AT-TURAIF DISTRICT IN AD-DIR’IYAH

NOMINATION DOCUMENT FOR THE INSCRIPTION ON THE UNESCO WORLD HERITAGE LIST

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# TABLE OF CONTENTS

## ANNEX A

**LORD CULTURAL RESOURCES,** September 2008,  
*Atturaf Operations Master Plan, Chapter 7 – Conservation Strategies*, sections 3 & 4 ............... p.4

## ANNEX B

**CRA**Terre,** September 2008,**  
*Conservation Manual for Atturaf Traditional Culture Demonstration Area*, chapters 4 & 5 ............... p.82

## ANNEX C

**AYER – SAINT-GROSS (ASG),** September 2008,**  
Design for the Salwa Palace, (presentation to ADA) ......................................................... p.128

## ANNEX D

**AYER – SAINT-GROSS (ASG),** September 2008,**  
Traditional Culture Demonstration Area, (presentation to ADA) ........................................... p.164

## ANNEX E

**ATM-3D,** December 2008,**  
3D Survey of the Excavations in at-Turaf Mosque (work in progress for ADA) ................. p.190
PART 3: PRESERVATION MAINTENANCE PROGRAM

3.1 INTRODUCTION AND GENERAL OVERVIEW

The maintenance of any facility, structure, or object, which has a continuing function, is absolutely necessary in order to prolong its function and usefulness. The object of preservation maintenance is to ensure that the historic fabric and values remain intact as long as possible. Of the many processes used to preserve historic structures, maintenance is almost always the most effective and least destructive. Unfortunately most preservation efforts focus on treating structures after they have “failed”, either completely or to varying degrees. Historically, different standards were applied – periodic and constant maintenance was the reality. Mud plaster was continually renewed as the needs arose; bases of walls were repaired when erosion occurred; and roofs were patched and repaired when they leaked.

Historic buildings and structures at Atturaif are not static. Repair and replacement of historic fabric is inevitable over the life of the building. Regular maintenance reduces the need for extensive modifications and alterations by detecting problems early. It is a well-accepted concept that “maintenance” is in fact the essence of preservation. Properly planned and scheduled maintenance activities are consistent with the primary preservation concept of minimal intervention and certainly are more likely to be consistent with the concepts of reversibility and the use of compatible materials. It is no coincidence that a preservation maintenance program is also often referred to as a preventive maintenance program. The prevention of deterioration is the underlying thesis of any good maintenance program for historic structures.

The purpose of a preservation maintenance program is to provide the basic components and the structure for a comprehensive maintenance program. It is based on the intent that the structure is well maintained, clean and attractive and of course that it be preserved. It is also based on the concept of maintaining and repairing features and systems rather than replacing those same features or systems. It may be more cost effective in non-heritage structures to replace building components rather than to continue to repair them, but the value of the historic fabric and the integrity of the historic structure add another important dimension and makes “repair rather than replace” the more appropriate approach.

There are three specific keys to a maintenance guideline: (1) the most important task or activity is the inspection; (2) that most activities can be scheduled ahead of time; and (3) any maintenance program is a “work in progress”: it should continually be updated and modified as conditions change and new materials and methods are developed or become available.

3.1.1 Inspections

Regardless of how well conceived and designed a maintenance activity is, if the historic structure is not inspected, the overall program will not be successful. However, if a structure is inspected on a regular schedule, work will often be undertaken even if there is no specific work plan. If only one activity can be accomplished, then look at the historic structure and record the findings.

Inspections are also ongoing. An initial inspection to confirm which systems and materials exist and to establish their conditions at that time is an important planning tool. From that initial inspection the basic parameters of the program are established. But unlike the approach of a typical building inspection, the even more critical inspections are those that come after the initial inspection and continue on into the future for the life of the structure.

3.1.2 Scheduling Activities

The effectiveness of any maintenance program is greatly dependent on the actual scheduling of maintenance activities. If activities are not scheduled, including inspections, there is in effect only a crisis management program in effect.

Many activities can be scheduled specifically and the scheduling of all activities that can be anticipated is a major component of a well-planned system. The ability to schedule results in a more efficient expenditure of resources and a preserved structure. Housekeeping activities are the easiest to schedule and routine activities are next easiest in anticipating and scheduling. Examples of routine maintenance activities are cleaning gutters and downspouts and patching mud plaster.

Cyclic maintenance activities can also be scheduled but that schedule is normally associated with major projects and expenditures of funds, such as the replacement of a roof system. Consequently, the scheduling is more associated with targets for raising anticipated funds for these non-annual reoccurring needs. These cyclic activities are much more dependent on the actual condition of the material, feature or system, and seldom will be simply replaced regardless of the condition.

3.1.3 Dynamic Document

A maintenance program should be a working document actively used by the owner or other responsible party. Whether a computerized program or in manual “hard copy” form it should be continually updated as conditions, equipment and needs change. A hard copy maintenance program can best be kept in a series of three-ring binders. Material can be replaced as the need arises; forms such as those for inspections can be removed and copied and then refiled in the same binder to keep a record of the inspections. Cut sheets for features and system that are replaced are themselves replaced with cut sheets of the new features and systems. For those reasons, this manual is provided in two forms – a bound copy and a copy in a three-ring binder.
3.2 DEVELOPING A PRESERVATION MAINTENANCE PROGRAM

Preservation maintenance is a proactive approach because it detects problems in materials and components before failure occurs. This approach preserves historic fabric and also has proven to be cost effective. In theory, a well maintained building can exist and function indefinitely. In practice, however, historic structures do deteriorate over time. Not all building component failures can be anticipated, much less prevented – structures experience random failures because of unknown conditions and natural and man-made disasters that no amount of planning or careful monitoring can prevent. Therefore, preservation maintenance alone is not the sole answer for the care of historic buildings. However, when major building repairs or restoration are required, the true value of regular, schedules preservation maintenance is seen.

Figure 3.1: Schematic diagram of the basic operations of the preservation maintenance system.

The preservation maintenance system is most effective when based on the best information and the continual updating of that information. Figure 3.1 is a schematic flow chart of how the system works. Information about the structures is collected, the initial step is a condition assessment of all the historic inventory. Additional information is fed into the system, particularly about non-historic features through a building inventory. The present museum and offices, Block 5 of the Salwa Palace, although primarily reconstructed, is considered an historic building and is treated as such. A condition assessment will identify the general conditions of the building systems. A building inventory of the structure will also identify non-historic features and items such as office equipment, mechanical equipment, plumbing and electrical systems – these need to be included in an overall building inventory in order to maintain all building features.

From the inventory, activities are planned and scheduled. The scheduling consists of (1) house keeping or janitorial activities; (2) routine activities; and (3) cyclic activities. Inspections are also scheduled but also take place on an unscheduled basic. In either case the information from the inspections is fed back into the inventory, it is updated and the scheduling of activities is modified as needed. The inspection also is used to update the condition documentation of the structure. From both the inspections and the inventory updating process an inventory of needed supplies and equipment can be developed for the execution of the work activities, whether janitorial, routine or cyclic.

3.2.1 Condition Assessment

The condition assessment is a comprehensive evaluation of a historic building’s physical condition; the condition assessment that preceded this manual (Crosby, 2007) was the initial condition assessment of the entire site and was a beginning. Additional research topics were recommended to continue to fill in the gaps and eventually result in a comprehensive understanding of the needs and requirements of all the features of the Atturaif Quarter.

For the purposes of the preservation maintenance system, particularly the scheduling of activities, the conditions can be updated incrementally through the inspections and a less comprehensive form of condition assessment. In this less comprehensive form structures are surveyed and assigned a condition ranking and an estimate of when a preservation activity will be needed. As an example, when early evidence of insect infestation is suggested, an estimate of when a reevaluation should be undertaken, or when an expert is needed, or when the application of an insecticide life is warranted can be scheduled. A condition-ranking scale (e.g., good, fair, poor) can be used to grade the physical condition of building materials, components, and systems.

A building condition assessment report is an essential tool for correctly planning activities in preventative maintenance, repair, and natural disasters planning. When the physical condition of a building’s materials, components and systems is known, these reports can be used to help assess the annual progress of the planned activities.
3.2.2 Building Inventory

The facility inventory is a compilation of all relevant information that assists in the planning of activities. It can grow into a considerable set of data. The results of all levels of inspections become part of this data base; the cost of supplies and equipment is also a part of the building inventory; cut sheets and samples of materials are also part of an effective database of information. Records of the effectiveness of previously scheduled activities also feed into and potentially upgrade the ability to make better decisions in the future. To be useful all of this information has to be accessible, easily accessible, or it is less than useless – it will simply occupy space and perhaps give the sense of an effective program.

Record and Sample Storage

Accessibility is the key to inventory information storage. Very often, critical information cannot be found or accessed-or when finally found, it is no longer in a usable condition. Records, documents, and samples should be organized and updated regularly in a central location. This storage space should be securely protected and environmentally controlled if possible. Some information may be valuable enough to justify strict control of its removal from the storage area. Legal documents should be kept in a secure place and copies should be made for maintenance uses. Copies of documentation that could be helpful to the overall preservation maintenance program should be readily available, such as all existing drawings and photo documentation.

There is often a fine line between the record inventory and the site archives. An on-site archive is important so that all site materials, such as material samples and earlier archeological reports and photo documentation are safely stored and available when necessary. The preservation maintenance inventory are those materials that will most directly assist in the site manager in scheduling activities and for meeting the overall needs of stewardship of the site.

3.2.3 Schedule Activities

Paper records, documents and other miscellaneous information can be stored in hardcover binders, filing cabinets or other protective devices. Some data can be stored at the point of repair for the specific building systems. This information needs to be protected from grease, dirt and moisture by a plastic laminate cover. The original document should be securely stored in the facility’s record-storage area.

Paint samples for matching colors should be made on high-quality paper, and the specific mixes and procedures for the painting are found in the details of the specifications. Paint samples on letter-size paper can be placed in notebooks as well. While digital prints, even on good quality are useful, they are not stable and the colors will change.

Storage space should also be provided for larger, more cumbersome materials and samples. Architectural drawings, if not stored in digital form should be stored flat in drawers or hung in a cabinet designed for that purpose. Fragile samples should be kept in individual acid-free containers with protective packing and clearly labeled for easy reference. Heavy samples such as samples of all the types of stone, soils and wood require storage space as well. The results of analysis of all of these materials are also part of the inventory. The inventory should also include record samples of all materials as part of an architectural material and features as a record collection.

The need for additional storage space should be acknowledged and planned for as the inventories grow.

Planning Work

Work is planned to the extent possible. Some work can be set up on specific schedules and carried out with little further evaluation as to the length of time between activities. A scheduled inspection is an example of one work activity that should be included on a
specific schedule. Normal janitorial work also normally comes under this category. Other work can be tentatively scheduled based upon anticipated performance periods, and then undertaken if necessary; the more complex and potentially more invasive work will fall into this category. However, even the more complex work needs to be anticipated to the greatest degree possible.

An important part of the planning is the development of specific instructions for each maintenance activity. Some of the activities will require extremely simple instructions and may consist only of a list of the equipment required to do the work. An example is the changing of a specific light bulb that requires a ladder for access. The instructions would include only a list of the equipment required, in this case a specific size ladder and the light bulb itself. Other work activities will require much more complex instructions such as for plastering a portion of the exterior wall where plaster has recently been removed or has delaminated.

