabric, to finally be drained towards the western canal. But there are many other similar situations where high run-off is guided towards archaeological remains instead of “to safe discharge areas”.



Main street at DK area. Water collected is blocked at its south end thus entering the old city fabric

In addition to those, at times paths constructed for visitors also play a negative role within driving run-off towards the wall structures with a high potential for a negative impact (mortar erosion, weakening of brick strength).



Path blocking run-off, HR area



Concrete path with slope driving run-off to a wall. L area

5.2. The presence of salts and their effects

As quoted in many of the earlier reports consulted, the presence of salts at the site and its destructive impact has been noted very soon after archaeological excavations were made starting from the 1920s. Thus, there has been numerous studies on that aspect with for a long period of time, focus being given to the idea that the main cause of the presence of salts was the water table. Many and costly efforts were developed to lower it (including water pumping) but the expected impact was not reached.

Besides that, more detailed studies were made to understand the destructive effect of salts on the building materials. Those are well summarized in a scientific article written by A.S. Goudie after visiting Pakistan in 1975-76 as part of the Cambridge archaeological mission to Pakistan (Goudie A. S., 1976). In this article, Goudie is concluding that there are two phenomenon that have destructive effects, linked mostly to the presence of Sodium sulphate, which are:

- . Surface crystallization linked to water evaporation and
- . Expansion when transforming from dehydrated state (thenardite) to an hydrated state (mirabilite)

This second phenomenon being favored by potential accumulations within time and the variation of the solubility with temperature, explaining that more destructive effects are observed in the cooler days of the year and on the northern (less exposed to sun) elevations.



Surface crystallization and base erosion



Loss and fall of pieces of fabric due to expansion

Concerning the wall structures themselves, another potential factor identified is the presence of gaps inside the walls, whether they be inside the original fabric or located at the interface of the old fabric and that of the restoration works. That would explain the presence of huge quantities of salts inside the walls, very visible when the restored fabric has collapsed. That calls for specific attention when restoring to make sure that gaps are fully filled and also that if the old and “new” fabric are not well connected, cracks can appear which then represent a double threat that of this high presence of salts in addition to the structural weakness.

When structures are weakened at the wall base (elevation side exposed to water flows or stagnation, or simply damp) they often develop cracks that drive rainwater down. Processes of dissolution of salt and migration again inside the structural fabric are most probable, a kind of vicious circle which constantly increase the problem.



Salt inside the wall visible after collapse, HR Area



Structural cracks allowing infiltration and salt dissolution

These phenomenon linked to the presence of salts are not specific to Moenjodaro. They also exist at other archaeological sites along the Indus River, and are also present in other regions, like in Egypt, at Medamoud archaeological site (Joffroy, 2022) and in Syria, at Mari (Bendakir, 2009). If conditions are different from place to place, what can be stated is that the high presence of salts at these sites are most probably the result of the continuous capillarity process which occurs through the porosity of the built structures and the evaporation of this water (damp) when exposed to air and to solar radiations.

Hot and arid climates favor that with dry air (having a humidity ratio diminishing with heat) tending to aspirate capillarity water from the water table. In addition, the continuity of capillarity capacity in built structures are more important than that of debris and/or ground level which has often a powder like surface that avoids evaporation. As a result, water movements are more important in the built structures than in the debris at their side that forms the “archaeological tell”. And ultimately, the issue is that the water evaporates, but not the salts, resulting in a constant evolution of salt presence. This process has been almost continuous for several thousands of years, explaining the high presence of salts, though mostly near to the surface of the archaeological mound and thus exposed archaeological remains.

For long, attempts to reduce the capillarity rise of water have been thought as being the solution. The idea was to lower the water table and the response was to establish a series of tube wells allowing to pump water from the water table towards the Dadu canal. In 1986, 26 tube wells were put into operation (NUST, 2011). But the extraction was costly when the change in the water table level appeared to be limited. The overall system was finally abandoned in 1997.

Actually, in Moenjodaro, presence of salt is visible up to the stupa base level (Clifton, J.R. 1980). This is not unique as the phenomenon can be observed at other places (e.g. Mali in Syria). This tend to prove that capillarity is often able to reach tremendous heights (stupa base is 19 m above water level). If that could be considered as the higher limit for capillarity action, any attempts to lower the water table would probably be insufficient for most of the archaeological remains which in their great majority are much lower in altitude.

This was already recognized, by the end of the 80s and as such, the conservation manual provides specific orientations to tackle the issue in another way. Three main activities are proposed, which are also part of the yearly regular maintenance schedule that include:

- . applying mud slurry on the surface of the walls, that behaves as a sacrificial layer in which salt crystalizes;

- . applying mud plaster, which plays a similar role, though having greater impact in places prone to condensation and as such salt expansion.
- . removal of salt-laden earth and replacement with “sweet-earth”, including the removal of waste from sacrificial coatings.



Presence of salts at DK Area



Use of mud slurry to form a salt crust against bricks

These measures are fully part of what is being done at the site today by the conservation team and on regular basis. Though salt presence and related decays appear to be still very much present. One of the hypotheses for this is that the efforts made up to now do not insist enough on salt removal. The removal was done, but probably insufficiently. As an example, it was witnessed at the beginning of the mission that the undergoing brushing of salty sacrificial mud slurry is not linked to removal from the site. That led to suggest that a system would be set so that the slurry dust would be collected and dropped outside the archaeological site perimeter. This measure was immediately adopted by the director of Moenjodaro Conservation Office (MCO) during UNESCO expert’s mission 1.



Removal of salty mud slurry, SD Area, using geotextile to collect and transport dust away from the site, 22.11

Hopefully this will contribute to a gradual diminution of salt content at the site. One of the hypothesis being that the structural fabrics are not only affected by the salt originating from the water table, but also from salt present on the ground level which can be dissolved during rains with potentially this salty rain water to penetrate the flooring and then migrates towards the wall through the capillarity process. That can explain the high salt content at some places.



Ground with high salt content, HR Area



Archaeological debris pits are also sources of salts

During UNESCO expert mission 2, additional observations were made with connecting some of these areas where high salt content is present with the overall topography of the site. That has resulted in new research questions calling for further investigations and practices. What was primarily realized is that at some point of the history of the conservation of Moenjodaro, dikes were built by the archaeologist using the debris from the excavated areas (see plan below, map exposed in the museum exhibition). An effect of this dyke, still in place (though no more useful with the presence of the main dyke along the Indus river) could be that water runoffs from the hills where the archaeological remains stand cannot flow away from the site. And thus, the dissolved salt that they probably contain also remain in place.



Plan indicating dyke and circular canal



Circular canal exit, blocked by sediments showing presence of salt

An additional factor that could be aggravating is that the circular canal built to drain the site is partially blocked on its northern side and also that it cannot work properly as the pumping station is no more functioning. This is probably an additional factor to that of the old dykes that reduces the “natural” drainage capacity of the site⁷ and as such the possibility for water run-offs to dissolve surface crystalized sand take it far away from the site during the heavy rains of the monsoon season.

⁷ The several settlements composing Moenjodaro have been erected on manmade hills, both protecting the structures from potential flooding (from the river), but also ensuring that the site would be well drained when heavy rains, possibly removing some of the salt dissolved by the water runoffs.

5.3. Processes of decay of wall structures

As mentioned in the report prepared in September 2022 by the Moenjodaro Conservation Office, the walls structures of Moenjodaro have experienced numerous destruction phenomena, resulting in a huge variety of current state of conservation as well as issues to be addressed. This is a bit contrasting with what had been reported in 1994 by R. Hughes, who visited the site after the heavy rains which also occurred on this year, though on a longer period of time which can explain the difference. There is also in the text a quote concerning the rainfall which is a bit contradictory with the official data.

“During July, August and September a considerable amount of rain fell throughout most of the Sindh. Extensive damage occurred in the urban setting, such as Karachi, and in most rural areas. Many villages were severely damaged. Moenjodaro received in total about 25 inches of rain (0.64m) and therefore it is surprising, and most pleasing, to report that only minimal structural damage occurred. It is generally felt that only 25 to 30 cases of wall collapse due to rain could be identified. The fabric character of these walls points to their already severely poor condition. The degree to which most walls survived is attributable to the emergency underpinning works that the consultants set in place in 1992 and 1993. Without these emergency works the loss of original features would have been most considerable. The main effect of the rains was considered by the consultant to be the wash-out of internal mud mortar, and here it was most interesting to note how the mud from the capping bricks was often washed down into the internal wall structure as well as down wall surface. Most walls fell as a result of shear-slumping down through the wall core. Some collapses may have been triggered by surcharge pressures of soil behind (the extra weight and volume). Foundation failure and overtopping were not noticeable.”

Obviously, the damage this year is far worse than what happened in 1994, after a long period during which Moenjodaro had been given much attention with very strong assistance brought by UNESCO and other partners for almost 20 years. And though, the recent measured rainfall has been much higher and within a very short period of time (less than two weeks), a reason for higher destruction level could also be less preparedness. Actually some of the destructions seem to have occurred in a similar way as what Hughes is reporting, with weaknesses at the top of the structures with insufficient capping protection.

Though what appears clear is that many destructions observed have often a double origin. At first, the wall bases may have been weakened by the water run-off of water stagnation, entailing a tendency of the wall (or when the case, the restored part of the wall, usually that forming the façade) to lean out. This having occurred, cracks are up to the top making possible infiltration of water as described by Hughes, which fasten the weakening process up to collapse.



Two column types of wall (L and DKG areas) illustrating well the typical collapse process starting from the base

Though this typical phenomenon as described above is developing in many different ways and is also much favored when the burnt bricks at the wall bases are already prone to salt degradation that has a serious effect on their bearing capacity.



Wall collapses where salt attack has played a strong role at DKG (left) and HR (right) areas.

Another factor which appears to favor wall collapses is that most of the restored parts of the walls have little connection to the original parts. This is something very common at many archaeological sites around the world as there is a global reluctance to touch the original fabric either through removing parts of it to make sure that there is proper bonding between the old and the new, or to install connecting assets (e.g. tie rods). In such cases, the weakening of the external part of the wall base has a much quicker effect than it would be on a full homogeneous (well bonded) wall as the surface concerned is far less.



Two stages of the process of separation between the new and the old parts of walls, DKG area.

A particular aspect of some of the walls at Moenjodaro is that they have been treated with concrete, either in the form of slabs as damp proof courses at the base of the walls, or for one of the upper burnt brick layers. If this has probably had a positive effect over time, these two systems have not prevented collapse last August.

Concerning the damp proof courses, most of them are only on a small portion of the wall, thus not really functioning as damp proof course. And for the upper layer at the top of the wall, though it has allowed to maintain partly the structure, what was supposed to serve as a protection and a sort of the beam did not prevent some collapses, leaving some of the wall structures in a strange form with the upper part overhanging over huge gaps.



Damp proof course at DKG partly efficient



Concrete layer between the two last brick courses at HR

Finally, what has been most destructive at Moenjodaro last August is similar to what had been described by Hughes in his 1994 report (at I.2). . “Some collapses may have been triggered by surcharge pressures of soil behind (the extra weight and volume). Actually, in many instances, walls have been pushed by the backfilling needed to get rooms at different levels (often above street level) This is generally connected to the issue of drainage more specifically when looking at it from the beginning, the top of the walls, at times very large and being able to collect huge amounts of water.

And the situation is even worse when there are no or too little water outlets from floors which are above streets levels, that entail water penetration in the infill, bringing about the extra weight and volume as described by Hughes. This has led to some of the major collapses, including a paramount one, the collapse and also dangerous leaning out of a major part of the exit canal from the baths at SD area.



Pressure against walls by backfilling of platforms / rooms floors, DKG area (left) and SD area (right)

In fact, most of the sensitive situations of wall structures are linked to issues related to drainage and presence of salts. Thus, in addition to maintenance / repair needs (wall capping and underpinning), those threats should also be addressed “locally” and before any intervention on the wall itself to avoid repetition of similar phenomenon in the future at the same places.

A dramatic example of such situations is that of the collapse of the wall forming the exit canal from the bath pool at SD Area. The degradation of the walls and the corbelled vault above them was the result of the formation over time of a large water collecting area that starts from the north east of the pool itself, and slopes driving the run-off at the side of the southern wall of this canal (see pictures next page).



Instability of retaining wall at the southern side of canal from bath in SD area originates from drainage system.



Arrows show the starting point of the collection of water and how run-off has made its way towards the damaged structure.

5.4. Specific cases / issues

5.4.1. Stupa

The stupa is part of the structures which have been affected during the August 2022 rains, though what has been collapsing is from the top cupola and appears to be only a little part of the protection that has been built around the original structure. The situation does not appear to be dramatic, probably the result of the care by Moenjodaro Conservation team during rains who protected the whole cupola with a tarpaulin. Today, the situation appears to be stabilized with the old structural still protected by the geotextile layer.

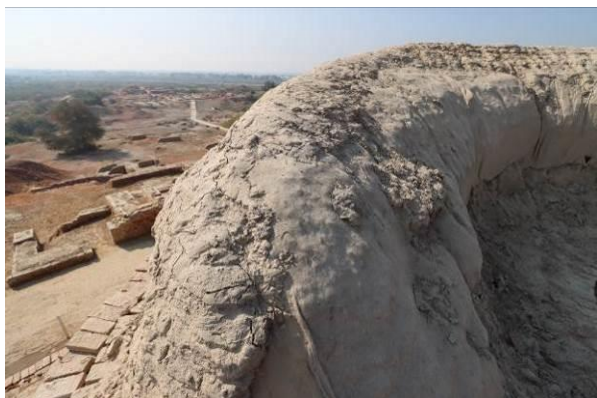


Stupa from south west side



Picture showing fallen part and protective geotextile

During the first expert mission, only a quick look was given at the stupa structure. Thus, during the training workshop, a much more detailed inspection was carried out by the expert who managed to climb up and go round the stupa base. That inspection led to the understanding of a much more difficult situation than expected, with several cracks showing that in addition to fallen parts, other remaining ones were not very stable. Moreover cracks at the top and at the sides would 1) offer the possibility to let rainwater penetrate in between the external protective layer and the geotextile and 2) make it difficult to find a strong base on which reconstruction of the protective layer be made.



Top of stupa on south east side



Top of stupa on north-west side

As the presence of such signs of decay was also visible inside the stupa (a more accessible place) the discussion on “what to do” was organised there. It was commonly agreed that the best solution would be to remove the protective coat and the debris and rebuilt them. On the other hand it was suggested that the protective geotextile be left in place.



Side of stupa on western side



Side of stupa on south side



Inside the stupa, much more accessible than its outside elevation

Another observation is that the walls at the base of the stupa are leaning out. This is a point of attention that will need to be tackled in the future, taking as a base the restoration reports that could give some indications on what has been done there (or not) and when? Such a question will need a long period of observation / monitoring to have a precise idea of whether there is a movement or not. This will not prevent a reflection on what could be the reasons (potential infiltration of water above this wall) and to install preventative measures.



The retaining wall at the base of the stupa (west side) is clearly leaning out

5.4.2. Stupa base (citadel core)

A similar question at SD area is that, under the base of the stupa, most of the walls at the northern side show signs of bending. This could simply be a local problem linked to pressure made by the successive backfilling at the side of the walls but may also be a sign of more deformation of the overall citadel “mound”.

In fact, this could be the result of the presence of humidity inside the core of the citadel under the stupa, made more than possible by the flooring system (bricks on a sand layer) installed also at the upper platform which represents a huge water collection area while being very much exposed to rains. And two months after the heavy rains of August, many of the walls, including on the south side (better exposed to sun) were showing darker zones indicating the presence of damp.

If a more detailed condition survey of these walls (type of leaning and visibility of cracks in the perpendicular walls) could give an indication, it would be good to check whether it is not the overall mass of the citadel which tend to settle down. The situation does not seem to be so critical, though it is recommended that a precise monitoring system be installed in the future to get a better appreciation of the reality of this process.



Stupa from L area



North side of citadel showing bended walls

5.4.3. Fallen mud brick wall

In DK-G area, part of a mud brick wall (probably originating from the Buddhist period) has fallen down. This wall is protected by an iron sheet roof, making it clear that the collapse originates from insufficient drainage at its base, possibly linked with accumulation of sand (from wind) and debris in the narrow passage located at its western side.



Overall protected wall (fallen part at the left)



The fallen part (south west end)

The fallen part needs to be removed as it now works like a dam. As it has no real potential for being restored this collapse then should be taken as an opportunity to undertake an in-depth study (archaeological) of this fallen portion that would entail its careful dismantling.

The data to be collected should include:

- . size of brick used (L., l., h.);
- . thickness of mortar (horizontal and vertical joints)
- . type of soil used both for the bricks and the mortar - all possible analysis that can be made, at MCO (grainsize distribution and Atterberg limits) and elsewhere in a specialized university laboratory (X ray, diffraction, ...).

Additional information have also to be collected from the still standing wall. It has very good potential where the collapse has occurred with now a fully visible section of the wall. Observations there will help checking dimensions and moreover what will be difficult in the fallen part, to measure the width at several heights, and deduce original form which was probably slightly inclined with a wall much larger at its base than at its top.

5.4.4. Visitors paths

The visitor's paths that have been built in Moenjodaro either within the excavated areas or between them have also been subject to destruction. These have occurred mostly where gullies have evolved substantially, but also in most of the places where runoff is collected. Even where some specific assets (pipes) had been installed, many of them proved to be insufficient to support the intensity of the flows. Even some very heavy concrete slabs have been moved some of them substantially.



Concrete slabs of various sizes have been affected giving an idea of the violence of the runoffs



Burnt bricks paths have suffered but are easy to repair The roads at the top of the dikes have also suffered

Worse is that at times the paths have led substantially to destruction of the ancient structures. This is due to the fact that some of these paths are very near to the structures with at times, either:

- . channeling runoff towards the wall bases;
- . representing a break to the runoff and as such forming puddles at wall basis.

For these two phenomena, concrete slabs which hardly absorb any water have been the cause of the worst cases.



L Area, path leaning towards wall base



HR area, concrete slab path blocking runoff

The revision of these paths is a huge work in itself and thus requires a specific study. To get an overall idea of the situation (quantitative and qualitative) to be able to prepare that, it has been agreed to prepare plans for each area and for the overall site showing the variety of cases and their extension

5.4.5. Building materials

An issue which quickly comes out of an overall evaluation of the condition of the archaeological structures at Moenjodaro relates to the quality of the building materials.

The conservation manual provides indications on materials standard but does not insist much on that. As a result, there might have had insufficient attention given to that while this now appears to be a paramount issue.

Actually, there exists many evidence that there are substantial differences in their behavior as even at same locations, the state of conservation is very different. The case of the burnt bricks is particularly illustrating that with in the presence of salts bricks in the same course can be in perfect state while another besides it is almost fully disintegrated.

The issue of soil selection for mud bricks making and mortar, also seems to be somehow underestimated, as there is, probably for several years now (as there are signs in the eroded wall capping) the use of soils that contain quite a huge amount of vegetal matters (plant roots). The loads of soils at the entry of DKG Area appear to be in that line which is a bit surprising when knowing that there is a laboratory and a lab operator which could check the soils already at the quarry level.



The variety of quality of burnt bricks is very visible on this wall at DKG area, very good state at the base, almost fully disintegrated in the middle, acceptable at the top



Soil just delivered at DKG Area with high humus content Same type of soil applied on wall capping at SD Area

This calls for launching a process for re-installing a more systematic process for the quality of the materials being used at Moenjodaro, both for the earth and for the burnt bricks:

5.4.6. Newly revealed archaeological structures

The torrential rains of August 2022 have not only affected the already revealed archaeological remains but also have increase the size and more specifically the depth of existing gullies in the archaeological mounds all around the site.

As a result, there are numerous places where structures have been revealed and are now quite visible. Some appear to have become at risk when new monsoon seasons will be coming. That would be quite a loss, knowing the potential that those still buried structures represents, as being fully original while those now visible at most of the areas (those open to the public) have been restored several times. However today, there are some difficulties to differentiate the original from the new.



Two examples of newly revealed structures that can be seen in various places at the site

Taking stock of that situation, the proposal is that a survey of these places be made (listing, mapping, minimum characterization), possibly by students of the archaeological dpt. of Sindh Universities under the supervisor of their professors and overall coordination by MCO staff. Criteria should be set so that a plan of action may also concern these newly revealed structures so as to ensure that those who would need preventive protection could be treated.

An exception given to the above proposal could be the structure observed at the eastern end of the citadel where what could have been the steps to the Buddhist stupa may have appeared. That might represent a major plus for the site and, as such, might be given consideration if a team could be mobilized to undertake a first cleaning exercise whose result might lead to programming a fully structured archaeological exploration / survey.



On the eastern side of the citadel area, the huge flows of water collected by the upper platform have revealed some structural elements which could be the original steps to the stupa.

Such an exploration was actually conducted in December 2022, though just led to reveal the presence of walls and bastions. In January, it was agreed that, though limited in size, these excavations be backfilled.

6. Recommendations made

6.1. Raw and building materials

To take stock of the potential for repeated and increased solicitation / threats due to climate change, the quality of the raw and building materials has been agreed as needing to be part of the paramount issues to be tackled. After a recall of the observation made discussion during the training workshop led to propose the following:

Decisions on the evolution of the practices / techniques

Soil for bricks and mortar:

1. Make a systematic test for detecting salt presence (with rejecting if positive)
2. Make a systematic test on particles size distribution content;
3. Adapt mixes accordingly (addition of sand for bricks and mortar / addition of straw for plaster);
4. Adopt lime as an additive in the mortar for underpinning work (using traditional recipe within volume: 1 Lime, 2 Sand; 4 Soil);

Burnt bricks:

1. Make a drastic selection of bricks to be used for underpinning, aspect, clear sound, prefer ancient brick that have proved their capacity;

Preparation for the future:

1. Continue to identify potential soil quarries, test soils (against salt) and try to secure the availability;
2. Prepare soil stabilization samples with using locally produced gypsum and lime, both traditional and industrial types) and test them through watering (by watering can), capillarity and immersion tests so as to get some first knowledge on their effect on the mechanical properties of products obtained and their behavior in humid state. Proportions to be tested: 5, 7.5 and 10 %. Later on, when press be available, compressive strength tests will be carried out.
3. Identify brick manufactures around Moenjodaro, in the view to identify producers that get best results (might be known within the local population);
4. Explore with them the possibility to prepare special orders for improved quality (mostly capillarity / salt resistance to be tested);
5. Explore machine producers in Pakistan and the evolution proposed by some of them that could help in improving burnt bricks quality (to be checked / tested if possible);
6. Explore the possibility to fabricate special burnt bricks (and possibly pipes) at the site.

As already suggested in the first mission report, that will require acquisition of specific equipment that needs to be identified (and also where to acquire it) to reinforce the lab capacities, with also taking into account the need to train additional young professional that will be able to take over the works already been done at MCO laboratory.

6. 2. Drainage and canals

To illustrate these issues, the site visits during the training workshop covered HR and DK South areas to study specific cases. Some known places were used as “exercises” with first trying to have the best understanding of what had happened, and second look for solutions

with when relevant, reflecting on a temporary solution before either means (to avoid having too much to do in a short period of time) or specific documentation be gathered so as to make sure that decisions would be well informed, based on precise data.



Two specific cases that were discussed in HR area.

Left: need to open canal from temple room; In-depth observation has led to understand that there was a need to consider both western and upper zones (above temple itself) to ensure that less runoff would be driven to temple. It was also decided that a shallow drain be installed at the eastern side,

Right: depression in a courtyard. Alerted by Ali Gul, foreman, this huge depression in the ground was studied. The observation of the topography led to deciding that a drainage pit (the only possible solution) should be provided. As a follow-up, a sketch and a rate analysis sheet were prepared.



Inspection of circular canal – northern zone.

Decisions on the evolution of the practices / techniques

1. Replace the sand layer of the pavement technique by mud mortar
2. Use of drainage pits at the center of the rooms where it appears impossible to install exhaust pipes
3. Use of wells for drainage when existing / possible (HR area)
4. Modify pavement slopes when they drive runoff towards wall basis (L area)
5. Add mud bricks pavement at the sides of concrete slab path to avoid depressions (and stagnation of water) at the side of the wall basis (HR area)
6. For each area / sub area, start with treating main drains and progress upward in the collecting zones. Exhaust pipes in rooms come last

Priority actions / areas for the next 6 months

1. SD area :
 - a. southern side: the two main need to be repaired + T connection of two canals to be improved with taking into account that this is located in the middle of a visitor's path
 - b. Change pavement around stupa (up to barrier)
 - c. Northern zone (series of rooms under stupa)
2. L Area :
 - a. Revision of path slopes (to be done simultaneously with underpinning)
3. HR area
 - a. Revise drainage slopes at south west of the bath to protect bath's canal structure
 - b. Repair bridge base (fill gaps of the concrete structure after cleaning of altered parts)
 - c. Install slopes both side of concrete path (north-south street at western side) using brick pavement technique
 - d. Dig trench south of "temple" to re-establish proper drainage. Increase floor level of temple (if necessary). Revise drainage above temple and at its eastern side
 - e. Dig 2 drainage pits in the two large room / space (those in depression area) indicated by site supervisors
4. SV Area (Room with well at floor level)
 - a. Repair well masonry from inside (replacing altered brick/mortar)
 - b. And renew completely floor pavement with new solution (brick on the edge laid in mud mortar with slopes towards well), that will include backfilling of gullies and its compaction.
5. DK south
 - a. Change drainage slope at south east (2 rooms, as indicated on plan)
 - b. Change drainage slope at the southern side of the concrete path (western side) with providing connection to canal from DKG North.

Preparation for the future:

1. Prepare a new rate analysis form for Drainage pits
2. Prepare plan for the rehabilitation of the circular drain (locating / quantifying works)
3. Prepare a plan indicating drainage slopes and location of temporary pools on the overall site (to be undertaken during next monsoon)
4. Explore the pertinence of superficial drains from all areas towards circular drainage canal (to be undertaken during next monsoon, after above point)
5. Prepare a plan for the proposed drainage pipes system in DK south area : number of pipes, where, size of pipes (bill of quantity)
6. Examine each situation and revise drainage plan to ensure better repartition of water flows (exploration mainly at the edges of each area)
7. Elaborate a strategic plan to gradually cover the overall site.

6.3. Capping

To address that topic, reference was made to on-going research in Egypt at sites also affected by climate change that also affects the northern part of the country.



*Left: Typical degradation process (formation of gullies) at Saqqara
Right : proposed solution for capping (Pepy 1st site) at Saqqara*

During discussion, the indications provided in the conservation manuals were revised that made realise rounded shapes were already quoted as a best solution for capping, though had not been set as compulsory, thus had not been applied for many years. When looking at new risks linked to climate change, it was decided that the adoption of rounded shape of wall capping should now be the rule. That led to the preparation of a sample for demonstration on one wall at the entry of DK-G area.



Rounded shape capping sample being prepared during field session

Decisions on the evolution of the techniques

1. Use the most elaborated version of the procedure as indicated in the Conservation manual (p.IX-13) that means:
 - a. Capping to be done with mud bricks masonry using mud mortar;
 - b. Ensuring the creating of a rounded finish at the top (to be prepared with bricks and mortar with central height depending upon width of wall);
 - c. Make best use of existing remains to be removed with reusing mud brick pieces for round shape and small pieces for the preparation of mortar;

2. For better protection and longer duration,
 - a. Add two brick layers (instead of one only) above burnt bricks before rounded shape;
 - b. First prepare the round shape with bricks and then add first mortar / plaster layer to form the final shape (half inch should be left at the sides for flush finishing of final layer)
 - c. Apply last course of mud plaster which will finish flush with the bricks faces;
3. Point 2-C potentially applies to a more regular maintenance need when what is needed is only replacing a mud plaster when that has been washed.
4. Adaptation of this method is done according to each situation. High of rounded shape. Potentially, more layers of mud bricks are installed on a side of wall so as to reach same level on the whole wall. Stepped bricks can also be used when addressing an original stepped structure.
5. When top of wall reaches a platform, a combination of half capping and flooring technique (bricks laid on the edge on mud mortar) is adopted presenting a continuity;
6. An additional possible combination is with introducing shallow drain between the half capping and the flooring system of the top surface / room

Priority areas / actions for the next 6 months

1. SD area :
 - a. Top part (around stupa platform)
 - b. North and western zones
 - c. Special attention above narrow pathway, with reconstruction of collapsed wall and putting into practice decision 4 (see above) with ensuring that shallow drain finds a continuity on the narrow platform and at its north and then in the pathway down to the shallow drain at the side of the concrete path already planned.
2. DKG south :
 - a. All walls with priority to those that do not have any remain of capping.
 - b. Select walls with more potential for reducing water flows in the main water flow (the one passing by "well preserved" house).
 - c. Select walls which needs repairs at their top so that those can be done simultaneously;

Preparation for the future:

1. Revise rate analysis form for "capping" to adapt to the new specifications;
2. Evaluate work to be done for each area and for the overall site to be introduced in 3-4 year Sindh Gvt. / UNESCO project;
3. Setting priorities and elaborating a strategic plan (in 3 to 4 year schedule) to gradually cover the overall site with first adding capping where not existing and then replacement of old capping, starting with the most affected ones. Priorities have been defined as :
 - Priority 1: no capping at all
 - Priority 2: remains of capping (less than 10 cm thick)
 - Priority 3: sufficient capping level (10-20 cm thick).