Housekeeping

Housekeeping is the removal of undesirable or harmful deposits of debris, soil or dirt in a manner that does the least amount of harm to the surface being treated. It is repeated at short time intervals before litter and soil can build up, so that the removal can be done with the gentlest methods.

Routine Maintenance

Routine maintenance involves service activities like tightening, adjusting, lubricating, reattaching, repairing, rescaling, and securing. There are a number of routine maintenance activities that are to be performed as the need arises (i.e. as determined by inspections). The scope of these activities will vary greatly depending on the nature of the identified deficiency and the elapsed time between its appearance and correction.

The routine maintenance schedule will list a series of concerns to remind the inspector of the building features and systems that should be inspected and of the problems that may occur.

Cyclic Maintenance

Cyclic maintenance is preservation maintenance activities, which may occur with a somewhat predictable regularity. Cyclic maintenance work will often require skill levels, which exceed the basic staff capabilities of the owner and may require contracting for services or to augment the owner on a temporary basis to accomplish the undertaking.

Example of a Planning Worksheet

Following is an example of a planning worksheet for the different levels of activities that are necessary at a specific location at Atturaif and instructions for inspections. In this case the example is the present museum and office, Block 5 of the Salwa Palace. It was chosen for this example as it represents a range of activities in all three scheduling cycles.

The sample worksheet is not complete, but is intended to provide a clearer understanding of activities. Such a sheet should be prepared for every structure on the site.

The following is an example of instruction for inspections and the various aspects of maintenance, including housekeeping, routine and cyclic. The example is for a specific site, in this case the Block 5 of the Salwa Palace, the present museum and office, and similar instruction should be prepared for each structure or series of structures at Atturaif.

This example begins with inspection instructions, including inspection tools, and follows with items and maintenance issues for different levels of maintenance, including “housekeeping” or janitorial items; routine, which includes items for which attention is needed on a schedule of approximately every 6 months; and cyclic. The cyclic items are those which occur only every few years. For example, housekeeping items would be performed every day or so and would include such items as sweeping, dusting, cleaning of bathrooms and emptying trash. Routine maintenance would include such items as checking and replacing filters in air conditioners, checking all electrical lighting, cleaning drains, checking roof and removing debris, checking safety devices and equipment such as fire suppressors, hand rails, steps and stairs. Cyclic maintenance issues will include items that should require attention every few years such as painting and roof replacement.

The main point in setting up the different categories of maintenance is that they all can be scheduled and planned for. There is a cost, both in fiscal and human resources, associated with each of the activities and that cost can be anticipated. In addition, as the information is continually updated, the projected costs will become more accurate.

Subject: Salwa Palace Block 5, Museum and Office

INSPECTION INSTRUCTIONS

General: Comprehensive inspections should be scheduled each six months and will require approximately two to three hours for a two-person inspection crew to collect the data in handwritten form and to collect record photographs of the conditions during each inspection. The handwritten information will then be entered into a computer software system, which will include narrative and graphic information. Non-scheduled inspections should occur when staff is on a particular site for any reason and that information also entered into the permanent record.

Inspection Tools: Inspection tools and equipment should include at a minimum (1) digital camera; (2) measuring tape; (3) 1-meter long straight hand level; (4) thin metal probes approx 30-45 cm in length; (5) clip board with graph paper; (6) writing implements; (7) scale and directional arrow; (8) drawings and photographs to record information; and a ladder for access to ceilings and roof drainage.

Lord Cultural Resources 38

Lord Cultural Resources 39
Inspection Instructions

Begin inspection by walking around the building to get a general idea of the conditions before starting the specific inspection checklist.

1) Check for signs of visitor vandalism
   a) Ground disturbance, fresh soil
   b) Evidence of visitor’s wandering off designated areas
   c) Disturbed signage and visitor support fixtures
   d) Other?

2) Roof System
   a) Inspect roof drains and down spouts
   b) Check tops of parapet walls for cracks.
   c) Check integrity of roof flashing.
   d) Check for buildup of trash and debris on roof.
   e) Is there staining or other evidence of moisture on ceilings and beams?

3) Walls
   a) Check all exterior wall surfaces first for evidence of staining, delamination of plaster and structural cracks (If there is evidence, compare with previous conditions recorded during previous inspection.)
   b) Note specific crack patterns and compare interior wall surface and exterior for extent of cracks.
   c) Check for evidence of staining at the base of the walls
   d) Check for evidence of insects and rodents
   e) Check connections of beams at wall contact

4) Mechanical System
   a) Check date of last service.
   b) Check equipment filters
   c) Check for evidence of leaking oil or water.
   d) Are all connections tight and sound?

5) Grounds
   a) Is a positive slope maintained at juncture of walls and ground or paving?
   b) Check for evidence of rodents
   c) Check condition of landscape plants

Activity Categories

1) Housekeeping
   a) Clean floors – Scheduled each day
   b) Clean stairs and walks – Scheduled weekly
   c) Empty trash from general areas and offices – Scheduled each day
   d) Clean toilets – Scheduled each day
   e) Clean and dust interpretive displays – Scheduled weekly
   f) Replace bait in rodent traps – Scheduled weekly
   g) Check and replace if needed interpretive brochures – Scheduled bi-weekly
   h) Check and re-supply if necessary computer supplies – Scheduled weekly
   i) Clean roof drains – Scheduled seasonally but minimum of quarterly

2) Routine Maintenance
   a) Replace air filters – Scheduled 2 times each year (see manufacturer’s data sheet for make and model number.
   b) Apply insecticide on wood beams
   c) Caulk roof flashing – Scheduled annually
   d) Patch mud plaster at base of walls near entrance and entrance steps – Scheduled annually
   e) Trim and prune landscape plants
   f) Apply finishes to doors and windows – Scheduled every third year
   g) Inspect security system – Scheduled annually by outside contractor
   h) Comprehensive inspection – Scheduled annually

3) Cyclic Maintenance
   a) Replace roof drain filter – Scheduled once every 4th year
   b) Resurface roof – Scheduled on a 10-year cycle
   c) Replace roof – Scheduled on a 10-year cycle
   d) Replace toilets – Scheduled on a 10-year cycle
   e) Replace air handling equipment – Scheduled on a 10-year cycle

As is evident from this limited example there is a direct correlation between the inspection and the planned activities. It is also obviously that the results of the inspections have a direct bearing on what activities are planned and scheduled. It is also evident from this limited example that there will be a large amount of information that will soon become available in the building inventory.
3.2.4 Inspections

There are different types of inspections and while all of them are important, the most important is the routine inspection. The purpose of the routine inspection is to identify the basic conditions and related requirements necessary to keep a particular feature, element or system functioning. This would include the identification of a loose door latch or missing hinge pins, but would not include the need to change the filters of the air supply; that would be done on a regular schedule and would not be condition dependent. It would include the identification of friable plaster on an exterior wall, but would not note the lack of paper towels in the bathroom. It would include the vacuuming of the termite frass and the documentation of the presence or absence of frass in the future. It would include the condition of components of drainage systems and it would include a cursory identification of any loose wood shingles. A more comprehensive examination of the roof would be a planned effort. This more detailed type of inspection would be scheduled if a potential problem were identified in the routine inspection. A routine inspection would normally be undertaken approximately once each six months.

In addition to the routine inspection there are other types of inspections. One is in effect a non-structured inspection consisting of a simple way to note deficiencies when they are noted while going about one’s normal daily routine. If a piece of plaster or plaster dust is observed at the base of an interior wall, they should be noted. Similarly, the development of water stains or a discoloration of the plaster on the lower parts of the interior walls should be noted. On the opposite extreme, a detailed conservation inspection carried out by a conservator would be required for the few remaining examples of historic plaster. This same type inspection may also be generated by results of the routine inspection if a specific problem was identified that could not wait until the scheduled conservation inspection.

Inspection Guidelines

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Inspection and Diagnosis

Aggressive annual inspection programs help to identify signs of building problems. Inspection programs should be flexible, thorough and tailored to the installations they serve. Written inspection guidance should include detailed checklists that show users what, where, and how to inspect the structure or structures.

In addition to annual inspections, general surveys should be made, as necessary, especially after violent storms, large-facility use events, or changes in building use. This will help reveal damage early and prevent related failures to other materials.

Proper diagnosis of building problems is based on the identification of both the causes and the effects of the building or feature pathology. Identifying the causes is essential because, if not corrected, they will continue to deteriorate and accelerate the degradation of related historical building components of the historic structures. Such degradation will not only inflate future maintenance and repair costs, but may seriously diminish a structure’s historic character and other important values. Early detection and repair of failures will help preserve the historic nature of building components, avoiding their unnecessary deterioration and loss.

Further Evaluation

Often a decision to delay an activity is appropriate. One possible reason for delaying is to observe the building failure, for a time, to determine the specific causes and corrective actions needed. In this case, additional monitoring and another inspection before the next scheduled inspection are also activities that can be planned and scheduled. There is often, a fine line between delaying a repair activity and deferring preservation entirely. Care must be taken when making these decisions, as delay, for whatever the reason could result in great damage to irreplaceable historic building components, and possibly even endanger building occupants.

The inspection also identifies special considerations noted during a building evaluation. Such concerns might include excessive wear in public areas of the building or possible problems with fire exits.

3.3 RECORDING AND DOCUMENTING

As mention previously a maintenance program is intended to be dynamic and is expected to change. One of the most important aspects of that dynamic nature is that the results of inspections and work is recorded and documented to become part of the maintenance history of the structure.

The documentation can and will take on many forms. One form is that of the completed inspection checklists. Another form is photographic documentation of existing conditions at some particular point in time. Still another is a list of materials, the cost of those materials and the labor requirements and the time associated with a work activity. All of these are most important for more accurately planning maintenance activities for the future. By knowing the time and skills and materials a particular activity required, better
cost projections and scheduling can be done in the future, resulting in the more efficient expenditure of resources and the more effective preservation of the structure and the site.

3.3.1 Computer Applications

Computer Applications

Managing the repair and preservation of historic structures involves the management of large quantities of information. The amount of information increases yearly as new data generated over a building's operating life. For a heritage site comprising hundreds of structures, the situation can become overwhelming, as thousands of new pieces of information about the site's condition and maintenance can be generated in a single year. The ability to effectively maintain and analyze all this information directly affects the ability to manage maintenance activities at the site.

While it is certainly possible to use a manual filing system to manage large amounts of information, there comes a point when excessive amounts of information makes computer automation appealing. Perhaps the most important reason to automate a maintenance management program is to simplify database handling; that is, to make it easier to store, sort and retrieve information about a structure’s condition and maintenance history. As time goes by, new information is generated, which adds to this database. Eventually, the amount of data will be adequate to serve as a statistically significant basis for updating activity schedules, which will reduce the number of unplanned repairs.

An important feature of any computer application is its report generating capabilities. Flexibility is a desirable feature as it allows each installation to tailor reports to their particular needs. The capability to make historical comparisons is a necessity for the proper management of historic structures and sites.