6.4. Walls / Underpinning

After having discussed a series of 21 pictures illustrating the basic principles of the phenomenon affecting the structures at the site, a site visit was organised at DK-G where the most preoccupying cases are. That brought about a discussion on what would be the best methodology of intervention with giving specific attention to security measures prior to intervention. That led to recommend the following logical series of activities:

- . provision of security equipment for the workers : helmets, security shoes;
- . detailed observation / understanding of the weaknesses and risks linked (more specifically when wall base is attacked on both sides);
- . definition of an intervention strategy, starting with the easiest part to be treated (often at the ends of the “destructive furrow” and further possibly portion by portion);
- . strutting with wooden structures if felt necessary for safety;
- . strutting with truck jack(s) or any other reliable equipment allowing easy access;
- . cleaning the gap to be treated (if presence of salt, possibly applying mud mortar for absorption);
- . possibly removing some bricks or parts of bricks so as to be able to accommodate full size new bricks (half or full / stretcher or header);
- . intervention with ensuring proper bonding / proper filling with mortar to avoid evaporation inside the wall and thus salt accumulation.



Wall seriously affected where most of the field discussion occurred (DKG south area)

Another potential practice has been discussed and approved, that of temporary dry masonry supporting structure, leading to a demonstration being made at one of the most affected wall in DK-G area (see pictures below). It was however concluded that such measures should not be kept for long periods as on the long run this solution may favor crystallization of salts between the original and dry masonry.



Before and after pictures of the demonstration of wall base treated temporarily with dry brick wall (without mortar)

Decisions on the evolution of the techniques

1. Make sure there is a full understanding of the causes, circumstances and processes of each specific decay observed (looking at the situation at large, including the surroundings, and also when it occurred) so that, in addition to repair, these causes can be eliminated to ensure durability
2. Security measures : when needed install struts against wall and possibly also truck jacks (with planks for the junctions with base and top); helmets and security shoes for the workers to be provided;
3. Preparation is paramount. That involves :
 - a. cleaning of debris;
 - b. dismantling of parts that have lost too much stability and bricks showing alteration;
 - c. sorting out bricks that can be re-used, wash them if traces of salt;
 - d. removing debris, more specifically when they contain salt;
 - e. when high concentration of salt is observed on the wall face apply plaster (or built a temporary mud brick wall when side of wall has collapsed) to absorb it – remove it when salt appears at its surface
 - f. prepare a good bearing surface at the bottom (that might also concern top) to ensure stability of the repair;
 - g. identify zones / bricks in the original wall that are weak that can be removed on priority to create proper bonding (possibility to introduce headers.
4. Choice of mortar:
 - a. For wall faces, mud mortar is sufficient
 - b. For wall basis, potentially exposed to dampness and water (flows and stagnation) use improved mortar, composed with: 1 lime putty (paste prepared on site from quicklime), 2 river sand and 4 soil.
5. Repair should follow the following rules:
 - a. Work slowly : not more than 3 layers of bricks laid every day so as to ensure that there is minimum settlement of the new masonry and thus best liaison with the old one
 - b. Make sure that the gap between old and new walls is well filled, potentially using brick pieces to avoid formation of gaps (shrinkage);
 - c. Insert as many headers as possible. If this is not possible, insert twisted iron bars (need to drill wall with strong bits) every 3 layers and lay them in cement sand mortar;
 - d. When the repair reaches the top of the gap, wait for the new masonry to settle, (at least three days) before filling the last mortar joint. The mortar joint is to be hammered so as to get maximum compaction and best connection between the repair and the upper part of the wall;
7. Temporary measures:
 - a. Temporary measures with piles of dry burnt bricks masonry is to be applied when work on a structure in danger cannot be treated immediately.
8. Strutting is a possible long term solution (metal systems exists at the site that can be used as examples)
9. Buttresses / Pushta are also potential solutions, more specifically when underpinning repairing appears very uneasy. Buttresses may also apply when archaeological plans indicate the presence of such structures (case of room 69/12 in block 1 in DKg south)

Priority areas / actions for the next 6 months

1. SD area :
 - a. Exit canal of baths
 - b. Wall at eastern side of main passage (divinity street)
 - c. Stupa
2. L. Area
 - a. Wall along the path (work to be undertaken while changing path slopes);
 - b. Well inside room (section C, block 4, room 85) – also linked to drainage plan
3. HR Area :
 - a. North south street (third street) at western side (to be undertaken together with change to the drainage)
4. VS Area:

Well (with connection to drainage /pathing)
5. DK North
 - a. House at the north end of west street (block 17 house IV, room 36)
 - b. Cleaning of canal at the south end of the same west street and revision of backfilling before the underpinning
6. DK South
 - a. Well preserved house
 - b. room 18 (western wall), House N°2 , Block 8
 - c. room 17, House 3, block 2 (shoring)
 - d. rooms 22 and 15, house 2, block 8
 - e. room 61 and 47, block 1
 - f. House without doors : Block 7, House VIII, Room 58, 60 and 61
 - g. Room 69/12 in block 1
 - h. Room under path on the eastern side (linked with drainage plan)
 - i. ... to be completed using the more elaborated survey to be prepared (plans, see hereunder)

Preparation for the future:

1. Revise existing underpinning / condition plan for each area with bringing more details according to level of risk with classifying under three categories:
 - a. High level of risk (major gaps in the structure, high walls,...), thus to be treated before the 2023 monsoon or first year of UNESCO project
 - b. Medium level of risk , to be treated within the next two years
 - c. Low level of risk (need only regular inspection before potential treatment after 3 years)
 - d. Houses / structures where there are special issues (concrete slabs, concrete tie beam, special masonry patterns,... ,) which makes it difficult to be classified without more investigations..
2. Prepare bill of quantity for all categories / area in view of establishing long term plan
 - a. Provide data on quantities
 - b. Provide data on time needed (Nb. of working days / team)
3. For each situation for category a, evaluate the urgency and feasibility before the 2023 monsoon with the following criteria:
 - a. Duration of the work

- b. Cost
 - c. Availability of the materials
 - d. Potential for establishing temporary measures (strutting, dry brick masonry support, ...)
4. Plan for research on mortar tests so as to fine-tune recipes for lower levels of masonry, potentially exposed to damp and water flows.

6.5. Salts effects and possible mitigation

The issue of presence of salt is not new, though recognized as a first priority for better understanding of the phenomena and to make all what would be possible to reduce its presence. The site visit during the workshop was the occasion to better share the observation that salt is very much present in many places, with the identification of place where pools form during the monsoon, favouring the presence of salts (and salt crusts) at the ground surface. It was also identified that wind could participate in the presence of salts in the structure, which could explain why salt is also present at some tops of the walls.

It was recognised that with climate change and potentially more rainy events, existing processes observed may increase in their frequency while questions were raised on why salt presence seem to constantly increase and thus on what solutions could be tried, to stop this process and also be more pro-active in removal of existing deposits (thick crust have formed on the ground at some places).

Decisions on the evolution of the techniques

1. Make sure that all raw and building material brought to the site are free from salt presence (see building and raw materials conclusions);
2. Be systematic in the need to remove salt infected matters and bring it far from the site (Indus river side, get authorization if needed). That includes :
 - a. Collecting dust when brushing walls (already done);
 - b. Collecting dust when daily cleaning paths / rooms / streets;
 - c. Collecting debris when preparing for underpinning works;
 - d. Collecting old matters when replacement of room or street floors is decided;
3. Be more systematic in the application of mud slurry;

Priority areas / actions for the next 6 months

1. Most affected areas in SD, DKg, HR and VS (to be identified more precisely)
2. All areas where other works will be carried out (drainage / underpinning) will have their surrounding walls/ floors being "treated" (see above);
3. Prepare some sample tests (for a thorough comparative observation later) on northern walls along major water runoff in DKg area with treating only the base of the walls (up to 1m) with light slurry, thick slurry and mud plaster (specifications in conservation manual p. IX-8);
4. Undertake test of treatment against salts on two walls (one in HR and one in VS) which are highly infested with applying a thick coat of mud plaster. (salt absorption test).

Preparation for the future :

1. Identify most affected zones in each area; evaluate potential relation with a nearby source (debris pit, pools, infected grounds, ...); map these information on a specific plan.
2. Revise (or add ?) rate analysis form to cover all types of removal of debris;
3. Evaluate work to be done in each zone to organize a mechanical superficial cleaning of salty surface soil and get quotations for it;
4. Review UNESCO experts reports to check what had been already proposed earlier, and other reports publications or research papers to explore the potential of some plants to absorb some of the salt and fix it in their leaves and if found possibly relevant to plan experimentation and further favor their development at the site;
5. Prepare for a long term research protocol for getting more precise data on the behavior of existing solutions (slurries of various thickness / plasters of various compositions). That includes identification of specific walls where that can be done with variety of orientations / surrounding conditions;
6. In relation with the above, undertake research within archaeological reports so as to identify potential evidence of plasters which could have been the solution used in the past (historic occupation) to reduce effect of salt (ref. Article by Dr. M. Jansen)⁸. Exploration should also be made at other similar sites so as to enlarge references within the larger scope of the Harrapan culture. (possibly organize an expert gathering to discuss the issue)

To be elaborated in relation with the establishment of drainage plans (including overall site plan) as described at point 6.2 so as to identify potential links:

7. Identify zones where there is stagnant water (pool like) during monsoon and evaluate work to be done to eliminate them (opening superficial drainage ways for ensuring continuity of runoff);
8. Get quotations for the cleaning of the circular drainage canal;
9. Setting priorities and elaborating a strategic plan (in 3 to 4 year schedule) to gradually cover the overall site.

6.6. Paths

The session of the training workshop devoted to paths was introduced with a short series of pictures (17) showing the main cases observed during the first UNESCO expert mission, and also covered some of the on-going works which were to be the location of demonstration of the advantage of using rammed earth technique for ensuring more stability of the paths on the long term.

In addition to the issues related to the understanding of the decay processes and what could be done to repair the paths at reasonable cost with maximum efficiency, the visit was the occasion to also introduce the question of safety of the visitors which led to consider the definition and setting of specific devices to limit access where paths are dangerous.

⁸ "... it would bring back the original surface and color to the walls which, as we know, were plastered with clay some 4,500 years ago". In: JANSEN, Michael, 2003. « Mohenjo-Daro - Pakistan, The problem of Adobe & Brick Conservation ». In : *Pre-print of papers, 9th international conference on the study and conservation of earthen architecture, Terra 2003*. Tehran : Iranian Cultural Heritage Organisation. p. 309-318.

Though paths were not considered as extremely urgent it was agreed that they should be given consideration, though as a secondary priority after the much required preventative works.



Discussion on the negative impact of a path (slope driving run-off on the wrong side) on a wall at L area



Observation of the decay of a concrete slab path and taking stock of its dangerousness, leading to the recommendation of closing this path to the public.



Demonstration of the rammed earth technique adapted to the construction of “high resistant shoulders” for ensuring long term durability of all types of paths (avoiding erosion at the sides), path under repair at the south east of DKG south area.

Decisions on the evolution of the techniques

1. Established pathways where there are strong compacted grounds (avoid archaeological debris pits);

2. Avoid sloped terrain both with lateral or longitudinal consideration to minimize risks of creating large flows of water and minimizing preparation work and side buttresses;
3. Carefully identify zones where water runoffs / gullies are existing; evaluate water flows levels to decide size / number of pipes needed and potentially prepare a design for the required "bridge" under the path;
4. Ensure that paths slopes do not drive runoffs towards archaeological structures;
5. Prefer burnt brick solution to precast concrete slabs solutions ; abandon in-situ cast concrete solutions;
6. To ensure durability of paths:
 - a. Make a drastic selection of burnt brick producers for ensuring best quality of the bricks ; In case bricks of lesser quality are identified, reject them;
 - b. Ensure that both sides of paths be treated with sloped and well compacted soil to serve as a buttressing asset and to avoid erosion;

Priority areas / actions for the next 6 months

1. Paths may not be seen as first priority, if not to ensure security of visitors at the most visited areas;
2. Thus, SD, DKg and L areas are the main priority zones;
3. Paths passing south of L area needing further evaluation / studies. They should be closed to public (still possible to access to HR area from northern path at L);
4. Bridge like zones (over gullies) may also be treated first;
5. Portions where there is a clear link with drainage issues.

Preparation for the future:

1. Revise "rate analysis sheet" for paths (N° 10) to adapt to the new specifications;
2. Use the plans prepared to evaluate work to be done for each area and for the overall site to be introduced in 3-4 year Sindh Govt. / UNESCO project
3. Setting priorities and elaborating a strategic plan (in 3 to 4 year schedule) to gradually cover the overall site.

6.7. Special cases

During the first UNESCO Expert mission several very special conservation cases were identified as being of specific interest, either for their specificity or for their representativeness. Those comprised:

- . Bath canal at SD area;
- . Sundried earth brick stupa at SD area;
- . Well preserved house at DKg south;
- . Baths canal in HR area (which were already discussed during the "Drainage site visit").

To that first list an additional place was added: the "no name" street located on the southern side of the little hill north west of HR area as well as the no door house at DKG south.

For each of these cases, during the training workshop, a site visit was paid with the aim of :

1. Getting an understanding of what were the causes of the pathologies observed;
2. Making sure that all possible "domino effect be explored;
3. Discussing the urgency of undertaking repairs;
4. Reflecting on the information available, if sufficient or not for decision making;
5. Making concrete proposal(s) either for repair or for a temporary measure (before conditions required for the repair be set).

Bath canal at SD area



The inspection made by the workshop participants revealed that the cause of decay was not the canal itself (the canal from the bath was obstructed, that was probably the cause of decays in the bath pool walls, already repaired). The cause was rather the water runoff which after careful observation of slopes started to form on the other side of the pool itself (more than 60 m away).

That established, the restoration was discussed but which led to a very specific question that of the reconstruction of a corbelled vault, which would not be too difficult, but in the case of this canal which is forming a turn (about 110°). What could be the bounding for that? As no response could be given, it was suggested that an enquiry be made (reports, pictures, if needed preparation of models, small size and full size) before engaging in the restoration. In that respect it was regretted that debris from the vault would not have been kept as they would probably have been paramount in understanding the bonding adopted for this special structure. Part of those may also had the possibility to be reused in the restoration process.

It was thus decided that what should be done as part of the emergency plan would be to:

- . Restrict access to that area;
- . Dismantle overhanging
- . Dismantle a small portion of wall blocking water flow and install a temporary shallow drain that would guide runoff far from the canal itself.

In the meantime exploration of existing documentation should be launched and reflection on design started.

Bathrooms canal at HR area :



Similarly to what has been observed for the bath canal at SD area, the diagnosis at HR area for the two covered canal concerned was that the destruction (partial) was not linked to the presence of the canal, but being the result of water runoff too close to the external wall.

Risk of further collapse is now quite limited and as there are many other works to be done elsewhere, it was decided that rather than launching a restauration process, a preventative measure should be taken, that of releveling the ground at the side of the canal so as to make sure that water runoff would be at least 3 m away on the south side.

That would also leave time to gather specific documentation that probably exist in the archaeological reports, and also in Moenjodaro office archives, with possibly pictures, surveys before, during or after restoration works. On the basis of that, hypothesis for the reconstruction project could be formulated and discussed before implementation of the solution found the most suitable.

Such a work at HR would be a very good preparatory exercise to that to the work to be done for the reconstruction of the baths canal at SD that presents more complexity due to the circular shape of part of the covering vault.

Sundried bricks stupa

During the visit, a much more detailed inspection was carried out by the expert who managed to climb up and go round the stupa base. That inspection led to the understanding of a much more difficult situation with several cracks showing that in addition to fallen parts, other remaining ones were not very stable. Moreover cracks at the top and at the sides would 1) offer the possibility to let rainwater penetrate in between the external protective layer and the geotextile and 2) make it difficult to find a strong base on which reconstruction of the protective layer be made.



Cracks at the top and view from the inside of the stupa showing collapsed sacrificial layer.

As the presence of such situation was also visible inside the stupa (a more accessible place) the discussion on “what to do” was organised there. It was commonly agreed that the best solution would be to remove the protective coat and the debris and rebuilt them. On the other hand it was suggested that the protective geotextile be left in place.

Concerning the reconstruction itself, the masons of Moenjodaro team who were invited to discuss were asked their opinion. Actually one of them participated in the process some 30 years ago and was fully able to explain how it had been done, making everyone confident that he could do that work (and train younger masons) without needing too much guidance. As the quality of soil that had been used appears to be high, it was also decided that the bricks and debris be re-used for the fabrication of new bricks as well as for the mortar and plaster.

It was also agreed upon that the reconstruction process should follow similar specifications as the one for underpinning, with slow progress of the work to be established (no more than three layers of bricks everyday) for ensuring best connection between the old and new part (through avoiding large settlements due to mortar shrinkage and compaction).

A later recommendation made through WhatsApp to the Director of Moenjodaro team was to also take a good period of time before applying the plaster coats, with again ensuring that a good amount of time be left between the two coats, while also recommending that the top should receive at least a third coat (similarly to what is the yearly maintenance need).

Well preserved house (DKG south)

The well preserved house has been seriously affected during the August 2022 rains. There are several walls that have suffered erosion at their base, on the two sides (mainly inside partition walls). The inspection has revealed that some of the walls have their stability endangered (see picture above).

Thus, the recommendations made for underpinning fully apply here (see page 21), to be implemented with maximum care for ensuring safety of the workers and structures.

House without door (DKG south)



Situation found at House with no door during the workshop :

Two rooms without openings in this house are filled with debris on about 1,5 m high. The southern room has the top of this debris leaning towards west while the northern room is leaning towards east. And a tree is growing in the southern room. The slopes of the debris are guiding rain water towards walls and as such there are degradations on the opposite face of the walls concerned.

Suggestions made for emergency measures:

Remove tree in southern room;

- . Collect old bricks which are in a good state at the surface of the debris and keep them (possibly after being washed – of salt is visible) for restoration purposes in the future;
- . Carefully check partition wall and more specifically its base, and (hopefully that will be possible) install a dry underpinning solution on its northern side;
- . Level the debris in the two rooms so as to have a slope from the 4 sides towards the center of the room (collection of rainwater in the center);
- . On the west side (of these two rooms), remove debris above the two pushta buttresses, and reopen water channel from the small south room to northern room and relevel the overall so that water cannot stay at the base of the two pushta buttresses.

This house will need further consideration, the idea for this year is to minimize risks as a full cleaning of the rooms would take too much time this year. Only next year, time will potentially allow to totally remove all the debris while also underpinning work will be needed on the west and east walls and pipes will need to be installed.

This house has been one of the first work being done by Moenjodaro conservation team (see pictures below received from Moenjodaro Director).



No name street

No name street has been temporarily given to that street as it has never received any name ! It is also in a part of SD area which could not be given sufficient attention these last years. As a result of limited attention and no monitoring some erosion has taken place that has probably much increased during the heavy rains of august 2022. As it is a typical situation which do need to be addressed in emergency, it was also taken as one the studied case study.



As it can be seen on the picture above the weakness here has probably its origin from a base insufficiently compacted for the shallow drain that was rightly installed to properly drain this sloppy street. That has led to infiltration and erosion under this pavement which now evolves towards presenting risks for the walls at its both sides.

This diagnosis has led to recommend that the path be removed and redone making sure that its base be seriously compacted and to lay the burnt brick shallow drain on mud mortar rather than on sand.

Overall lessons learnt through the special cases:

The main origin of problems is Water, though on various forms :

- . direct exposure (rain)
- . water flows (runoff)
- . humidity – possibly coming from far

The main aggravating factor is the presence of salt, while the presence of capping (or not) and the drainage system is also paramount to consider.

In terms of methodological approach to understanding / intervention, in addition to the existing suggestions in the conservation manual it was concluded that the following should be applied :

- . Look at decay precisely but step back and consider the overall environment; check on the sides, behind;
- . While cleaning debris of a fallen structure, make sure that bricks and, even more important, specific elements (cut bricks or specially designed bricks) be kept as a source of information and also for reuse in the restauration;
- . Try to understand what has happened; crosscheck with observations at other similar places.
- . Before thinking of repair think on risk mitigation: what are the required preventive measures (capping? drainage ? other ?)
- . Think of the best adapted method for repairing. Does it require regular or more special specifications ?
- . Identify potential reference material (archaeological reports / intervention reports, specifications that can guide the decisions (values, special issues to be revealed) to make sure that your intervention makes sense (technically / aspect - authenticity);
- . Install safety measures before intervention
- . Fencing (public) if needed;
- . Undertake works with carefully documenting (before, during, after)
- . Define / address maintenance needs / potential frequency
- . Monitor (best period for it: the beginning of the rainy season)

6.8. Revision of the conservation manual

The manual for the conservation and maintenance of Moenjodaro was elaborated in 1997 in the framework of a UNESCO / UNDP contract. It was prepared by Franck Briscoe who referred or collaborated with many national and UNESCO experts who had earlier participated to the huge UNESCO campaign for the restoration of Moenjodaro also including expertise from ICCROM, ICCOMOS and ICOM.

In its summary this manual suggest the following important ideas and concepts:

“This manual is intended to be a reference tool for those in technical or administrative positions / the conservation and maintenance of Moenjodaro. It is primarily a collection of information about how conservation has been conducted at Moenjodaro between 1974 and 1997 under the International safeguarding campaign, and the principles and scientific basis that have informed and guided its application. The treatments described have been chosen for their technical and cost effectiveness, for the minimal negative impact the have on the ancient fabric, and with exceptions, for their “reversibility”. These methods have been tested, and some have already been is use for many years at Moenjodaro.

The manual has been organized so that it can be revised without requiring the entire

document to be reprinted. Just as the site is constantly changing – due to the effects of weathering, necessary interventions to preserve the site, and the introduction of new conservation methods – this manual will require regular updating and refinement accurately to reflect how the conservation of this important World Heritage Site is being carried out.”

This text clearly calls for a dynamic use of this manual. Though for the last 25 years, it remained unchanged and the staff at Moenjodaro often relate to it during discussions, even though some of its prescriptions or recommendations are not fully taken into account.

The fact that the document is not available in electronic format does not help, but moreover it seems that there is some kind of fear to adopt new ideas (when they actually exist) as the procedures to revise this document are not clear: who could propose, who should be consulted, who would decide?

Whatever the situation is concerning this document, as called for in this introductory note, it is clear that this manual needs some level of revision while making sure that the precious information that has been compiled in it be kept. Some are truly precious, with very sensitive and accurate information provided on how conservation theories can be applied at Moenjodaro and how important aspects concretize on the practice in the field, both for maintenance and more exceptional conservation works. Some practices that had been established during this exceptional 20 years UNESCO campaign remain quite innovative for some its aspects. They have given very good results for these last 25 years and some should even be more considered elsewhere at other World Heritage Sites throughout the world.

But looking at the situation, with considering both the extent of restoration works to be undertaken and the need to revise the level of risk due to heavy rains as seems to be established by climate change, it becomes obvious that at least a new 3 years campaign be launched that would address reconsideration of all points of the conservation manual with, when necessary (and only when necessary) revision of the prescriptions and standards to be followed.

The revision of the conservation manual should be the occasion to update its format and presentation which is a bit dated and would advantageously be given a more “modern look” to make it more attractive and easier to be used on regular basis.

6.9. Conservation plan, Disaster Risk Reduction Plan or Management Plan ?

The issue of conservation plan as suggested in the expert's ToR was discussed as part of session 7 of the training workshop.

What was first presented is the evolution of the concept of planning within the framework of the implementation of the 1972 convention related to cultural and natural World Heritage. Since the 1980s, it has become clearer and clearer to the international heritage community that heritage conservation should not only consider simple physical protection and making sure that the Outstanding Universal Value of the sites be kept, but that a multi layered approach to management that takes into account social, economic and environmental concerns should be adapted. That would provide a basis for giving the heritage a function in the life of the community, as embodied in Article 5 of the Convention.

This suggestion to adopt more holistic approaches to heritage conservation has led to a shift of paradigm from conservation plan towards the concept of conservation and management plan, if not more simply Management plan. Actually, since the beginning of the 1990s, the

preparation of Management plans for Heritage sites has become compulsory when applying for World Heritage status and a process has been launched to ask State Parties to elaborate Management plans for properties inscribed earlier, and moreover to update them on regular basis.

Concerning the concept of Disaster Risk Reduction, it is more recent, developed since 1990 though having taken more importance after the creation in 1999 of UNDRR, which has gradually led to the idea of developing specific plans for Disaster Risk Reduction. What is though interesting is that the process suggested for preparing such plans is similar to that of Management Plans though with focus more specifically given to specific natural or man made hazards.

For the specific case of Moenjodaro, and in response to the work that has been done these recent months, what is clear is that there is already capacities to prepare conservation plans (yearly plans are prepared by Moenjodaro team). But more in-depth planning efforts are really outdated. The only document available is a Master plan that dates back from more than 50 years. Thus the preparation of a comprehensive plan is really needed. And while the preparation of a management plan can easily include issues related to specific Risks threatening sites, it was recommended that this would be the good way to address the specific case of Moenjodaro.

Thus, during the January workshop, existing resources on the elaboration of management plans have been quoted, more specifically those that can be found in the UNESCO World Heritage Centre web site with a more specific reference within “The World Heritage Resource Manual Series”: Managing cultural world heritage.

<https://whc.unesco.org/en/managing-cultural-world-heritage/>

In this regard it has been stressed that cultural heritage need to be considered as places where social and cultural factors have been and continue to be important in shaping them, rather than as a series of monuments offering physical evidence of the past.

This wider scope of heritage has led to recommend that many more players or stakeholders be involved in heritage management towards the development and implementation of an agreed vision that takes into account both the physical and social contexts. Such a more inclusive approach to heritage management has the advantage to ensure a good integration of the site (and activities related to it) within the broader spectrum of sustainable development in its surroundings, both involving and to the benefit of the local community.

To that end it has been suggested that stakeholders such as local decision makers, police, army (airport), representatives of the local community, artisans, souvenir shop owners, etc. would be involved at a stage or another so that their concerns /expectation / ideas could be taken into account with potentially synergies being found for the elaboration and moreover implementation of some aspects of the plan.

That would of course not refrain Moenjodaro conservation team from keeping full responsibility though additional resource persons (national and international experts) could be invited to participate to assist both in the definition of the process and to provide external eyes for taking stock of the situation in a holistic way.

After having reflected on these consideration, a draft “table of content” of such a plan for Moenjodaro was presented by UNESCO expert, which was discussed and led to some suggestions by the participants concerning stakeholders to be involved and first ideas on what could be done to help the local community, with a very specific interest in the current situation as many people are still suffering from the high floods that occurred in 2022.