Five areas are well suited for the application of automated systems:

1. Work order management
2. Work scheduling
3. Inventory control
4. Management of facilities inspection
5. Computer-based modeling

Work Order Management

Work orders are generated for the activities scheduled as the instructions to the person responsible for doing the work. Automated systems for work order and inventory control are well developed and readily available. More than 50 such systems are commercially available. Most can generate and track work orders, maintain and update parts inventories, schedule maintenance and produce a variety of reports.

Generally, work orders can be categorized under repairs, preventive maintenance, building layaway, or natural disaster planning. Most available work order management packages allow differentiation between types of work orders.

Work orders are usually quite similar, regardless of what kind they are. A work order normally identifies the location, describes the activity, asset, component or piece of equipment requiring service: specifies an expected completion date; assigns the task a priority; and specifies the craft or trade involved. Typically, a work order will note an estimated and actual work time, and the form has a place to record the materials and quantities used.

Each item on the work order constitutes a piece of information within a database; each piece of information can be entered into a computerized database system. When recorded in this format, the work orders can be tracked easily and statistically analyzed. For example, procedures, tools, and equipment needed for various jobs can be stored in the database as part of a library. Information from this library can be sorted to help create plans and projections of future resource requirements.

Work Scheduling

An automated system can be used to evaluate past maintenance records for forecasting future needs. The system could schedule labor and materials for pending work orders along with resources required. While it is inherently impossible to schedule emergency repairs, the disruptive impact of such work can be reduced through preparation based on trends in recorded historical needs.

Inventory Control

Because manufacturing facilities are the largest users of maintenance management software, most commercial computer applications are geared toward maintenance of machinery. However, an important component of maintenance management software is inventory control – capabilities designed for tracking the stock of equipment, spare parts, materials, and supplies – and there is no reason these capabilities cannot be adapted to tracking historic building inventories and many have.

Any computer system designed for tracking historic building inventories must have hardware and software capabilities for processing, storing, and retrieving large amounts of information. Data to be stored and reused includes facility component location, age, and remaining useful life. Managers must also make sure that any software used for tracking historic facility inventories is compatible with other software systems already in use on the installation.

Computer-Based Modeling

Predicting long-term facility renewal and replacement costs is very difficult. Even more difficult is quantifying the impact of deferred maintenance. Both tasks depend on
uncertain estimates of the service lives of dozens of building components, as well as a substantial amount of “educated guesswork” about the interaction between components and such factors as extent of use, weather conditions, and environmental pollutants, level of maintenance, workmanship, and so forth. While deferred maintenance almost always results in some form of premature failure, predicting the exact nature and timing of that failure is virtually impossible.

Currently there are limited commercially available computer applications specifically developed to model future maintenance or renewal costs for historic building components. However, there are some applications that address such resources as building components, roofs, paint, pavements, and bridges. These systems were designed to enable personnel to be more proactive in planning and prioritizing installation maintenance. While none of these systems was designed specifically for historic facilities, advances are being made and some can be used as tools in a proactive historic maintenance program. It should be noted, however, that successful application would require input on estimated building component life cycles and estimated future replacement costs.

3.4 TRAINING

3.4.1 Introduction

Training is an important aspect of every conservation program and it is critical that an active training program be part of the program at Atturaif. Training takes on many forms and all forms are important. In the most general sense training consists of formal training and on-the-job training and all the staff, present and future should be involved in both aspects.

There are various disciplines that should be included in a training program including architecture, conservation architecture, archeology, history, architectural history, engineering and various crafts such as stone masonry, painting, plastering, mud brick masonry, and carpentry. While there are currently professionals in each of these disciplines, specialized training to meet the conservation needs at Atturaif will be necessary. The training of personnel representing all of these disciplines should be undertaken as interdisciplinary, as all disciplines will have to work collaboratively to accomplish all aspects involving the protection of the site. In addition to these disciplines, interpreters and managers should also participate in an appropriate amount of the training for the site conservation disciplines. It will also be important to include typically non-cultural skills and crafts in some of the training program, such as plumbers, electricians, roofer, and mechanics. They will also often have responsibilities that have a direct effect on the values of the Atturaif buildings.

Although a great deal of the training should be across disciplines, some will logically be most effective as discipline-specific training. An example of this specific training is the conservation of archeological artifacts, for which the archeologist and archeological conservator would be responsible and for whom the specific training would be the most meaningful.

The following comments and examples emphasize the discipline of architectural conservation, although many of the subjects apply to the other disciplines as well. This focus is appropriate as the purpose of this manual and the condition assessment that preceded it is the conservation of Atturaif. It is also assumed that a professional architect, with specific training in architectural conservation would be the lead in developing the conservation program at Atturaif.

3.4.2 Architectural Conservation

“Architectural conservation” is the science of preserving architecture and its historic fabric. It is the scientific approach to observing and analyzing the evolution, deterioration and care of buildings the conducting of investigations to determine the cause, effect and solution of building problems; and the directing of remedial interventions focused on maintaining the integrity and quality of the existing historic fabric. It is the technical means through which the whole spectrum of preservation treatments can be ultimately accomplished (that is, restoration, rehabilitation, adaptive use, stabilization and maintenance).

The “architectural conservator” represents a multifaceted profession which has evolved from the merging of special architectural and scientific skills, required in preserving cultural resources. The architectural conservator is both a generalist who preserves for the future those unique qualities of the past found in today’s built environment, and a specialist, or building pathologist, charged with the examination, diagnosis and treatment of buildings injured by accretion or neglect. The architectural conservator is a professional who must combine the perspective of an architectural historian with the overall approach of an architect and the scientific focus of a conservator.

Guidelines for Training of an Architectural Conservator

The following guidelines are not offered as a definitive list of requirements and training which should be rigidly adhered to, but rather as a basis from which the philosophical approach and scope of a training program and its subject matter in architectural conservation could be developed. It should be noted that any training developed from these guidelines will be most effective if the trainees have a basic professional background and experience in architecture. No professional discipline should be restricted from the specific training for the architectural conservator, but additional knowledge in the architectural profession will require additional training, most likely additional course work from an accredited university or program in conservation. The following training guidelines focus on six aspects of a training program: goals, methodology, the degree, scope, curriculum and intensity.
Goals

Every training program should be guided by its own well-defined goals, and periodically each goal should be critically assessed, both internally and by outside observers. Whatever the details of a training program in architectural conservation, it should instill the following: (1) an understanding of the design, construction, history, deterioration, and care of the built environment; and (2) the skills of observation, analysis, research, and treatment necessary for the solution of conservation problems.

Methodology

The combination of classroom and field practice provides a training experience which cannot be met individually. The classroom provides an atmosphere in which a trainee may learn through discussion and research and may creatively experiment under the guidance of more experienced professionals, with the help of well-equipped facilities. Field practice, on the other hand, provides an atmosphere of real problems combined with daily routine and administration; contact with clients, professionals, and craftsmen; the necessity for quick, accurate decisions; and applications of technology. To achieve the best of what both have to offer, this training program should (1) organize frequent field projects with other site staff; (2) bring outside conservation practitioners in the field to a classroom setting; and (3) support outside experience practical work experiences.

Within a training program, there should be diversity of both content and approach. Courses and training opportunities should (1) emphasize active participation; (2) be oriented to project/problem solutions; (3) utilize to the fullest interdepartmental consultants, facilities, and resources; and (4) apply a variety of teaching methods.

Scope

A training program in architectural conservation should strike a balance among three elements: science, architecture, and history. Such a program should strive to instill in the participants a combined outlook and expertise that the study of these diverse areas affords. For example, when considering a building material such as wood, the architectural conservator should be able to view it in terms of the mechanisms of its physical and chemical deterioration, as a scientist, would; in terms of how it is properly employed as a building component, as an architect would; and how it has worked traditionally, as a historian would.

The synthesis of these areas of technical expertise and knowledge should form the basis for the scope of any training program in architectural conservation. For that program to be comprehensive it should encompass the following subject areas: (1) general theory and practice, (2) conservation sciences, (3) architectural analysis, (4) multidisciplinary teamwork in preservation, and (5) history of design and construction.

Additional Training

Each of the disciplines represented on the Atturaif staff should be fully trained and fully competent in their profession or craft skill. Additional training should be directed to more specific knowledge and skills in the specific requirements for the future protection of Atturaif. Examples of additional training are (1) historic woodworking and decorative painting; (2) 19th century plastering techniques; (3) historic mud brick and stone masonry; (4) historic roof systems; (5) contemporary roof systems; (6) preventive maintenance systems; (7) disaster planning and response; (8) effective record keeping; (9) material analysis; (10) building systems pathology; and (11) team building. Additional training subjects could be in (1) in-situ conservation of archeological artifacts; (2) historic engineering principles and effectiveness; (3) architectural evolution at Atturaif; (4) shoring and bracing; (5) erection and maintenance of scaffolding; and (6) conservation philosophy. This is not mean to be a comprehensive list of a course curriculum, but rather just examples of what subjects might be developed.

In addition short courses, a few hours in duration could be provided in such subjects as (1) effective inspections and documentation; (2) recording and measuring; (3) principles of engineering for the mason; and (4) historic building principles for the archeologist.

3.4.3 Course Outline in Mud Brick Conservation

The following course outline can be developed for as little as two days, or for as long as two weeks. Other specialized course are available internationally at the International Center for Earth Construction (CRATerre - www.archi.fr/RECHERCHE/annuaire/pdf/Craterre.pdf); The International Center for the Study of the Preservation and Restoration of Cultural Property (ICCROM - www.iccrom.org) and many special programs at universities and special conferences and symposium around the world.

- **Earth architecture, use/ history.** Review of the different types of earth construction around the world and the different construction systems. Slide show presentation will show examples from North America, South America, Central America, Europe, Africa, the Middle East and China. The history of use will be discussed, including contemporary use.
- **Failure Patterns; The material and system pathologies.** This session will begin with looking at mud brick samples that have been subjected to water in order to study the effects of capillary moisture and surface rusting. Lecture will discuss the decay mechanisms associated with mud brick building systems, emphasizing the cause and effect relationships of deterioration. Visual presentation will examine specific failure types and several case studies will be reviewed. This session will end with a review of an actual mud brick structure looking at material and system conditions.
- **Examination of structural deformation and failure.** A series of small mud brick walls will be constructed of dry-laid masonry and stressed to deformation.
and then failure. The purpose of this exercise is to develop a better understanding of failure patterns and their causes.

- **Material characteristics.** A brief lecture of the physical, mechanical and physical properties will be followed by a class exercise of looking at different soil types, blending the types and making “mud pies”. Testing procedures will be discussed, but emphasis will be on field-testing to select the proper soil for repairs. A lab exercise will be conducted using small pre-manufactured mud brick columns to look at the process and the effect of capillary moisture. Class will proceed to a site and go through the process of making mud bricks; monolithic earth walls using different parameters of soil types, mixing techniques, water contents.

- **Condition recording.** Examples of survey and condition recording project will be examined and discussed from the most sophisticated to the most basic. Tools will be described from the elaborate to the basic and a basic “kit” will be discussed. The relationship of condition recording and assessment will be discussed. Group will then be divided into 4-6 person teams to conduct their own condition recording and assessment. The team exercise will be conducted on an historic earth building that is to be repaired later during the class. Each team will develop a presentation and present to the rest of the class.

- **Mud brick construction and monolithic earth construction.** A small mud brick wall will be constructed as well as a small wall of monolithic earth construction. Each person will participate in each construction type. Adequate supplies of mud, adobes and basic tools will be on hand for use. A field discussion of building codes will be discussed.

- **Repair of historic mud brick building.** The entire day will be utilized to identify appropriate repair treatments for at least two different problems and enough problem areas will be examined so that the class can be divided into work groups of about four people. Work will be stopped when necessary for detailed discussions. Discussion of issues will be encouraged throughout the field exercise.

- **Class Summary and Review.** A brief review with emphasis on class discussion and input will bring closure to the training session.

### 3.4.4 Summary

The present and future conservation needs at Atturaif can best be met by local development of the necessary expertise and skills. Creating staff positions and providing training, education, and opportunities for hands on conservation treatment would be critical first steps. Additional invaluable training would result from working on the structures at Atturaif during the initial stabilization and conservation treatments. The development of skills would not be limited to treatments and interventions, but equally important would be in the development of expertise in the analysis and interpretation of conditions that require intervention. Such a team would probably consist of skilled journey level carpenters and masons, archeologists, architects, engineers and conservators. In addition to the responsibility of the site conservation work, members of the conservation staff should participate actively in training and interpretation.

### 3.5 Natural Disaster Planning

Natural and man-generated disasters present an enormous ongoing risk to historic structures and archeological sites and their contents. However, disaster planning can reduce the disaster’s destructiveness and aftermath on these heritage resources. When a disaster occurs, preparation can pay off in saved lives and reduced building vulnerability. Planning ahead also helps to reduce repair expenses and minimize recovery time.

Disaster planning for historic facilities must consider damage mitigation to the building and its equipment. Although the relative rarity of natural disasters may make disaster planning seem less than a top priority, the opposite is actually true.

#### Preliminary Assessment Questions

In creating disaster preparedness plan the following questions must first be answered:

- What kinds of disasters are possible and most likely in the given location?
- Whose input is needed to develop a disaster readiness plan?
- How can the plan be communicated effectively to all participants?
- Who governs policy? Who sets a plan in motion? Who is second in command?
- How should resources, people, and supplies be organized?
- What are the most important things to save?

#### 3.5.1 Planning Process

The following systematic planning process for natural disaster preparedness plans is adapted from Chapter 10 of the National Park Service Museum Handbook, Part I (NPS, September 1990).

- **Assign responsibility for planning.**
  A chief executive or director can be the disaster coordinator. It is more effective however, to appoint a staff person to prepare the plan because of familiarity with everyday procedures, and because the staff will ultimately be responsible for implementing the plan.

- **Gather planning tools.**
  Information can be gathered from local and national disaster agencies. Model disaster plans of similar installations, organizations, and cities should also be collected.
Contact local protection agencies.
Disaster coordinators should contact police, fire, and emergency agencies to let them know about potential needs in an emergency, and also to determine the extent to which agencies will be able to respond when faced with a large disaster.

Identify hazards and threats.
Hazards should be systematically identified and analyzed (using CA report and HBI information) to determine which ones may be threats, and to assess damage risks. Priorities for dealing with all hazards and threats should be set.

Identify and set priorities for historic resources.
Historic resources should be surveyed and inventoried. If a PMP is already in place, the HBI and CA report can be integrated into the natural disaster plan. From this information, resources can be prioritized. Prioritization focuses attention on the most vital resources as a disaster develops- and especially afterward.

Formulate protection methods.
Actions to prevent complete losses, to reduce others, and generally prepare for a response during an emergency should be developed. These actions can be included with preventative maintenance objectives. This step also includes setting priorities for recovery and determining what outside resources and supplies will be needed to cope with the disaster.

Plan for command and control.
A disaster plan will change an institution’s priorities and methods, but not its organizational structure. Preparations should be made to go into an emergency operations mode using the existing structure and chain of command. The emphasis should be on flexibility, innovation, and streamlined operations. Examples of this could be the designation of an alternate emergency worksite (a construction staging, a temporary shop, a place to store tools and materials, etc.) Plan how to organize and work with volunteers, who will show up to help after a disaster.

Write the plan
The characteristics of a well-written disaster plan include flexibility, simplicity, and adaptability. Identify emergency priorities, needed resources, and sources of assistance.

Train staff how to use the plan.
Training helps to ensure that personnel will act automatically in an emergency rather than waste time trying to figure out what they should do. It helps each person become familiar with his or her responsibilities so duties can be handled without confusion or panic when a disaster strikes.

Test the plan
The first test should be made while the written plan is still in draft. After the plan is adopted, periodic drills will indicate if it functions as intended. Whenever a test reveals deficiencies, the plan should be revised.

Evaluate the plan
If a disaster strikes, analyze how well the plan worked. Assess its components and the performance of all participants with written records and photographs. Solicit opinions from everyone involved through interviews and meetings.

Keep the plan current.
The disaster plan should be reviewed regularly – every three to six months and never less than once a year. Carefully record amendments by noting the dates of changes, the nature of change, and the pages of the plan affected. Maintain a list of plan holders to notify as changes are made. It is essential to keep names and telephone numbers current and to ensure that new staff members are included in preparations. Review the plan with emergency management officials, and make sure they have a copy. Ask to be included in installation emergency exercises.
PART 4: CONSERVATION SPECIFICATION

4.1 introduction to specifications

The specifications that follow are considered as dynamic as they should and will change as they are applied to the actual conservation work at the Atturaif Quarter. They are an important part of this manual, which itself is equally dynamic. The fourteen sections that currently compose the specification for conservation have been developed for the conditions and the conservation issues at Atturaif, but they are not specific to any specific structure or feature of a structure. They represent sound conservation principles that emphasize the protection of the existing character and values of the historic center with minimal intervention. The approaches are also valid when more extensive interventions are required.

The specifications are composed of fourteen sections, two of which are developed for archeological conservation and the protection of features and structures primarily during archeological activities. These are sections 04296 Protective Shoring and Bracing and 04297 Sand bag Protection. Eleven of the other sections are primarily for mud brick conservation issues, but some of them are written to include stone masonry as well. One section is specifically for stone masonry and has a different section number, Section 04500 Stone masonry.

Illustrations in these specifications are intended to provide a general understanding of the conditions and the conservation work. The work illustrated is based on sound conservation principles and the success of these approaches at other sites and monuments around the world. This version of the specifications also utilizes many photographs and images from Atturaif as well as other sites where activities have been undertaken. As this September 2007 edition of the specifications will be revised in the future, the general conservation principles will not be changed – the respect for the important values of the Atturaif Historic Quarter will not be compromised.
MUD BRICK CONSERVATION
SEPTEMBER 2007

PART 1 GENERAL

1.1 DESCRIPTION: The work of this section includes the general stabilization and conservation approach of the mud brick structures at Atturaif. It includes the general conditions, the project sequencing, the project tools and equipment, the materials needs, as well as examples of the general approaches, detailed in other sections.

A. Mobilization: The area for mobilization for specific components of the conservation project and for the storage for all materials and equipment that is located at the site shall be designated by the owner’s representative.

B. Security: The mobilization area and the specific work areas at Atturaif shall be secured at all times, 24 hrs a day and every day during the life of the project. The methodology shall be approved by the owner’s representative.

C. Safety: Proper safety precautions are necessary prior to the beginning of all conservation work. Scaffolding shall be erected according to the Occupational Safety and Health Administration, Department of Labor (OSHA) Standard 3124, “Stairways and Ladders”, and 3150, “Scaffold Use in Construction Industry”, or the national equivalent. Tools shall be properly stored and used, first aid kits shall be available, and other safety measures shall be put in place to ensure a safe working environment.

D. Materials and Equipment: The mud bricks and the soils are described in detail here and the other materials are listed with their approximate quantities. Following the listing of the materials is a list of the tools and equipment that will be required for the work.

1.2 CONSERVATION APPROACH

For the purposes of this document, the overall approach to the conservation of the structures at Atturaif is to protect the existing form, fabric, and character of the mud brick structures, and their relationship to its immediate surroundings while reestablishing structural integrity and providing the basic conditions that can be protected into the future by an active and ongoing preventative conservation maintenance program. In addition, the structures and the site are particularly important and valued for the research potential.

The site mud brick structures have undergone many changes over the past ca 200 years, and their present condition and character reflect those changes. The important character to protect is represented by the series of images that are at the end of this Section 04200 (Figures 1 – 4). The most important character is the overall color, textures and the overall building geometry. The general character of the site and a very important character-defining feature is the general relationship of the natural landscape and landforms built environment. The conservation
interventions have and will continue to reflect the significance of this character. Other important character-defining features are the different renders and masonry coursing, and the comparison of stone masonry. The character defining features and are more clearly defined in the project Condition Assessment.

1.3 PROJECT SCHEDULE (SEQUENCING)

A. General Project Sequencing: Installation of Bracing, Shoring and Buttressing

Prior to any site conservation or work on the site infrastructure, the most vulnerable walls (normally those in poor condition, or with a slenderness ration of greater than 6:1) additional shoring and bracing should be fabricated and installed following a structural analysis identifying those areas and structures most at risk. San bags should be stock piles on the site to use for bracing of lower walls and to form temporary buttresses as needed. The priority consideration for conserving these structures is to first ensure that all the wall bases are structurally sound and that the workers will be safe while on site.

Much like the emergency stabilization, the stabilization phase is emphasizing the repair of the lower portion of the walls, the “free – standing” walls (those without well attached intersecting walls and corners) the exposed ends of walls, voids in the mud brick mass and the tops of the walls. Interventions not for conservation purposes shall not be part of this phase of this conservation project.

Prior to any archeological investigations or similar work or studies that occur within 5 meters of the tall mud brick walls, a thorough investigation of the subject walls shall take place. This investigation shall be for the purpose of identifying all potential safety conditions and mitigating those conditions. No work shall proceed prior to this investigation and resulting mitigation. This is in-addition-to and not in-place-of the installation of appropriate bracing and shoring.

B. Conservation Intervention

1. Install bracing and shoring as needed.

2. Undertake emergency stabilization of the Sabala prior to determination of final treatment, either preservation or restoration.

3. Repair lower walls of decay, basal erosion voids, animal intrusions on the walls that have been identified as the most vulnerable

4. Install shoring and bracing in the rooms and structures reoccupied during the 20th century. In some areas, it may be appropriate to remove the existing roof systems rather than brace and repair them.

5. Restore the major wall cracks of the tall walls with the priority in the Salwa Palace complex, particularly Blocks three and four. After the first priorities repair wall cracks based on their structural priority, but including the west walls of the Abdallah Palace and the important character defining walls in the north area of Abdallah Palace.

6. Stabilize the structures in the archeological zone identified for preservation in the Condition Assessment.

7. Stabilize the tops of all the walls, interior and exterior walls, with the addition of a sacrificial cap where determined necessary.

8. Reattach historic plasters on the Salwa Palace areas as well as the original plastered capitals and columns in the Thinayyan Palace.

9. Repair and fill all minor holes in the walls, including in some cases, open masonry joints. This will discourage animal activity.