What a management plan for Moenjodaro World heritage site should probably contain (to be further elaborated with all stakeholders when preparation is actually launched)

Part A : Description

1. Brief description; OUV + criteria ; Statement of authenticity / integrity
2. Map showing the boundary of the core and buffer zone.
3. Rules applying to these core and buffer zone
4. History of excavations
5. History of conservation with a critical approach
6. Description of the site to date
7. Threats, state of conservation and conservation requirements (maintenance) **to address risks (Disaster Risk Reduction), more specifically linked to climate change**
8. Museum description
9. Other visitors facilities
10. Visitors and visitors management
11. Staffing and overall management structure / decision making levels / office facilities and equipment
12. Development issues within the local community / Larkana District

Part B, analysis of the situation and proposed overall response

13. SWOT analysis of the situation: Strength, Weaknesses, Opportunities and Threats
14. Vision and / or Guiding principles for the future of Moenjodaro

Part C : Plan for 10 years

15. Management mechanism and responsibilities (if to be different) **to address the identified needs, including Disaster Preparedness (Mitigation, Preparedness, Response and Recover)**
16. Objectives and strategies
 - a. Research
 - b. Conservation
 - c. Equipment
 - d. Facilities (offices, museum, park, ...)
 - e. Visitors / visitors management / communication
17. Time frame for implementation

Appendixes

- Extract of law on heritage applicable and other legal documents
- Maps and plans
- Bibliography

7. Overall planning for short and long term

7.1. Plan for urgent interventions (to be undertaken before 2023 monsoon)

To discuss the feasibility of the emergency plan, participants to the workshop, Ali Hyder and Aijaz Ali Mashori, did take a full day off the workshop group to:

- Adjust existing "rate analysis" sheets to adapt to the proposed evolutions of the technical specifications (capping, paths, flooring, etc.);
- Prepare a new "rate analysis" sheet for the construction of drainage pits;
- Prepare an updated bill of quantity (very detailed pivot table excel file) for all types of works, based on the indications plotted on the plans prepared;
- Prepare a specific bill of quantity for the works that had been listed during the workshop as first priority, to be inserted in emergency plan.

As a result, the table hereunder could be presented during the first part of session 7 (full size table is in appendix 3).

REQUISITION FOR SIX MONTHS WORK AT MOHENJODARO 2023																	
S.#	Items of work	Unit	Qty	Mason @ RS 1500/P/day	Labour @ RS950/ Poly	Donkey @ RS950/- poly	Sweat earth	Standard Bricks 11" x 5 1/2" x 2 1/4"	Burnt Bricks special size 11" x 5 1/2" x 2 1/4"	Burnt Bricks 9" x 4 1/2" x 3"	Husk/s/row in Md	Tractor makes No. of trip @ RS.2000 /- p each trip	PCH for reject water etc.	Geo textile	Gravel/Brick blast	Miscellaneous /Uniforms/Safety etc.	Total
				Nos.	Nos.	Nos.	P.100 Cft	P.1000 Nos.	1000 Nos.	1000 Nos.	P.Md:	No.of trip	liter	sq. meter	P.100 Cft	L.S	
1	Under pinning to the decay and undermined walls with burnt bricks (both old and new) laid in mud mortar. The old salt saturated bricks likely to be reused for the purpose should be free from salt and it can easily be got done by dipping them in canal water for such a time till it is confirmed that no salt lies in	P.100 Cft	2460	55,35	334,56	98,4	861	0	29520	0	0	0	57	0	0	0	0
	Total			83025	317832	93480	17220	0	826560	0	0	0	13167	0	0	0	1 351 284,00
2	Providing mud capping of the top of the walls with sundried bricks laid in two layers.in convex shape as advised by UNESCO expert on visit in oct.2022	P.100 Sft	39800	199	927,34	0	15920	537300	0	0	1500	0	398	0	0	0	0
	Total			298500	880973	0	318400	6447600	0	0	1500000	0	91938	0	0	0	9 537 411,00
3	Provision for removal of saline earth from inside the structure and spreading it in low laying areas away from the site by means of manually or mechanically lead up to about 1/2 miles to 5miles.	P.100 Cft	15000	0	579	300	0	0	0	0	0	200	0	0	0	0	0
	Total			0	550050	285000	0	0	0	0	0	400000	0	0	0	0	1 235 050,00
4	Dry brick on edge paving (with sundried bricks) above the thin layer of Mud mortar, including preparation of bed by watering, ramming earth and bringing the same to proper camber for draining rain run off away from walls so as to prevent of rain water into the foundation of structure/walls, as required.	P.100 Sft	47000	314,9	1541,6	0	5546	246750	0	0	400	0	470	0	0	0	0
	Total			472350	1464520	0	110920	2961000	0	0	400000	0	108570	0	0	0	5 517 360,00
5	Construction of Brunt brick approach paths in the streets and lanes of the excavated remains at Mohenjodaro. The paths shall be prepared with 4 1/2" thick dry brick on edge soling over a 6" wall rammed bed of river sand in.	P.100 Sft	700	4,69	13,37	0	392	0	0	3675	0	0	70	0	0	0	0
	Total			7035	12701,5	0	7840	0	0	44100	0	0	16170	0	0	0	87 846,50
6	Construction of collection well in the center of room /hall with perforated wall masonry and duly installing of Geo textile with proper jointing with appropriate solutions and filling/spreading gravel in required rate etc. complete.	P.each well	2	2	6	0	50	0	0	240	0	0	10	22	142	4000	0
	Total			3000	5700	0	1000	0	0	2880	0	0	2310	3300	6390	0	24 580,00
	Total Qty of Labour & Material			575,94	3401,87	398,4	22769	784050	29520	3915	1900	200	1005	22	142	4000	
	Amount in Rs.			863 910	3 231 777	###	455 380	9 408 600	826 560	46 980	1 900 000	400 000	232 155	3 300	6 390	0	17 753 531,50
																	887 676,58
																	18 641 208,08

The total amount which was calculated comes to 74 564 USD. This is more than what could be provided by UNESCO for these works within the amount provided by the World Heritage Fund. However, as a special grant has been provided by the Government of Sindh to Moenjodaro conservation office, it was with great pleasure that the participants were informed by the Director of Moenjodaro that there will have no problem for implementing the proposed plan, result of the collective reflection during the workshop. Actually some additional works, some of them already launched (like on paths and canal from DKG to North of canal) will easily be tackled too.

7.2. Preparation for longer term plan: to be fine tuned

Reflection has been continued taking as a base the initial draft proposal as presented in first UNESCO expert mission report after discussion with Moenjodaro team, Sindh Ministry of culture and UNESCO World Heritage Centre. Actually this report did serve as a base for the preparation the “*STATE OF CONSERVATION REPORT*” prepared in February 2023 “*In compliance with the extended 45th session of World Heritage Committee, UNESCO, providing update on the site in order to raise international technical and financial support - a framework for the preservation in the coming years, including the strategy to cope with natural hazards and possible effects of Climate Change*” which has been ratified by M. Manzoor Ahmed Kanasro, Director General, AA&C Department, Ministry of culture, Sindh province Government.

The idea was to make sure that in addition to emergency measures, efforts would be continued so that UNES the Government of Sindh and UNESCO would have in their possession all information needed to prepare a comprehensive project document for a three year project to be submitted to a selection of interested potential donors, probably after the approval (hopefully) of the project’s idea by the World Heritage Committee during its 45th session to be organised in Riyadh in September 2023.

Items already discussed during the workshop / mission (mostly technical in nature) covered in chapter 6 of the present report

- Drainage
- Underpinning
- Salts
- Capping
- Paths
- Building materials

Additional items proposed by UNESCO expert for discussion

Research themes to be addressed:

Building materials with including presence of salts as a specific constraint

Archaeological reports to be explored with specific attention to :

- . Drainage systems (partially covered by Prof. Altaf Aseem)
- . Presence of plastering when excavations where made
- . Use of lime / gypsum
- . Wells
- . Steps
- . Roofing method evidences
- . Masonry details

Mapping of recently exposed archaeological remains and studying them (Including identified canal towards north (from DK-G)

Gathering (conference) of experts on Moenjodaro (and other Harappan archaeological sites) to discuss the question of plastering (evidences during archaeological researches, potential for conservation today and tomorrow) raised in article by Dr. M. Jansen (see p.57).

Archives

Establish list of the documents (books, reports, and other sources of information) present at Moenjodaro archives;

Identify potential sources (Persons, institutions,..) that could possess additional documents, pictures, ...;

Organize the documentation for easier access and quick identification.

Museum ;

The question of taking into account the museum within the proposed 3 year project was raised. Though as this museum was not affected by heavy rains, the relevance to include it in a DRR project was questioned, thus could rather be seen as separate project. To be further discussed.

Equipment:

A list was already prepared for the laboratory (see 1st expert mission report). It may still be reconsidered if new equipment would be identified as having some specific additional potential;

In addition to other equipment already recommended in the same report (water pump) will be added :

- . drone for quick eye bird surveys;
- . pneumatic or mechanical rams (for paths and compacted grounds);
- . piezometer for monitoring water table level (to make comparisons with pools existing at the site who can be simple indicators).

New documents / Revision of documents

- . Progress reports;
- . Special studies / research reports;
- . Documentation of conservation works;
- . Conservation manual (see chapter 6.8 of this report, p.65)
- . Management plan (see chapter 6.9 of this report, p.66).

As a result of discussions on these issues, a list has been compiled with indicating specific responsibilities that were suggested / accepted by the main stakeholders, though may still be discussed when being implemented according to availability / competences required.

A. To be prepared by Moenjodaro team

1. Data to be further elaborated at the site :

That concerns:

1.1. Drainage / renewal of flooring system

Based on the numerous existing thematic plans elaborated by end of 2022, elaborate more detailed plans for each area with indicating precisely the level of urgency:

- . very urgent : to be undertaken immediately (emergency plan: before July 2023)
- . urgent : to be implemented in year 1
- . necessary : to be implemented in year 2
- . wished : to be implemented in year 3

1.2. Provision of underground drainage system in DK south area

- . prepare overall design proposal according to existing slopes
- . evaluate needs (size and number of pipes for each section)
- . prepare final design with details for quotation (BoQ)

1.3. Provision of water outlets for all rooms

Based on the existing plans elaborated by end of 2022, elaborate more detailed plans for each area with indicating :

- . very urgent : to be undertaken immediately (emergency plan: before July 2023)
- . urgent : to be implemented in year 1
- . necessary : to be implemented in year 2
- . wished : to be implemented in year 3

1.4. Underpinning

Revise underpinning / wall condition plan for each area with bringing more details according to level of risk with classifying under three categories:

- a. High level of risk (major gaps in the structure, high walls,...), thus to be treated (or stabilized with temporary measures) before the 2023 monsoon
- b. Medium level of risk , to be treated in year 1
- c. Low level of risk (need only regular inspection before potential treatment during years 2 and 3

1.5. Capping

Revise existing plans for each area with distinguishing:

- . walls that should be treated before 2023 monsoon (emergency plan)
- . where there is no capping , to be priority for year 1
- . where there is still remains of capping , to be treated during year 2
- . where there is still sufficient capping that can wait for year 3.

1.6. Paths

Revise existing plans for each area (and overall site plan with better indicating priorities:

- . paths to be revised as they are representing a danger to some archaeological structures to be treated before 2023 monsoon during (emergency plan)
- . zones where there is danger to be closed to the public (limited access) before they can be treated
- . sections of paths to be repaired during year 1;
- . sections of paths to be repaired during year 2.

1.7..Prepare plan of the overall sites indication slopes and temporary pools / existence of protective dykes between areas (see plan in museum, dykes dating back from first half of 20th century).

Prepare plan indicating old dykes, slopes and temporary pools with in mind the need to evaluate works to be undertaken to re-level the site to avoid the formation of pools during rains and better functioning of circular drain

Identify areas with high salt content (crust at ground surface)

1.8. Prepare plan of the state of the circular canal / identification of volumes to be cleaned

Mainly three assets need to be evaluated :

1. Vegetation (trees and plants)
2. Silts deposits
3. Other specific items (e.g. pathway to school building, ...)

2. Revision of data / Bill of Quantities / new quotations

2.1. Revise the existing rate analysis sheets taking into account the new specifications that have been agreed upon (improvement of conservation practices thus requiring additional materials / time

2.2. Rate forms analysis could also be revised (prices) according to results of exploration for best quality bricks production)

- 2.3. Overall bill of quantity to be revised with clear distinction between:
 - . Emergency action plan, to be fully separated and subtracted
 - . 3 year plan, based on the distinction of the priorities for each year. It will be presented in separated excel sheets for each year (that will help planning release of funds but also adapt to inflation risks).
- 2.4. Getting quotation for a variety of solutions for cleaning the circular canal
- 2.5. Getting quotation for pumping system from circular canal to Dadu Canal
- 2.6. Getting quotations for the underground drainage system at DK south
- 2.7. Getting quotation for making openings in the old dikes and releveling of the site so as to get gentle slopes towards circular canal
- 2.8. Prepare an evaluation or get quotations for removal (scraping) of salt crusts at the ground surface where identified
- 2.9. Enquire possibilities for having access to an upgraded internet connection and evaluation of cost

3. Proposal for the gradual implementation of all works planned (over 3 years)

On the basis of the results of activities described at point 1 and 2 above, prepare a graphic presentation (excel sheet) of the implementation of works over the three years of the project with indicating periods of implementation for each area using data extracted from bill of quantities, with as done for the emergency plan data on the number of days that a team needs for implementing works (per team).

B. To be prepared by UNESCO expert

1. List of equipment to be acquired for 3 year project

Laboratory

A list has already been prepared for the upgrading of the laboratory.

This list will be checked by Moenjodaro team / UNESCO office in Islamabad

Other items listed

- . high performance drone / camera to be added
- . pneumatic or mechanical rams for fastening work on paths and compacted grounds
- . piezometer for monitoring water table level (to make comparisons with pools existing at the site who can be simple indicators).

2. Laboratory installation and training

A first project has already been drafted (first mission report).

Contributions are welcome to fine-tune it.