1.4 RELATED WORK

A. SECTION 04210 – MUD BRICK MANUFACTURE

B. SECTION 04220 – SURFACE RENDERING

C. SECTION 04230 – CRACK REPAIR

D. SECTION 04235 – PLASTER STABILIZATION

E. SECTION 04240 – MUD GROUTING

F. SECTION 04250 – MUD BRICK CONSTRUCTION

G. SECTION 04253 – MECHANICAL TIES

H. SECTION 04260 – WALL BASE REPAIR

I. SECTION 04270 – VOID AND HOLE REPAIR

J. SECTION 04280 – MUD BRICK CAPPING

K. SECTION 04296 – PROTECTIVE SHORING AND BRACING

L. SECTION 04297 – SAND BAG PROTECTION

1.5 SUBMITTALS

A. No mud brick conservation work shall begin until mud bricks and soil are approved.
1.6 QUALITY ASSURANCE

A. All preparation and conservation work shall conform to the highest international standards for conservation interventions. Techniques developed for conservation and restoration shall be employed to protect the fabric and form of the structure.

B. Do not change basic materials and equipment including scaffolding, mud bricks and soil during the course of the work, without approval.

C. The specific conservation site decisions shall be the responsibility of the owner’s representative, who shall have specific training and experience in the field of mud brick conservation and shall rely on the project conservation architectural consolidants and other expertise in making decisions.

D. The progress and the details of the interventions specified here shall be thoroughly documented, and the records resulting from that documentation added to subsequent project report submissions. A documentation plan shall be approved by the owner’s representative prior to the beginning of the work. In addition to the conservation interventions, the plan shall include the documentation of architectural and archeological features that are uncovered during the conservation work.

E. Scaffolding, ladders or working platforms required for executing this work shall not be attached directly to the structure unless specifically approved. Scaffolding legs shall have steel plate feet, fixed or adjustable as needed, and each foot shall be supported on one or more layers of continuous, high quality wood planking to distribute load after the ground surface is leveled. Scaffolding shall be approved by the owner’s representative.

F. The basic approaches developed for all interventions shall not be approval by the owner’s representative.

G. Product Handling: Store cement and lime in safe dry condition. All materials, including soil, sand and mud bricks are to be are to be kept clean and dry and protected from insects and animals. All water shall be kept clean and potable.

1.7 ENVIRONMENTAL CONDITIONS

A. Wet Weather: Do not mix mortar nor repair tops of walls during rain. Protect holes in tops of walls and cracks during rain.

B. Cold Weather: Do not repair or construct at temperatures less than 5 degrees Celsius, or if temperatures are expected to be less than 0 degrees Celsius within 24 hours.

C. Hot weather: If temperatures are above 40 degrees Celsius, or the wind speed is greater than 7 meters/second, protect rendered surfaces and fresh mortar from rapid drying by shading and misting. Continue to test surfaces and mortar during the drying process and treat as needed.

1.8 TEST PANELS (MOCK UPS)

A. The crew, under direction of the owner’s representative, shall prepare “test panels” for each of the conditions of conservation intervention outlined in these specification sections.

B. All work including test panels shall be reviewed and approved by the owner’s representative prior to continuation of the conservation work.

C. The approved test panels and previous work shall be considered a part of the finished work and shall serve as a standard for the remaining work performed under that specification. All test panels shall be adequately documented and identified.

PART 2 PRODUCTS

2.1 MATERIALS

A. Mud Bricks: Mud bricks shall be made to replicate the dimensions in the specific areas or repair. The sizes of the mud bricks vary somewhat from structure to structure, although there are relative standard sizes. Each new mud brick should be stamped while moist with the project identification stamp, which is to be determined. One suggestion would be “AT07”, representing “Atturaif” and the date. The stamp should be in Arabic. An example is presented in this specification section for another project as Figure 5. In this case each mud brick is stamped “PYIFA”- representing the Universities of Pennsylvania and Yale and the Institute of Fine Arts, NY University. Also see Sec 4210. Color shall match the existing mud bricks as much as possible. The amount of clay for the mud bricks shall be similar to the original, but not exceeding 25% in any case. In most cases the clay content will be less. The material shall be continually evaluated and changes made in the manufacturing as appropriate. The aggregate in the mud shall not exceed 1 cm.

B. A supply of mud bricks and mud brickbats for repair shall be kept on hand. The required number of mud bricks shall be prepared beforehand, allowing adequate time for curing. The mud brickbats shall be collected from the normal breakage of the mud bricks when in use.

C. Store mud bricks by stacking after air died to continue the drying process.

D. Mud for Mortar and Mud Bricks:
1. Soil for mud mortar should have a low clay content, ca. 10% by weight, and fine sand and silt and shall be from the same source as the new mud bricks. The mortar will be continually evaluated during use and adjustments made as needed.

2. All soils and mud bricks shall not have organic material in the form of vegetation or decayed vegetable or animal material. It shall be free of alkali, acids, or oils.

E. Water: Potable, free from injurious amounts of oil, soluble salts, alkali, and acids, organic impurities and other deleterious materials, which might impair strength.

F. Other Materials: Following is a general list of materials and initial quantities needed for the conservation work at Atturaif, inclusive of those, the mud bricks and soil and water, already mentioned in more detail above.

The delivery and storage of these materials shall be coordinated with the project superintendent and shall be adjusted as necessary.

1. Mud bricks – 50,000 (9x13x27 cm)
2. Mud brick soil (for mortar) – 75 meters
3. Clay rich soil – 15 meters
4. Lime (Calcium hydroxide) – 2 bags (.02 meters)
5. String (heavy-150 meters) – 20 rolls
6. Construction tape – 500 feet (1500 m.)
7. Fence stakes (for construction tape) – 250
8. Flagging pins – 250
9. Plywood sheets (4x8x 5/8” – equivalent metric) – 10
10. HDPE (high density polyethylene) bars (1/4"; 6-8mm) (to be cut in short lengths to attach Tensar Geogrid material across cracks) – 100 meters
12. Lubricating oil & oiler – 5
13. Sand bags – Produced on site as needed
14. Tensar Earth Technologies Biaxial Geogrid (3 x 30 meters roll for horizontal reinforcement).
15. Lumber (2x4s; 2x6s; 2x8s; 1x6s) – 1000 board feet
16. Lumber (random sized pieces 1 meter long) – 100 board feet
17. Nails (steel, common) – 10 kilos of 4" (10 cm); 5 kilos of 3" (7-8 cm)

2.2 TOOLS AND EQUIPMENT:

A. Tools and Equipment: The following is based on approximately 3 conservation crews. Common tools and equipment are listed separately and they are to be used as needed by each of the crews. There is also a separate list of tools and equipment that will be set up for each of the crews and will be kept separate from the common tools and are the responsibility of each of the crews.

B. Water – Water to be available in combination of containers and by water hoses from the Dig House.

C. Common Tools and Equipment

1. Steel pry bars (1.5 meters long) – 2
2. Small steel pry bars; ca. 24"X1/2" (look like large screwdrivers and used for raking out deep mortar joints) - 5
3. Cleaning water (separate ca. 150 l.) – 1
4. Hack saw – 2
5. Hack saw blades – 2 sets
6. Set of hand tools (Vice-grips – curved jaw 175mm & 250mm; 6” slip joint pliers, 10” groove joint pliers; 18, 19 mm crescent wrenches for scaffolding; 175mm cutting pliers; 4” & 6” flat-point screwdrivers; 7 mm wrenches for mechanical ties) – 1 of each
7. Tool bag (small canvas; ca. 14”X19”) - 1
8. Ratchet Tie downs (4.9 meters; 1361kg capacity) - 2
9. Mortar pans; available supplies – 5
10. Grout Bags - 3
11. Plastic hoses for grouting; (ca. 38 mm) – 75 meters
12. Wheel barrow (large) – 15
13. Shovels or hoes - 5
14. Hydraulic jacks (5-ton) – 1
15. Chisels (masonry; ca. 2 ½ inch wide flat blade; all steel) (used for cutting mud brick and cutting out mortar joints – 5
16. Flat steel bars (ca. 1/4 X 1 inch and ca. 30 cm long with one pointed end) - 10
17. Ladders (wood; ca. 3-4 meters) – 5
18. Ladders (extension-13 meters) – 1
19. Measuring tapes (10 meter) – 3
20. Hand saw – 1
21. Framing square – 1
22. Nylon cord, 1/4” (6 mm) for tarp grommets – 150 meters
23. Sledge hammers (large – 5 kilo) – 2
24. Duct tape – 2
25. Bailing wire – 20 meters
26. Water containers; 15-20 liters (drinking) – 2
27. Plastic or metal container with air tight lid (100-130 liters) for lime mixing and storage – 1
28. Masonry drills (brace and bit - 25-30 cm x 12-15 mm diameter) – 3
29. Brace and bit (manual brace for drilling holes in mass mud brick)
30. Water drums (ca. 150 liters; either steel or plastic) – 1
31. Rope (ca. 10-15mm hemp-50 feet) – 2
32. Sledge hammers (hand, 3 #) – 1
33. Grout Pan – 1
34. Grout nozzles – 2
35. Rubber Plunger (toilet bowl type) – 2
36. Levels (1-meter bubble) – 2
37. Eye goggles – 5.
38. Nail hammers (medium weight ca. 20 oz.) – 2
39. Plumb bob – 1
40. Portable generator
41. Electric Hammer drill – medium size
42. Earth anchors – medium and small sizes (attaching geogrid to mass masonry).

D. Conservation Crew Tools; Each of the 3 crews shall have the following:

1. Hand Pump Tank Sprayer – 2
2. Plastic Water Container (ca. 20 liters) – 1
3. Pointing trowels (6 ¾ X ½ inch; 6 ¾ X ½ inch) – 2 of each
4. Steel bristle brushes – 1
5. Small masons trowels (pointed – 8 X 4 inch) – 4
6. Large masons trowels (pointed 11X5 inch) – 2
7. Masons line – no. 18 yellow nylon (from USA) – 500 ft. rolls – 1
8. Small trowels (6 X 2 ½ inch pointed; 5 X 2 inch square) – 5 of each
9. Brooms, whisk – 3
10. Mason’s hammer, pointed – 3
11. Wide bristle brushes (organic fiber) – 3
12. Buckets (for water and mortar; 7 ½ - 10 liters) – 4
13. Dust masks – 6
14. Gloves, cotton work – 4
15. Hardhats – 5
16. Measuring tapes (2 meter) – 1

E. Other tools and equipment may be substituted for the above, depending on availability and local uses.

PART 3 EXECUTION

3.1 GENERAL

The execution of all site work shall be consistent with the specific materials and details for each of the conservation interventions in the sections of these specifications. The work for each of the specific work elements shall be consistent with the general work ethics and philosophy for the overall conservation of the site found in this Section 04200 and throughout this document. Any apparent conflicts shall be resolved by all parties, with the final decision the responsibility of the owner’s representative.

3.2 CREW SIZE

The basic conservation crew consists of approximately 7 to 8 people and will be adjusted for the individual tasks at hand. This does not include the preparation and transport of mortar and mud bricks to the specific work areas. The crew for preparation of mortar consists of approximately 8 members. A professional architectural conservator with at least one, locally trained mason and 1 to 3 local assistants to prepare and supply materials shall initially direct the team. Promising assistants should be encouraged to develop their skills and sensitivities under careful supervision. Highly experienced assistants should be promoted to lead their own teams. It is believed that after careful training, a single professional architectural conservator could supervise the actions of 2 to 3 teams, depending on the complexity of the tasks and the ability of the workmen to be self-motivated and conscientious.

No conservation work should be carried out without professional supervision.

The logistics of the project indicate that a total of 3 conservation teams could be efficiently employed under the supervision of a professional architectural conservator. This assumes that all workmen are properly trained and experienced and that all necessary tools and supplies are on hand at the site.

The rate at which the work is carried out will depend directly on the number of experienced and supervised workmen available on site.

3.3 SITE SAFETY

Proper safety precautions are necessary prior to the beginning of the actual repair. Scaffolding shall be erected and secured where access to repair area by scaffolding is required. Protection from falling debris shall also be in place prior to work. No visitors or others not part of the conservation team shall approach to within 20 meters of the work areas. All workmen shall have appropriate eye, head, foot and hand protection equipment.

PART 4 REPRESENTATIVE IMAGES OF SITE CHARACTER AND GENERAL CONSERVATION APPROACH.

4.1 SITE AND STRUCTURE CHARACTER THAT IS TO BE PROTECTED

The general characteristics reflected in Figures 1 through 4 are examples of those characteristics of the site and the site structures that are to be protected. The important characteristics are identified in Part 1.2 of this section.
Figure 1: Earthen architecture with a variety of textures. The walls range from ca. 1800 to ca. 1960. Photograph March 2007.

Figure 2: A complex pattern of wall ventilators in the Abdallah Palace that is an important characteristic of palace architecture.

Figure 3: Typical texture of one of the mud brick wall types.

Figure 4: The character of the coursing pattern of the mud bricks and stone and the general geometry of the ruins are other characteristics that shall be protected during the conservation interventions.
PART 5 REFERENCES


MUD BRICK MANUFACTURING
SEPTEMBER 2007
Atturaif Quarter, Dirriyah, Saudi Arabia Conservation Specifications
SECTION 04210 MUD BRICK MANUFACTURE

PART 1 GENERAL

1.1 DESCRIPTION: The work of this section includes the manufacturing of the mud bricks to be used for the conservation work at Atturaif. Section 04200 provides the overall conservation guidance and this as well as the remaining sections provide the detail for specific conservation interventions.

A. Mobilization: The mud bricks shall be manufactured off site at the discretion of the contractor or project supervisor as approved by the owner’s representative. The mud bricks shall be delivered to the site and stored as indicated in this section in the location approved by the owner’s representative, in conjunction with the Conservation Architect.

B. Materials and Equipment: The selection of the appropriate soil for the manufacturing of the mud bricks is described in Section 04200, PART 2, 2.1 MATERIALS.

1.2 RELATED WORK

A. SECTION 04200 – MUD BRICK CONSERVATION
B. SECTION 04240 – MUD GROUTING
C. SECTION 04250 – MUD BRICK CONSTRUCTION
D. SECTION 04260 – WALL BASE VOID REPAIR
E. SECTION 04270 – VOID AND HOLE REPAIR
F. SECTION 04280 – MUD BRICK CAPPING

1.3 SUBMITTALS

A. Submit sample of soil to be used for the mud bricks to the owner’s representative prior to manufacturing.

B. Mud brick samples shall be selected and evaluated for compliance with these specifications at the discretion of the owner’s representative during the manufacturing process.

1.4 QUALITY ASSURANCE

A. See Section 04200 Part 1, 1.6 for the general requirements of the conservation project and the specific requirements related to the selection of materials and the handling of the materials for the manufacturing of the mud bricks.

B. Materials and mud bricks shall be consistent in quality and material used.

C. Cracks in mud bricks shall be restricted to surface cracks and shall not be deeper than 1 cm beneath the surface.

D. Breakage shall not exceed 10% of total of the mud bricks delivered to the site.

E. If soil source changes test soil mix by making series of mud bricks and curing to complete final test of soil.

F. Do not add chopped straw or other vegetative materials.

1.5 ENVIRONMENT CONDITIONS

A. Do not manufacture mud bricks at temperatures less than 5 degrees Celsius, or if temperatures are expected to be less than 0 degrees Celsius within 24 hours.

B. Protect drying mud bricks from direct rainfall during the curing process and while stacked on the site during project.

PART 2 PRODUCTS

2.1 MATERIALS

A. Mud bricks shall be manufactured consistent with the material requirements of Section 04200.

B. Mud bricks shall be produced in various sizes depending on where they are to be used.

C. Selection of soil for mud bricks shall conform to Section 04200, PART 2, 2.1 Materials.

PART 3 EXECUTION

3.1 GENERAL

A. Non-natural materials shall not be used in the manufacturing of the mud bricks. Only unamended soils and sand shall be used. Additives that shall not be used include, but are not limited to, cement, lime, asphalt emulsions, synthetic or natural plastizers, consolidants and water repellents.
B. Variation in the size of the cured mud bricks shall be limited to variations in curing and material. See 2.1 B. above. Use of single or multiple rack mud brick forms is acceptable.

3.2 SOIL MIXING
A. Screen or hand separate soil to remove large debris. Screen shall not allow particles larger than 1 cm to pass.
B. Debris or organic materials that are visually identified shall be removed.
C. Mix soil and water (potable) prior to placement in forms. Mix with minimal amount of water. Making a groove approximately 5 cm deep in the mix indicates proper amount of water; the mud formed by the groove should bulge, but not flow together. Add more dry soil if necessary and remix.

3.3 FORMING
A. Forms for mud bricks shall be smooth and clean. Wet forms between forming. If forms are wood, dip in water prior to next placement of mud.
B. Place forms on level clean ground and place the mud in the forms.
C. Force the mud in the corners of the mold, fill all voids and strike the surplus mud from the top.
D. Strike top surface of brick to avoid “hump-back” brick. Use straight edge to remove the excess mud by pulling a straight edge from one side to the other in a sawing motion, or use the hand.
E. If surface cracks appear immediately, sprinkle water on the top and smooth.
F. Lift the form carefully from the mud bricks and leave them in place on the ground.
G. Stamp project title on each mud brick after pulling of forms (See Section 04200, Figure 5 and Figure 1 and 2 of this section for examples of stamping).

3.4 CURING
A. Leave the mud bricks undisturbed for minimal of 4 to 5 days, and then stand them on their edges.
B. Allow the mud bricks to dry on their sides for another approximate 10 – 14 days. Break several to check for dryness.

C. Scrape any loose materials and debris from ground from the bottom of the mud bricks after curing, but before stacking to complete the curing process.

3.5 STORING / STACKING ON SITE
A. Mud bricks are stacked on site of manufacture after initial curing and cleaning to continue the curing process. Transportation to the work site shall be done carefully to avoid excessive breakage.
B. Mud bricks shall be unloaded by hand and not dumped or thrown from delivery vehicle.
Figure 2: Photograph of a new mud brick stamped with a project title.

END OF SECTION 04210
SECTION 04220 SURFACE RENDERING

PART 1 GENERAL

1.1 DESCRIPTION: The work of this section includes three types of surface renderings. One is a mud plaster to protect selected portions of the walls that exhibit accelerated weathering. This type rendering is more consistent with a repointing of mortar joints but with a mud plaster equivalent to a base coat of plaster with stones and mud bricks remaining visible and is for the purpose of stabilizing the wall surface. The second mud plaster replicates existing mud plaster on both mud brick and stone walls. The specific texture varies to some degree, dependent on the specific location. The third is a purely sacrificial layer that may be applied to simply protect mud brick walls from continued erosion. This latter type is intended to be primarily on the tops of tall walls where the specific replication of the existing plaster is not important.

1.2 None of these renderings are permanent and have to be renewed periodically.

1.3 The mud plaster is a sacrificial layer that will protect the original surface, or the mortar from erosion by wind and rain. It will be used primarily on the west or weather side in the area of the archeological zone and other locations with severe differential surface erosion. It is NOT the intent of this intervention to provide a smooth, flat and finished surface. The final treatment must blend visually with adjacent plaster surfaces. The finished treatment shall replicate the primary characteristics of the existing surface from a distance of 15 meters including, but not limited to color and texture. The specific areas that are to be plastered will be determined in the field and approved by the owner’s representative.

Section 04200 provides the overall conservation guidance while other sections of these specifications provide the detail for specific conservation interventions.

1.4 RELATED WORK

A. SECTION 04200 – MUD BRICK CONSERVATION
B. SECTION 04250 – MUD BRICK CONSTRUCTION
C. SECTION 04260 – WALL BASE VOID REPAIR
D. SECTION 04270 – VOID AND HOLE REPAIR
E. SECTION 04280 – MUD BRICK CAPPING

1.5 SUBMITTALS

A. Submit samples of the selected soils for the approval of the owner’s representative prior to delivery of the materials to the site.

1.6 QUALITY ASSURANCE

A. See Section 04200 Part 1, 1.6 for the general requirements of the conservation project and the specific requirements related to the selection of materials and the handling of the materials for general conservation requirements.
B. Soils for the mud plaster shall be consistent in quality and material.

1.7 ENVIRONMENT CONDITIONS

A. Do not apply mud plaster at temperatures less than 5 degrees Celsius, or if temperatures are expected to be less than 0 degrees Celsius within 24 hours.
B. Protect drying mud plaster from direct rainfall during the curing process.
C. Protect mud plaster surfaces from rapid drying and resulting cracking of the surface by shading from sun, by erection of wind screens, and/or by misting surfaces.

1.8 TEST PANELS (MOCK UPS)

A. The crew under the direction of the owner’s representative shall prepare mock ups for each of the steps in the application of the mud plaster on each of the walls to be plastered. The test panels shall be 1.5 meters X 1.5 meters square. The panels shall be approved by the owner’s representative and shall remain as an example of this treatment throughout the plastering project. The panels will be part of the areas to be treated and not separate areas.

PART 2 PRODUCTS

2.1 MATERIALS

A. Materials and Equipment: The selection of the appropriate soil for the mud plaster shall be from the two soil types supplied as described Section 04200, PART 2, 2.1 MATERIALS, D. 1. and 2.
B. Mixture for mud plaster base coat: Base coat should have a higher clay content than the finish coat - approximately 35% clay and silt and the remainder of sand.
C. Mixture for mud plaster finish coat: The finish coat should have less clay than the base coat – approximately 10-12% clay and the remainder of silt and sand.
PART 3 EXECUTION

3.1 GENERAL

A. Non-natural materials shall not be used in the soil used for mud plaster or the mud wash. Only unamended soils and sand shall be used. Additives that shall not be used include, but are not limited to, cement, lime, asphalt emulsions, synthetic or natural plastisizers, consolidants and water repellents.

B. Proper safety precautions are necessary prior to the beginning of the actual work. Scaffolding shall be erected and secured where access to work area by scaffolding is required. Protection from falling debris or tools and equipment shall also be in place prior to any construction repair. Persons that are not part of the conservation team shall not approach to within 20 meters of the work areas.