3. Proposed research program

The research program to be undertaken from the beginning of the implementation of the 3 year project will be drafted (2 page document). This research program will cover the following topics:

- Raw and building materials (including issues related to salt)
- Archaeological reports to be explored with specific attention to :
 - . Drainage systems (partially covered by Prof. Altaf Aseem)
 - . Presence of plastering when excavations were made
 - . Use of lime / gypsum
 - . Wells
 - . Steps
 - . Roofing method evidences
 - . Masonry details
- Recently exposed archaeological remains mapping & studying
- Canal towards north (from DK-G)

4. Proposed experts gathering (conference and debate on conservation strategies adapted to Moenjodaro WH site)

A gathering of experts on Moenjodaro (and other Harappan archaeological sites) will be organized to share knowledge / experience on maintenance of these sites both in the past (historic time, with potential evidences of maintenance / repair practices) and today (practices, difficulties met / solutions envisaged) with a specific focus the question of plastering (evidences during archaeological researches, potential for conservation today and tomorrow).

A brief paragraph will summarize the idea and an overall evaluation of the cost of the organization of such an event will be proposed.

5. Proposal for elaboration of new documents / Revision of existing documents

Evaluation of costs, participation (who) and time frame for the preparation of the following documents will be proposed

- . progress reports
- . special studies / research reports
- . Documentation of conservation works
- . Conservation manual (revision)
- . Management plan

C. To be prepared by UNESCO Office in Islamabad

1. Draft project / evaluation for upgrading Moenjodaro Archives / documentation center

- a. Identification of potential sources (Institutions / experts)
- b. Collection of documents / pictures / plans / reports
- c. Digitalization of documents
- d. In-situ and online access
- e. Evaluation of costs and planning

2. Draft project/ evaluation for Moenjodaro museum facilities / collection

- a. Upgrading of existing museum facilities / exhibition / storage
- b. Process of reflection for planned extension of the museum
- c. Valorization of the specific qualities / values of the existing museum building
- d. Evaluation of costs and planning

Appendixes

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Numerous pictures are available at : <http://archnet.org>

Appendix 2 – Proposal for an immediate capacity reinforcement for Moenjodaro conservation office (October 2022).

Budget estimate for a first 4 months immediate capacity reinforcement at Mohenjodaro for undertaking urgent stabilization works:

A lot of work has already been done by the existing team of workers at the site since the large destruction that occurred by the end of August 2022. That includes the cleaning of the debris at SD area, cleaning the baths and reconstructing its side walls, and stabilizing some walls with underpinning. The cleaning efforts have also been extended to L and DK areas. But looking at the progress already made for the necessary cleaning it is clear that without a serious reinforcement of its capacity (human resource and equipment), it will take too long for this team to complete that work and as such will delay the implementation of what needs to be done for the actual stabilization and also to together launch a campaign for better preparation before.

To undertake and overall ensure that all conditions are met for the team to be efficient, it is proposed, as a first important measure that a capacity reinforcement budget (elaborated in below table) be immediately provided to Mohenjodaro site for the next four months, before a more detailed cost estimate of the more comprehensive restoration plan be prepared (during January 2023).

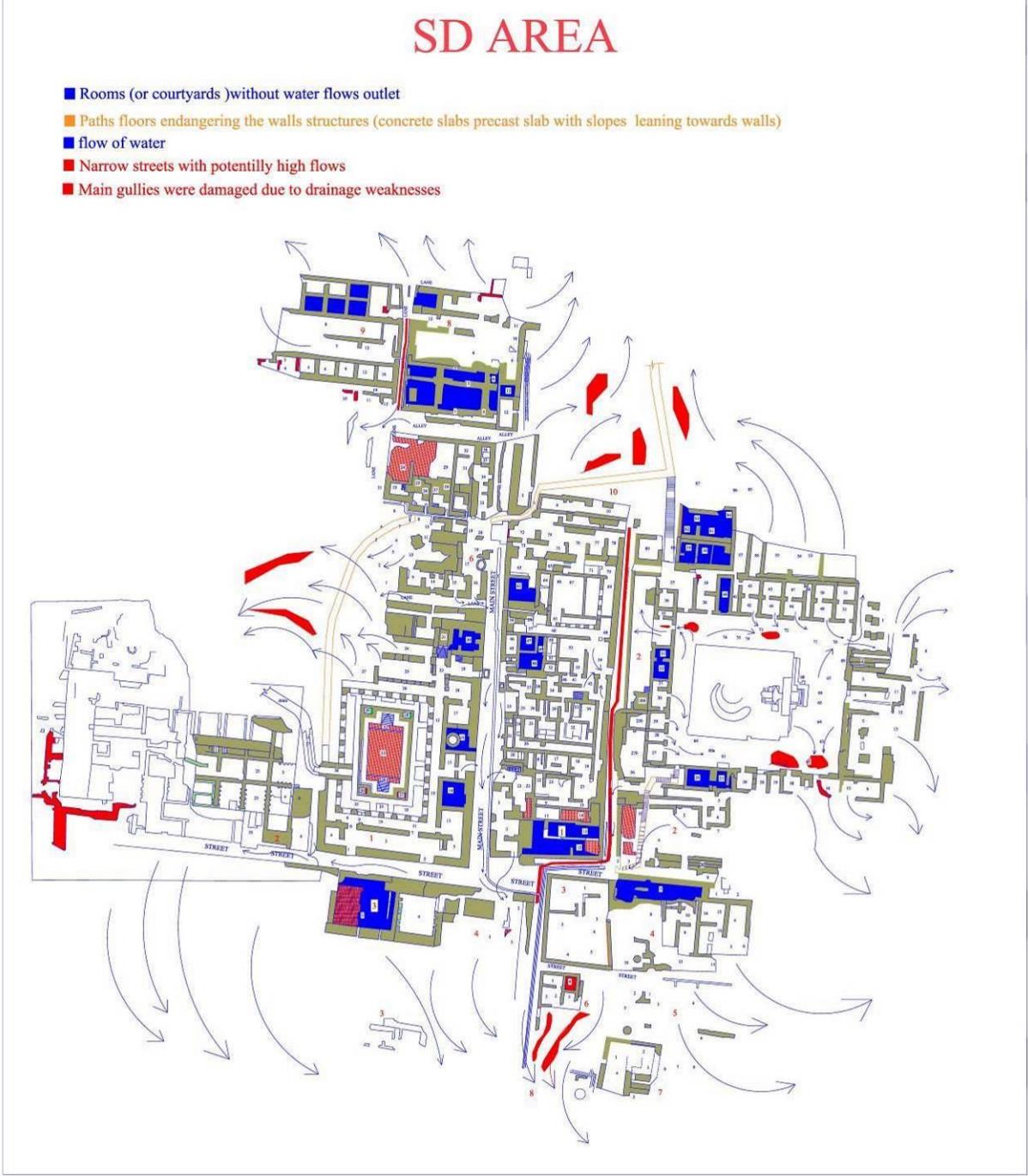
Such a four months capacity reinforcement would comprise :

- . Recruitment of about 28 workers (laborers but also masons and foremen) so as to establish 4 new operational teams that would be in charge of the still required cleaning of the site and all preparatory works. That would allow the existing staff which has the skills for it to concentrate on the stabilization works themselves: releveling of drainage system, underpinning and reconstruction of walls that have a retaining role.
- . Recruitment or temporary deployment of 2 assistant conservators;
- . Provision of two laptops and the necessary softwares;
- . Provision of building materials (mainly fresh soil and burnt bricks, and wood for propping / strutting purposes);
- . Provision of sufficient tools for the additional workers (pickaxes, shovels, wheelbarrows, rams, ...);
- . Satellite connection for internet, to established proper communication with national and international partners and experts, for the preparation of the long term restoration plan;
- . Logistical support for transport of materials, reception of guests, journalists, and communication.

Budget estimate:

	Designation	Q	Unit	Cost / Unit	Total
1	Team of workers (8 persons)	16	Month	1700	27200
2	Assistant conservators	8	Month	900	7200
3	Building materials		Bulk amount		16000
4	Tools and small equipments		Bulk amount		10000
5	Computers (Laptop) with softwares	2	Pieces	2000	4000
6	Satellite internet box	1	Piece	2500	2500
7	Satellite connection	4	Months	100	400
8	Logistic support	4	Months	500	2000
				Grand total	69300

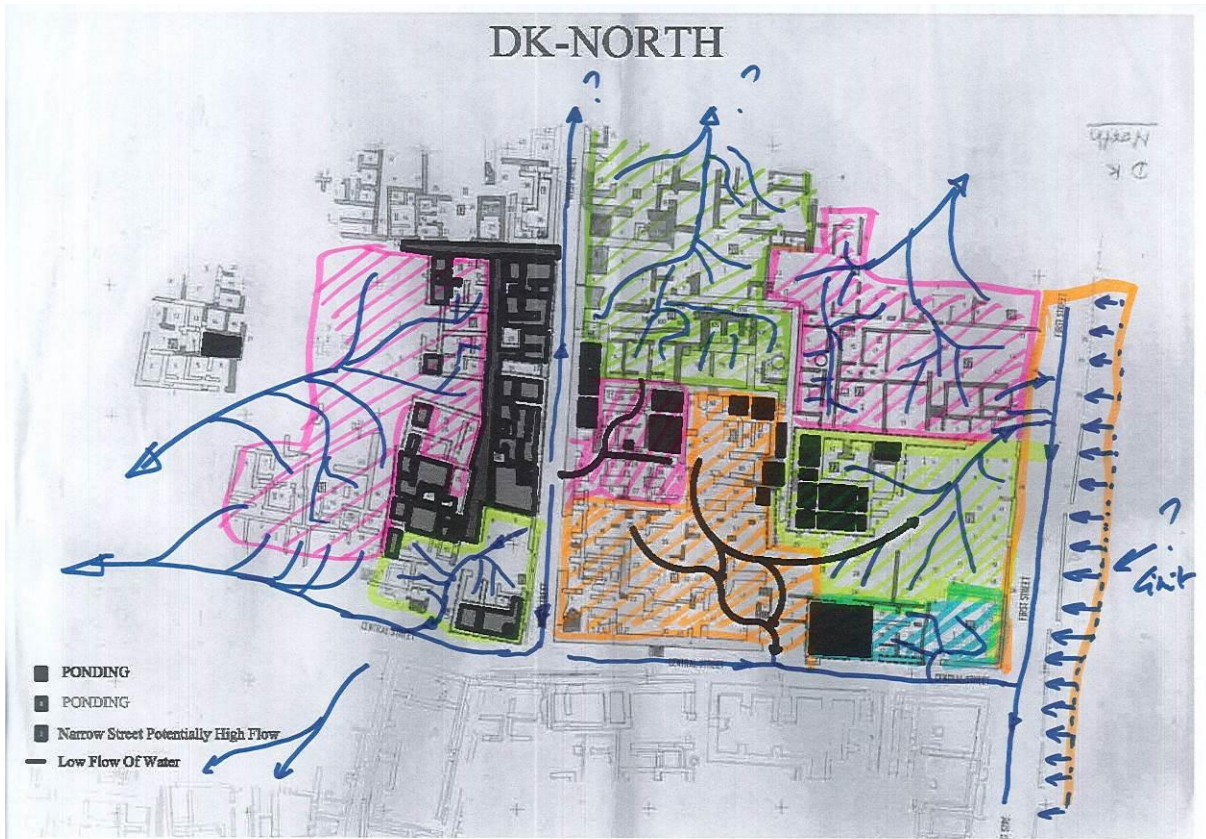
Appendix 3 – Examples of condition assessment plans prepared by the Moenjodaro team (state of progress in January 2023)



V-S AREA

- Good Condition
- Underpinning
- Destroyed and need full reconstruction (or reconsideration)
- Structures disappeared duo to passeege of time





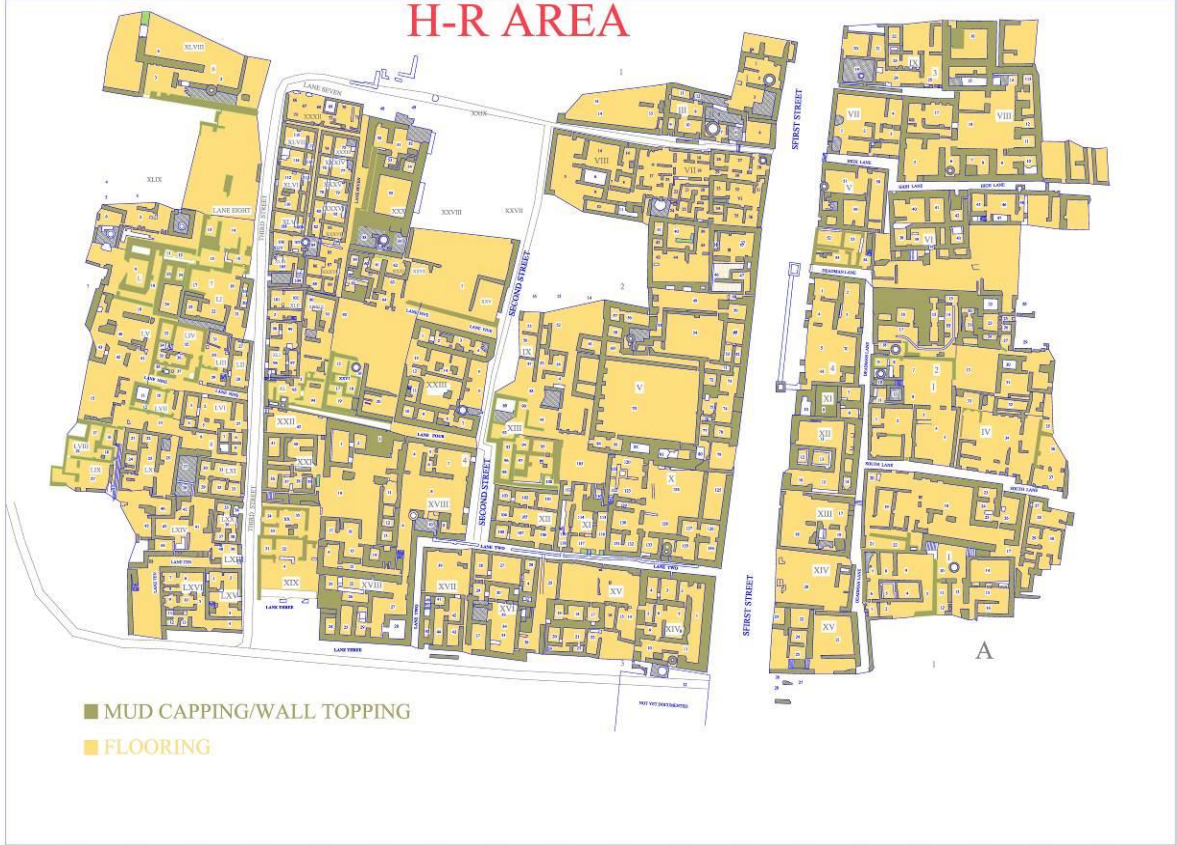
Example of plan provided to illustrate comments made during zoom meeting to MCO team for improving the clarity / pertinence of their production