3.2 SOIL MIXING – MUD PLASTER

A. Screen soil to remove large debris. Screen shall not allow particles larger than 1 cm. In some cases the existing plasters have differing gain sizes and the new mud plaster will approximate the existing in gradation.

B. Debris or organic materials that are visually identified shall be removed.

C. Mix soil and water (potable) prior to use. Mixture with clay soil shall be soaked a minimum of overnight prior to application. Mix with minimal amount of water. Making a groove approximately 5 cm deep in the mix indicates proper amount of water; the mud formed by the groove should bulge, but not flow together. Add more dry soil if necessary and remix.

3.3 PREPARATION OF SURFACES

A. Surfaces to be plastered shall be brushed clean of loose, friable material, animal scat and droppings, and organic materials such as nests.

B. Mist the surfaces lightly with water spray several times in succession as necessary to ensure even penetration. Misting of surfaces should continue as initial mud plaster coat is applied. Do not apply water spray to the extent that it results in the formation of mud drips.

C. Fill holes that remain in mortar joints and mud bricks greater than 5 cm in diameter to within approximately 3 cm of the surface. Do not fill holes flush with the surface. Fill holes with same mud as used for the mud mortar (Section 04200 Part 2, 2.1, D.).

D. Allow the filled holes to dry prior to the application of the mud plaster.

3.4 APPLICATION – MUD PLASTER

A. Apply the mud onto the surface of the damp mud brick wall surface.

B. Force the mud into the surface and the remaining cracks and undulations with the heel of the hand and trowel.

C. Apply this base coat to a thickness of approximately 12 – 15 mm thick with a trowel or by hand and shape by hand. Allow to dry completely 1-2 days before continuing. Cracks that form shall be covered by the final coat of mud plaster.

D. Prepare surface as described above in 3.3 Preparation of Surface, A. and B. of this section.

E. Apply the final coat to a thickness of approximately 12 – 15 mm thick with a trowel or by hand and finish by hand. Allow to dry 1-2 days before continuing.

F. For the purely sacrificial mud plaster that is not intended to replicate existing mud plaster textures the finished surface shall “echo” the undulations of the surface of the original mud brick that is covered. The surface shall not be smooth and shall contain the basic existing wall undulations and texture. See Figure 1.

G. If cracks appear, mist the surface and “work” the surface by hand, or with a sheepskin or sponge until cracks are filled.

H. Figures 2, 3 and 4 show examples of several wall surfaces both with existing plaster to be replicated and walls with differential weathering where plaster will be applied to stabilize the wall surface.

3.5 CURING

A. The final coat of mud plaster will cure naturally. Restrict rapid drying of each of the two plaster coats as described above in Part 1, 1.5, D. of this section. Restrict cracking, but if cracks appear, treat as Part 3, 3.4, F of this section.
Figure 1: A sketch showing a typical mud brick wall and the application of the rendering. The finish condition on the left is the effect specified; the effect on the right is incorrect as it obscures the wall texture.

Figure 2: A detail of a stone wall that requires mud rendering to stabilize the stone. The individual larger stones should remain visible.

Figure 3: This is an example of an existing mud plaster surface that may need to be replicated. The replication plaster should echo the general character of the existing.

Figure 4: An example where a sacrificial mud plaster might be applied to protect this surface from continual erosion.

END OF SECTION 04220
PART 1 GENERAL

1.1 DESCRIPTION: The work of this section includes repair of structural cracks in the mud brick walls at Atturaif. The structural cracks are primarily described as vertical cracks that extend across sections of mud brick masonry, unrelated to original coursing and horizontal mortar joints. Some of the cracks are perpendicular to the surface and some or parallel to the vertical interior or exterior surfaces. A large number of cracks are separation cracks where perpendicular walls are no longer in contact (Figure 1).

Some of the cracks can be repaired by grouting, Section 04240, and others will require mechanical ties to ensure structural integrity. Still other cracks require that some of the adjacent mud brick masonry be removed and the removed portions replaced with new mud bricks, the new masonry bridging over the crack.

All crack repairs shall be completed in association with structural repairs to the condition of the masonry that caused the cracking. Examples of these structural repairs are the restoration of missing sections of wall, the installation of permanent buttresses and supports and the restoration of the bases and ends of walls. Structural cracks are a result of deformation and unless the cause is mitigated, the crack will return. The intent of the crack repair is to provide an additional level of structural integrity.

Two specific crack repair methods are described individually below in Part 3 of this section. In reality, the repair of some cracks requires a combination of approaches. The actual specific approach is a field decision and in addition to including these basic approaches will also require variations dictated by conditions. See figures 2 – 4 for more examples at Atturaif.

1.2 RELATED WORK

A. SECTION 04200 – MUD BRICK CONSERVATION
B. SECTION 04210 – MUD BRICK MANUFACTURING
C. SECTION 04220 – SURFACE RENDERING
D. SECTION 04240 – MUD GROUTING
E. SECTION 04250 – MUD BRICK CONSTRUCTION
F. SECTION 04280 – MUD BRICK CAPPING
1.3 SUBMITTALS
A. Any substitute materials submitted for the repair of cracks shall be approved by the owner’s representative prior to their use in any of the crack repair procedures. In addition, the specific use of the substitute materials shall be demonstrated in test panels prior to approval.

1.4 QUALITY ASSURANCE
A. See Section 04200 Part 1, 1.6 for the general requirements of the conservation project and the specific requirements related to the selection of materials and the handling of the materials for general conservation requirements.
B. All repairs as specified in this section shall be tested on site to ensure that the specifics of this section are compatible with the site conditions and the materials that are utilized in the repairs. The owner’s representative shall approve modifications and/or changes to the specifics of this section. No modifications or changes shall be made to the general intent of this section and all modifications and/or changes shall be consistent with the general intent as stated in Section 04200, Part 1, 1.6 and this section, Part 1, 1.1 above.

1.5 ENVIRONMENT CONDITIONS
A. Do not repair at temperatures less than 5 degrees Celsius, or if temperatures are expected to be less than 0 degrees Celsius within 24 hours.
B. Protect drying mud brick masonry from direct rainfall during the curing process.
C. See Section 04200, Part 1, 1.7 Environmental Conditions for general restrictions.

1.6 TEST PANELS (MOCK UPS)
A. A repair for each of the crack repairs shall be prepared and approved by the owner’s representative prior to the continuation of those repairs. The mock ups shall be part of the original structure and shall remain after approval as the standard for that part of the work. It shall also remain a part of the final conservation treatment.

PART 2 PRODUCTS
2.1 MATERIALS
A. Soils and mud bricks for mud brick masonry crack repair shall be consistent with Section 04200, Part 2, 2.1, A. and D., 1. and 2. and all of Section 04210.
B. Tensar Structural Geogrid polypropylene Biaxial BX 1100.
C. Mechanical ties, either Earthanchors or threaded steel rods and toggles, to secure the Tensar geogrid.
D. Hydraulic lime or slaked lime may be used if determined to be more appropriate.
3.3 CONSTRUCTION CRACK REPAIR

A. This method of repair requires the replacement of some of the mud brick masonry that has been damaged by the structural crack. It will include the use of horizontal reinforcement.

B. Remove cracked mud bricks in a “toothed” pattern to the extent that a sound repair is possible (Figure 4).

C. Clean the crack if it continues to extend into the mass masonry and grout with mud mortar. Repair cracks that remain as specified below in 3.4 of this section.

D. Mist surface of new and existing mud bricks lightly with water spray several times in succession as necessary to ensure even penetration. Misting of surface should continue as initial mud plaster coat is applied. Do not apply water spray to the extent that it results in the formation of mud drips.

E. Key new mud bricks in the mud brick masonry mass perpendicular to the wall surface in addition to the “toothed” and stepped pattern parallel to the wall surface. With larger, more extensive cracks, remove additional mud bricks in a stepped pattern on both sides and the top of the crack and restore by installing new mud bricks. With smaller repairs lesser amounts of mud bricks will have to be removed.

F. Place horizontal reinforcement every 5th course. Mechanical ties to secure geogrid may be required. The horizontal reinforcement shall bridge over the crack and extend the length of the new mud brick masonry (Figure 5 and 6).

G. Ties shall be laid on a thin bed of fresh mortar and then followed with another thin bed of mortar on top of the tie prior to laying the subsequent course of mud bricks. The total thickness of the mortar joint shall be approximately equal to the thickness of the associated existing mortar joint.

H. Geogrid and mechanical ties shall not be exposed and held approximately 5cm back from exterior surface. Remove all new tool marks with brush.

I. Repair cracks that remain as specified below in 3.4 of this section.

J. Replicate the coursing pattern of the existing exposed surface. Place new mud bricks that are not exposed in an alternating stretcher-header bonding pattern to wall surface or top of wall.

3.4 CRACK FILL REPAIR

A. This method does not involve the removal of mud bricks on either side of the crack that is to be repaired. The void shall be filled with compatible materials to ensure that the future decay and erosion is consistent in the original materials and the new materials used to fill the cracks. This is not a structural repair; it does not include “knitting” the original mud brick masonry.

B. All separation cracks between perpendicular walls shall be filled mud grout to reduce additional movement from wind loads and thermal expansion-contraction.

C. Clear debris from crack by probing, brushing, and blowing.

D. Mist surface of new and existing mud bricks lightly with water spray several times in succession as necessary to ensure even penetration. Misting of surface should continue as initial mud mortar is applied. Do not apply water spray to the extent that it results in the formation of mud drips.

E. Force mud mixture into the crack as deep as possible with hands, wood and metal probes. Use as dry a mix as possible, but mix must be thoroughly mixed. Use mud brick batts to fill larger crack voids.

F. Use grout where necessary to ensure mud is forced into smaller/deeper cracks. Mud grout will be fluid in order to flow into crack. Either grout bags or gravity flow shall be used depending on the conditions.

G. Fill cracks in a series of applications rather than one large application. Single applications shall not be thicker than 10-12 cm and not thicker than 6 cm if width of fill exceeds 10 cm. Deeper and wider voids are allowed if cured mud brick batts are used in the repair.

H. Final application shall not be flush with the surface, but shall be one-half the width of the crack below the surface. Remove all tool marks with brush (Figure 7).

I. Allow applications to dry one-half to two days before continuing. Exposed mortar shall be thumbprint dry and bricks are firmly set in the bed mortar.

J. Protect repairs from rapid drying by misting, shading, protecting from dry winds.
Probable cause of separation crack is basal erosion.

Figure 1: separation cracks at intersecting walls. The reason for the deformation, lower wall erosion has to be solved; the crack will then probably require only grouting to provide contact to reduce cyclic movements.

Figure 2: Crack on top of wall being cleaned out.

Figure 3: Crack shown in Figure 2 has been cleaned and loose bricks and materials removed.
Original mud bricks removed to allow keying of new mud brick repair

Figure 4: Sketch showing schematic of the removal of section of mud brick masonry at a crack in preparation for the reconstruction of the area with new mud bricks.

Figure 5: Detail of crack prepared for grouting and after grouting, bed mortar placed with geogrid.

Figure 6: Schematic sketch of wall section showing an area that was removed and horizontal reinforcement and mechanical ties installed prior to the reconstruction of the damaged portion. The red vertical is the location of the existing crack.
SECTION 04230 CRACK REPAIR

Figure 7: Detail of the final completed crack repair. Note that the surface is held slightly beneath the wall plane and is textured to remove tool marks.