H-R AREA

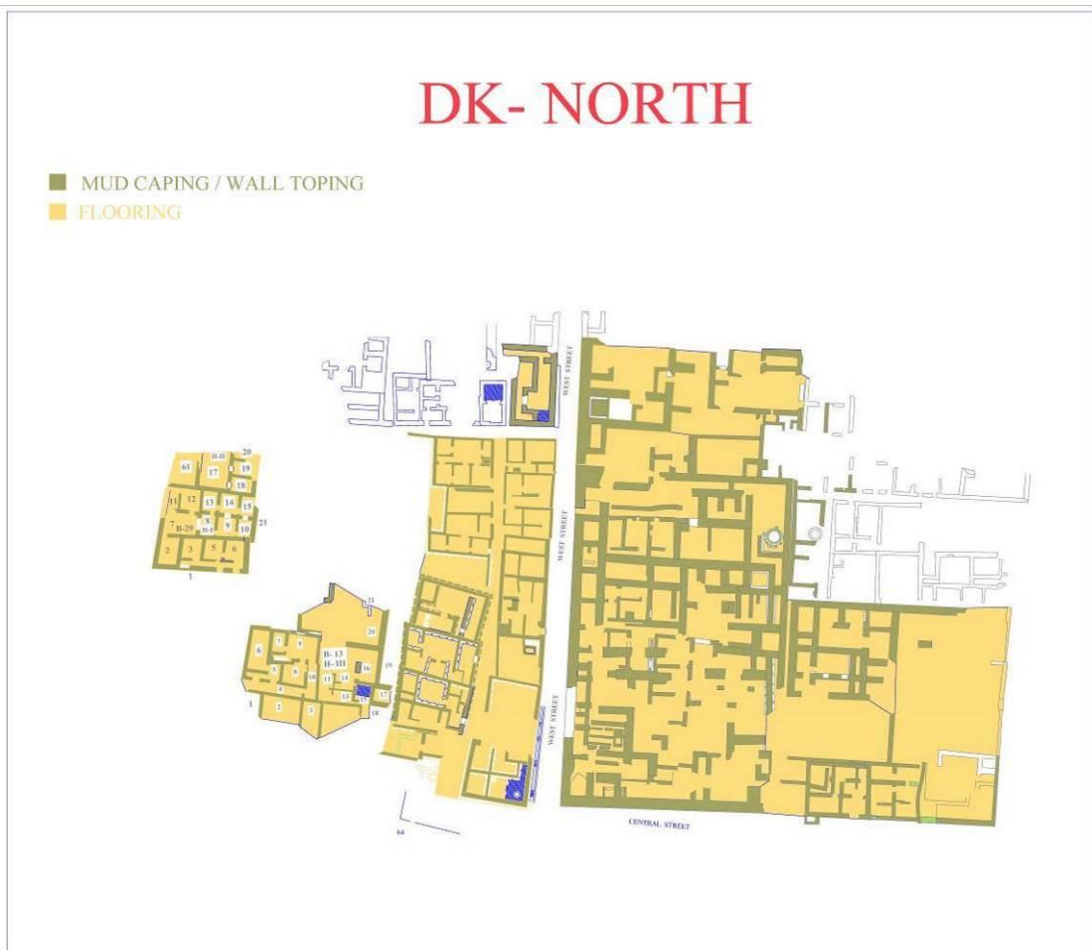
- Rooms (or courtyards) without water flows outlet
- Paths floors endangering the walls structures (concrete slabs precast slab with slopes leaning towards walls)
- flow of water
- Narrow streets with potentially high flows
- Gullies appeared due to weak drainage system

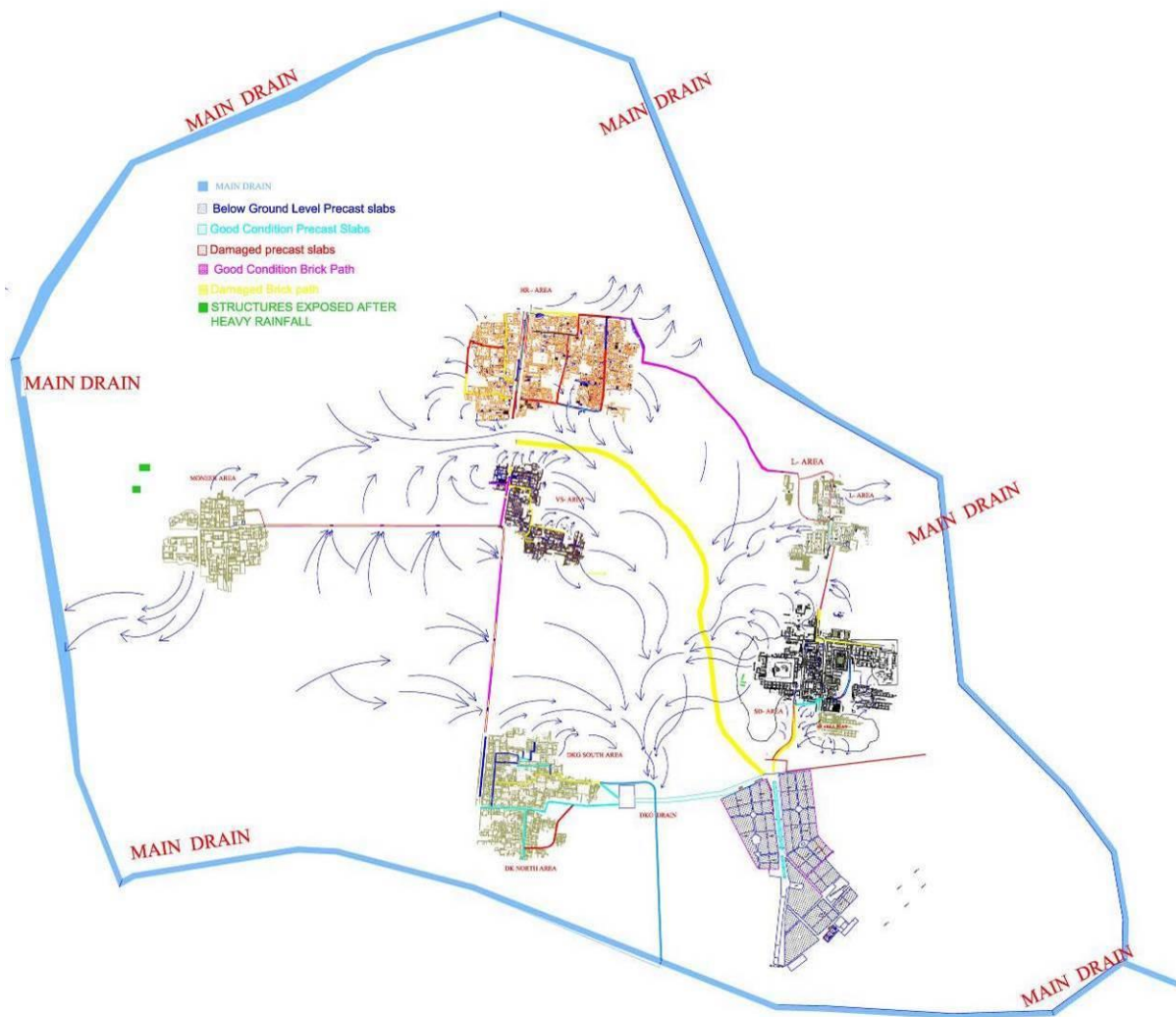


H-R AREA



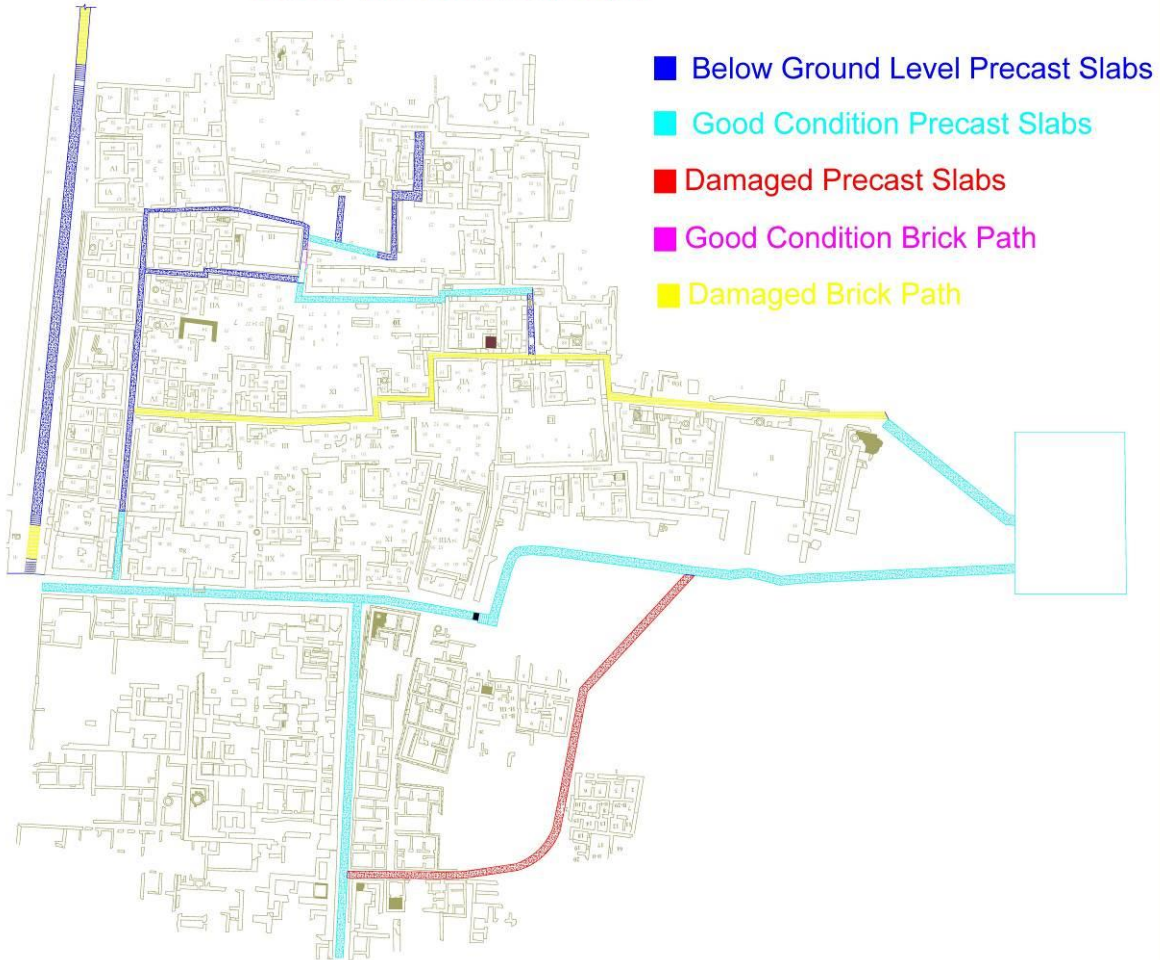
DK- NORTH





Plan of the overall site showing paths and main drainage slopes / canals

DKG SOUTH AREA







DK NORTH AREA

H-R AREA

-  Below Ground Level Precast slabs
-  Good Condition Precast Slabs
-  Damaged precast slabs
-  Good Condition Brick Path
-  Damaged Brick path

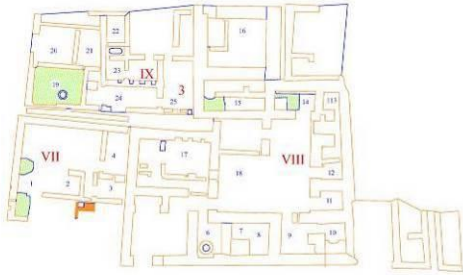


SD AREA RAIN DAMAGED 2022

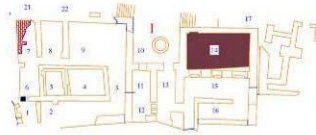
-  Good Condition
-  Underpinning
-  Destroyed and need full reconstruction (or reconsideration)
-  Structures disappeared due to passage of time



Well on platform on
HR Area section A



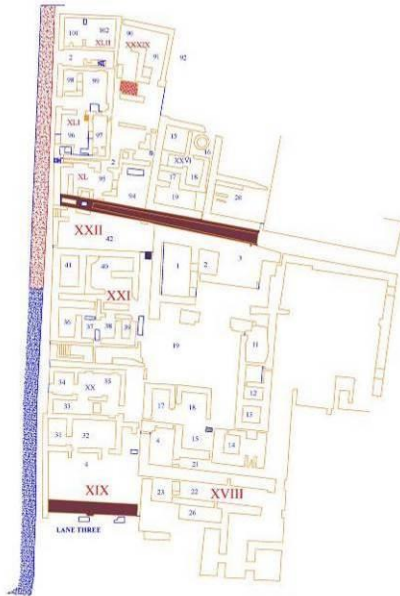
Temple in HR Area



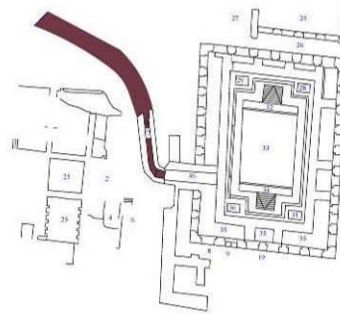
well preserved house



Bath Canal at HR area Section B



Great Bath canal



Appendix 4 – Revised estimate for the suggested 3 years project

(Updated in May 2023)

Budget for the necessary 3 years project for full recovery of the state of conservation of the site and the implementation of climate change mitigation measures.

The overall budget for this large project has been estimated to 1,5 million US Dollars, Though the figures indicated hereunder do need to be taken with care, the idea being here to give an overall global idea of what such a project would probably involve to ensure that:

- . most damaged parts of the site will have been restored;
- . the visitors paths have been put back in service with eliminating the less adapted to the benefit of more discreet solutions;
- . there is better visibility in the aspect of the restoration works of structures dating back from different periods (more specifically differentiating the most ancient to the Buddhist one).
- . revised restoration techniques with improved capacity to resist to heavy and repeated rains conditions have been experimented and are proved;
- . additional practices in place for mitigation / reduction of the presence of salts at the site
- . the team in charge of the conservation has reinforced capacities (quantitative, qualitative), office and updated site work equipment;
- . upgraded lab facilities and systematic control processes are in place;
- . conservation manual has been revised;
- . conservation and management plan for the whole site has been prepared.

Cost estimate :

Budget for the works themselves (materials and labor): 600 000 USD

Tools and equipment for works (mixer, scaffolding, etc, ..): 100 000 USD

Mobile pumping station (2): 40 000 USD

Office equipment (hard and soft): 25 000 USD

Drone and photographic equipment: 10 000 USD

Upgrading of Lab + training: 80 000 USD

Expertise (national & international): 160 000 USD

Research, experimentation and testing: 120 000 USD

International conference: 50 000 USD

Students involvement: 30 000 USD

Logistic support: 85 000 USD

Revision of conservation manual: 40 000 USD

Elaboration of management plan: 80 000 USD

Communication: 30 000 USD

Backstopping and missions: 250 000 USD

Overhead costs: 150 000 USD

Total: 1 850 000 USD

Appendix 4 – Emergency plan – Bill of quantities

Details on why and how this table was produced is described p. 35 of this report.

REQUISITION FOR SIX MONTHS WORK AT MOHENJODARO 2023																		
S.#	Items of work	Unit	Qty	Mason @ RS 1500/P day	Labour @ RS.950/P day	Donkey @ RS.950/P day	Sweat earth	Sundried Bricks size 11" x 5 1/2" x 2 1/4"	Brunt Bricks special size 11" x 5 1/2" x 2 1/4"	Brunt Bricks 9" x 4 1/2" x 3"	Husk/straw in Mtd	Tractor trolley No. of tnp @ Rs.2000/-	POL for sweet water etc.	Geo textile sq. meter	Gravels/Brunt brick blast	Miscellaneous /Unforeseen/Solutions etc.	Total	
			Nos.	Nos.	Nos.	P.100 Cft	P.1000 Nos.	P.1000 Nos.	P.1000 Nos.	No. of tnp	liter	sq. meter	P.100 Cft	L.S.				
	Under punning to the decay and undermined walls with burnt bricks (both old and new) laid in mud mortar. The old salt saturated bricks likely to be reused for the purpose should be free from salt and it can easily be got done by dipping them in canal water for such a time till it is confirmed that no salt lies in	P 100 Cft	2460	55,35	334,56	98,4	861	0	29520	0	0	0	57	0	0	0	0	1 351 284,00
	Total			83025	317832	93480	17220	0	826560	0	0	0	13167	0	0	0	0	1 351 284,00
2	Providing mud capping of the top of the walls with sundried bricks laid in two layers in convex shape as advised by UNESCO expert on visit in oct: 2022	P 100 Sft	39800	199	927,34	0	15920	537300	0	1500	0	0	398	0	0	0	0	9 537 411,00
	Total			298500	880973	0	318400	6447600	0	1500000	0	0	91938	0	0	0	0	9 537 411,00
3	Provision for removal of saline earth from inside the structure and spreading it in low lying areas away from the site by means of manually or mechanically lead up to about 1/2 miles to 5 miles.	P 100 Cft	15000	0	579	300	0	0	0	0	0	2000	0	0	0	0	0	1 235 050,00
	Total			0	550050	285000	0	0	0	0	0	400000	0	0	0	0	0	1 235 050,00
4	Dry brick on edge paving (with sundried bricks) above the thin layer of Mud mortar, including preparation of bed by watering, ramming earth and bringing the same to proper camber for draining rain run off away from walls so as to prevent of rain water into the foundation of structure/walls, as required.	P 100 Sft	47000	314,9	1541,6	0	5546	246750	0	400	0	470	0	0	0	0	0	5 517 360,00
	Total			472350	1464520	0	110920	2961000	0	400000	0	108570	0	0	0	0	0	5 517 360,00
5	Construction of Brunt brick approach paths in the streets and lanes of the excavated remains at Mohenjodaro. The paths shall be prepared with 4 1/2" thick dry brick on edge soling over a 6" wall rammed bed of river sand in.	P 100 Sft	700	4,69	13,37	0	392	0	0	3675	0	0	70	0	0	0	0	87 846,50
	Total			7035	12701,5	0	7840	0	0	44100	0	16170	0	0	0	0	0	87 846,50
6	Construction of collection well in the center of room /hall with perforated wall masonry and duly installing of Geo textile with proper jointing with appropriate solutions and filling/ spreading gravel in required rate etc. complete.	P each well	2	2	6	0	50	0	0	240	0	0	10	22	142	4000	0	24 580,00
	Total			3000	5700	0	1000	0	0	2880	0	0	2310	3300	6390	0	0	24 580,00
	Total Qty of Labour & Material			575,94	3401,87	398,4	22769	784050	29520	1900	200	1005	22	142	4000	0	0	17 753 531,50
	Amount in Rs.			863 910	3 231 777	###	455 380	9 408 600	826 560	46 980	1 900 000	400 000	232 155	3 300	6 390	0	0	17 753 531,50
																		887 676,58
																		18 641 208,08

Appendix 5 – Specific estimate for upgrading of MCO lab facilities and skilled personnel (updated May 2023)

Objective: to upgrade the equipment and personal qualification of the existing laboratory at Moenjodaro to establish a more systematic quality control of the raw and building materials used for the restoration works and to launch a campaign of tests / experimentation for upgrading the quality of the material used in the most exposed parts of these restoration works (wall basis, floors, ...) to guarantee more durability and best response in case of major rainy events.

This would entail:

1. To renew / some of the existing soil and water testing equipment.
2. To complement the existing capacity additional equipment;
3. To extend testing procedures so those necessary for better mastership of building materials compressive tests (dry / humid) and to capillarity tests;
4. To train at least two members of the Moenjodaro conservation Cell to the use of the equipment
5. To train the overall team of Moenjodaro conservation Cell to make the best use of the results of the variety of tests
6. To set up a regular quality control process.

To give an idea, here is a first raw cost estimate for each of these items :

1. Small equipment : 5 000 USD
2. Additional small equipment : 5 000 USD
3. Press for compression tests and accessories : 26 000 USD
4. 2 x 3 months internship in a laboratory : 15 000 USD
5. Expert for onsite one week training workshop (+ one week preparation) : 17 000 USD
6. Experts fees and workshop : 12 000 USD

Total updated (may 2023) estimate: 80 000 USD.

Detailed list of equipment / supplies required (see next pages):

	Small equipment
10	Trays stainless steel 40 x 20 cm
2	Stainless bowls, Φ 20 cm
3	Plastic jar 3 l
5	Glass jar 1 l
1	Mortar and pestle
1	Kneading roller
2	Soft brush (either a low pressure blower)
3	Graduated plastic beakers of 3,000 ml capacity
3	Electronic measuring balance of 15 kg with precision of 1 g.
1	Electronic measuring balance small size
1	25 kg capacity scale with an accuracy of 5 g
1	Glass stick 2 pieces
2	Lab burets graduation of 1 ml with support
	Shrinkage tests
5	Brass or stainless steel rings (5 cm diameter)
2	Linear shrinkage moulds
1	Square metal mould 1.5 cm x 10 x 10 cm
	Grainsize distribution
1	Sieves of Φ 250 cm, 7 cm deep. Sieves sizes of 5, 2, 1, 0.5, 0.25, 0.125 and 0.063 mm
4	Small painter brushes (2 cm diameter)
4	Wire brushes with fine bristles for cleaning the sieves
	Sedimentometry (Grainsize distribution small particles)
8	Sedimentation graduated test tubes of 1,000 ml capacity
4	Hydrometer / densitometer : 995/1 030 g/l
2	Glass thermometer with range from -10 to 105 °C sub-divided in 0.5 °C
2	Beaker borosilicate glass of 250 ml capacity
2	Sodium hexametaphosphate (1,000 g)
1	Stirrer of 4,000 rpm
1	Laboratory Disc Magnetic Stirrer
	Atterberg limits
1	Density meter (Casagrande hydrometer) density around 1000 g/l
1	Liquid limit Atterberg device: Glass plate, brass or stainless steel rod Φ 3 mm x 150 mm long
2	Plastering knife (flexible spatula) 15 cm
1	Porcelain basin Φ 150 mm
20	Small containers for water content measurement
	Metylen blue test
1	1 rotating agitator at adjustable speed (400 to 700 rpm) with analog display with its stative and pale agitation.
1	Micropipette of 0.1 ml
1	Consumable filter paper 100 sheets d90 mm
2	Blue methylene (100 g)

Salts testing	
1	PH meter, from 0 to 14, 0,01 precision
1	Testing set for chlorides
1	Testing set for Nitrates
	Testing set for Sulphates
1	Testing set for Hardness
Items for testing building materials	
1	Compression testing machine with computer station, and sensitivity 500 kN size for Φ 16 cm and 32 cm height samples
1	Flexion testing device for bending test
1	Abrasion device: wire brush with weights and vice (to be repaired)
2	Iron brushes
10	Buckets 10l
2	Basin, big size, plastic but better if rubber troughs
1	Basin small size, plastic
3	Electric mixer handle
2	Watering can, plastic
3	Pressure water sprayer 2 l
2	Sieves of 10 mm grid, big size (1 x 2 m)
2	Sieves of 5 mm grid, big size (1 x 2 m)
1	Hammer 1 kg
1	Drill driver with battery and set of drills and bits
10	Measuring tape 5 m
9	Mason level
4	Carpenter saws different sizes
10	Wooden moulds of various sizes (to cope with existing brick sizes)
2	Covering sheets: Tarpaulin 4 x 5 m

Appendix 6 – List of participants to the Workshop –January 2023

LIST OF PARTICIPANTS, OF WORKSHOP ON
 “CONSERVATION ISSUES & POSSIBLE METHODOLOGY FOR
 REHABILITATION OF MOHENJODARO SITE
 14th to 23 January 2023
 Culture, Tourism & Antiquities Department, Ministry of Culture Sindh
 in collaboration with UNESCO

1	Dr. Syed Shakir Ali Shah	Director	Mohenjodaro
2	Mr. Thierry Joffroy	UNESCO Expert	UNESCO Expert
3	Dr. Cristina Menegazzi	International Expert on Culture & Heritage,	UNESCO Islamabad
4	Mr. Jawad Aziz	Culture Program officer	UNESCO Islamabad
5	Mr. Ali Hyder,	Archaeological Engineer	Mohenjodaro
6	Dr. Javeria Shaikh	Dean, Architecture	Aror University, Sukkur
7	Dr. Altaf Aseem	Rtd. Professor Archaeology	Member T.C.C NFM Mohenjodaro
8	Mr. Rohal Ameen	Curator	Archaeology
9	Mr. Shabir Ahmed Joyo	Archaeological Conservator	Mohenjodaro
10	Mr. Naveed Ahmed	Architect	NFM Mohenjodaro
11	Mr. Imtiaz Ali	Conservation Assistant	NFM Mohenjodaro
12	Mr. Ali Gul	Conservation Forman	NFM Mohenjodaro
13	Mr. Rahim Bux	Site Supervisor	Mohenjodaro
14	Mr. Rustam Ali Bhutto	Archaeological Conservator	In-charge, WASIL
15	Ms. Sana Gul	Lecturer Archaeology	Aror University Sukkur
16	Ms. Kaneez Umme-e- Farwa	Lecturer Architect	Aror University Sukkur
17	Mr. Kamran Siraj	Lecturer Architect	Aror University Sukkur
18	MS. Mishal Abbasi	Student Archaeology	Sindh University, Jamshoro.
19	Ms. Muntaha Mahar	Student Architect	Mehran University, Jamshoro.
20	Ms. Suaellah Qureshi	Director	Soach Media
21	Mr. Aijaz Ali Mashori	Admin:	Directorate, Mohenjodaro Conservation

Appendix 7 – List of persons and institutions met

Name	Position
Ministry of culture, Sindh	
Mr. Syed Sardar Ali Shah	Minister
Mr. Manzoor Ahmed Kanasro	Director General, AA&C Department
UNESCO	
Mr. Lazare Eloudou Assome	Director, WHC
Ms. Himalchuli Gurung	Head Asia-Pacific Desk, WHC
Ms Hayashi Nao	Programme specialist, WHC
Mr. Jawad Aziz	Project officer, Islamabad office
Ms Cristina Menegazzi	Senior Project Officer, Islamabad office
Moenjodaro Conservation Office team	
Mr. Syed Shakir Ali Shah	Director
Mr. Rohal Amin	Curator
Mr. Ihsan Ali Abbasi	Assistant Curator,
Ali Hyder, Gadhi	Archeological Engineer
Mr. Shabir Ahmed Joyo	Archaeological Conservator
Mr.Arshad Ali Jatoi	Upper Division Clerk,
Mr.Altaf Hussain	Lower Division Clerk,
Mr. Aijaz Ali Mashori	-do-
Mr.Raheem Bux Wasan	Site Supervisor,
Suhban solongi	Conservation Foreman
Mr.Saindad Jatoi	-do-
Mr.Wajid Ali	-do-
Mr. Muhammad Saleem Mashi	-do-
Mr.Javed Ali	-do-
Mr. Muhammad Ismail	-do-
Mr.Muhammad Azam	Site Cooly, B-2
Mr.Allah Rakhio	Site Attendant
Mr. Naveed Ahmed Sangah	Architect Engineer
Mr. Imtiaz Ali Domki	Conservation Assistant
Mr. Ali Gul	Conservation Foreman
Mr. Sheikk Javed Ali	International guide
Members Technical consultative Committee	
Dr Kaleem ullah Lashari	Chairman
Prof. Altaf Aseem	Retired Professor of archaeology
Soch Media	
Ms. Suahela Qureshi	Director