END OF SECTION 04230
ATTUARIF QUARTER, DIRRIYAH, SAUDI ARABIA
CONSERVATION SPECIFICATIONS
SECTION 04235
PLASTER STABILIZATION

PART 1 GENERAL

DESCRIPTION: The work of this section includes stabilization of the remaining plaster on the mud brick walls and on stone features of the structures at Atturaif. The plaster that remains is located on the surfaces of many of the walls, primarily on the non-weather side and consists of mud plaster, lime plaster and cement based hard stucco. The cement plaster is from 20th century and will probably be replaced with a more compatible lime plaster rather than conserved.

This specification includes two approaches to plaster stabilization. One is for the majority of cases where the plasters are intact on the walls, but are fragile and/or delaminating. The second case is for sections of significant plasters that may have become detached and require removal and reattachment. Figures 1 and 2 show two examples of the plasters on the walls of the structures.

1.1 RELATED WORK

A. SECTION 04200 – MUD BRICK CONSERVATION
B. SECTION 04220 – SURFACE RENDERING
C. SECTION 04240 – MUD GROUTING
D. SECTION 04260 – WALL BASE VOID REPAIR
E. SECTION 04297 – SAND BAG PROTECTION

1.2 SUBMITTALS

A. Any substitute materials submitted for the stabilization of plaster shall be approved by the owner’s representative prior to their use in any of the plaster stabilization procedures. In addition, the specific use of the substitute materials shall be demonstrated in tests prior to approval.

1.3 QUALITY ASSURANCE

A. See Section 04200 Part 1.1.6 for the general requirements of the conservation project and the specific requirements related to the selection of materials and the handling of the materials for general conservation requirements.

B. All repairs as specified in this section shall be tested on site to ensure that the specifics of this section are compatible with the site conditions and the materials that are utilized in the repairs. The owner’s representative shall approve modifications and/or changes to the specifics of this section.

1.4 ENVIRONMENT CONDITIONS

A. Do not repair at temperatures less than 5 degrees Celsius, or if temperatures are expected to be less than 0 degrees Celsius within 24 hours.
B. Protect wall surfaces and detached plaster from potential rainfall, direct sun and human and animal traffic until cured.
C. See Section 04200, Part 1.1.7 Environmental Conditions for general restrictions.

1.5 TEST PANELS (MOCK UPS)

A. The stabilization of the attached plaster shall be prepared and approved by the owner’s representative prior to the continuation of the stabilization. The mock ups shall be part of the original structure and shall remain after approval as the standard for that part of the work. They shall also remain a part of the final conservation treatment.
B. The stabilization and reattachment of the detached plasters shall be prepared and approved by the owner’s representative prior to the continuation of the treatment. Examples will serve as the test panels.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Soils for plaster stabilization shall be consistent with Section 04200, Part 2, 2.1, A. and D., 1. and 2.
B. Slaked lime
C. Trowels
D. Syringe and needles with diameter of approximately 2-3 mm.
E. Small sand bags
F. Wood or metal panels to be used as flat smooth working surface.
G. High strength absorptive Japanese paper.
H. Hand water mister.
I. Small trowels, pipettes, scapulas and spatulas.
SECTION 04235 PLASTER STABILIZATION

J. Tensar Biaxial Geogrid, BX 1100.

PART 3 EXECUTION

3.1 GENERAL

A. Proper safety precautions are necessary prior to the beginning of the actual repair. Scaffolding should not be required for access. Protection from falling debris shall be in place prior to the stabilization. All visitors and others not part of the conservation team shall not approach to within 20 meters of the work areas.

B. The removal and the loss of original fabric shall be minimized during the stabilization.

C. The effect of the stabilization shall not distract from the existing visual character of the wall where the stabilization takes place.

3.2 DETACHED PLASTER

A. Identify areas of detached by probing, sounding and by visual observations (Figure 3).

B. Secure detached plaster in place with flat working surfaces and sand bags prior to actual conservation treatment.

C. Salvage detached in largest possible fragments and arrange on flat working surface with the exposed surface facing down (Figure 4).

D. Plaster that is not detached completely shall be removed by inserting a flat working surface in contact with exposed surface and removing.

E. Once plaster is secure on a horizontal working surface, face down, mist repeatedly with water the mud brick and mud and mud plaster attached to the rear of the finish plaster if it exists. Allow the moisture to penetrate and loosen the mud backing and begin scraping. The object is to remove the mud plaster and any attached substrate leaving the surface or finish plaster (Figure 5).

F. Mist plaster and apply a thin coat of mud plaster, followed by a layer of geogrid, BX 1100, which has been cut to fit. Immediately apply another thin coat of mud plaster over the geogrid, and allow to dry (Figure 6).

G. Prepare mud brick by removing all loose materials. Remove enough of the existing mud brick surface where the plaster will be reattached to allow for the added thickness of the mud plaster and geogrid backing plus a layer of mud plaster applied to the mud bricks.

H. Dampen the surface of the mud brick substrate and apply mud plaster. This mud plaster will serve to reattach the detached plaster. Some experimentation will be necessary in order to assure the proper mix with the proper thickness (Figure 7).

I. Transfer the geogrid reinforced plaster carefully to its former location on the wall by means of the flat working surface. Press gently but firmly back in place (Figure 8).

J. Secure the working surface with sand bags and allow to dry.

K. Continue setting smaller pieces of plaster back in place in the wall plane.

L. Begin injecting or packing the edges of the reattached plaster with additional mud plaster until no more mud plaster can be forced between the plaster and the mud brick substrate without displacing the plaster or breaking the bond forming between the plaster and the mud brick (Figure 9). Repeat process after allowing mud to cure until all edges are filled and secure.

M. Finish edges with mud plaster to an angle of approximately 30-45 degrees.

N. After fully cured, remove sand bag supports and flat working board (Figure 10).

3.3 ATTACHED PLASTER

A. Mix soil and water (potable) prior to use. Mix shall be determined for each application on the site and approved after successful application on a test panel. Mix with minimal amount of water and comply with Section 04220, Part 3, C. Specific application made dictate more or less water than is specified. Lime grout may be used depending on the substrate and the plaster type.

B. Using a gentle mist, spray the area of plaster to be stabilized. Do not apply water to the degree that it stands or beads on the surface.

C. Gently place the Japanese paper over the section of plaster to be stabilized. Using a pipette, apply small amounts of water to the paper, not directly to the plaster allowing the water that soaks through the paper to pull the paper against the surface of the plaster.

D. Carefully clean area adjacent to plaster by gentle air pressure generated by blowing through a small tube and by gently picking with small scapulas.

E. Gently press the paper onto the surface with hand and finger pressure only. The paper will protect the actual surface. The pressure will slightly consolidate the surface.
F. With the paper in place, build up the edges of the plaster with mud mortar at an angle of approximate 30% to the surface of the substrate (Figure 3). Work the mud grout under exposed edges.

G. Apply gentle pressure to the surface of the plaster through the Japanese paper as pressure is applied to the mud mortar edge. Continue to press during the drying process if edge cracking exists.

H. Keep the paper only wet enough to keep it in place by gentle misting. The paper will also help in the curing process.

I. When the area is cured, and the paper is completely dry, remove the paper.

J. Figure 11 is a sketch of the general process.

K. In addition to the surface often the thick plaster has also become delaminated and filling the voids and gaps with mud grout is necessary. The grouting shall be done using small tools and slowly working the grout into the voids.

Figure 1: Plaster remains on the lower part of a door in the south part of the Abdallah Palace.

Figure 2: Plaster remains between pilasters on the East Enclosure Wall, east side.

Figure 3: Detached plaster prior to removal from wall.
Figure 4: Large piece of intact plaster after removal from wall on flat working surface.

Figure 5: Large piece of plaster with partial removal of the mud plaster substrate.

Figure 6: Detached plaster with geogrid being attached to the back with mud plaster.

Figure 7: Mud plaster being applied to mud brick substrate for reattaching the plaster.
Figure 8: Plaster is being pressed back into place on the mud brick wall.

Figure 9: Packing mud along the edges and behind the plaster.

Figure 10: The reattached plaster in place after it has cured and the sand bag supports have been removed.
Figure 11: Sketch section showing basic relationship between plaster, paper and mud mortar edge.

END OF SECTION 04235

MUD GROUTING
SEPTEMBER 2007
1.1 DESCRIPTION: The work of this section includes the use of mud grout to fill crack and voids and replacement of mortar joints of existing mud brick and stone masonry. The specific grouting of cracks, voids, and mortar joints are described below in Part 3 of this section.

The types of cracks and voids vary but include vertical structural cracks, separation cracks, cracked and missing mortar joints, deep, narrow holes that are the result of animal and insect activity or water erosion, small voids and cracks resulting from shifting and movement of individual mud bricks and wall sections, and small cracks and crevices that will develop between existing mud brick masonry and new conservation treatment masonry.

Grouting techniques are utilized when it is difficult or impossible to access voids with mortar and hand tools (trowels, etc.) and when deep voids exist.

Figures 1 and 2 are examples of the type of cracks that will be repaired by the specifications in this section.

1.2 RELATED WORK

A. SECTION 04200 – MUD BRICK CONSERVATION
B. SECTION 04220 – SURFACE RENDERING
C. SECTION 04230 – CRACK REPAIR
D. SECTION 04250 – MUD BRICK CONSTRUCTION
E. SECTION 04270 – VOID AND HOLE REPAIR
F. SECTION 04280 – MUD BRICK CAPPING

1.3 SUBMITTALS

A. The material for grout shall be unamended mud and a natural lime grout, depending on the specific conditions and when lime has to be added to increase the workability of the material. That special condition and the use of other materials shall be approved by the owner’s representative prior to use.

B. Any substitute materials submitted for use shall be approved by the owner’s representative prior to their use in any of the grouting procedures. In addition, the specific use of the substitute materials shall be demonstrated in test areas prior to approval.

1.4 QUALITY ASSURANCE

A. See Section 04200 Part 1, 1.6 for the general requirements of the conservation project and the specific requirements related to the selection of materials and the handling of the materials for general conservation requirements.

B. All repairs as specified in this section shall be tested on site to ensure that the specifics of this section are compatible with the site conditions and the materials that are utilized in the repairs. The owner’s representative shall approve modifications and/or changes to the specifics of this section. No modifications or changes shall be made to the general intent of this section and all modifications and/or changes shall be consistent with the general intent as stated in Section 04200, Part 1, 1.6 and to this section, Part 1, 1.1 above.

C. Additives that are considered for use shall comply with provisions of Section 04200, Part 1, 1.5, A. and B.

1.5 ENVIRONMENT CONDITIONS

A. Do not repair at temperatures less than 5 degrees Celsius, or if temperatures are expected to be less than 0 degrees Celsius within 24 hours.

B. Protect drying grout from direct rainfall during the curing process.

C. Protect grout from rapid drying from temperature, sun, and wind by shades and wind breaks.

D. See Section 04200, Part 1, 1.7 Environmental Conditions for general restrictions.

1.6 TEST PANELS (MOCK UPS)

A. Grouting techniques shall be worked out and demonstrated on site and approved by the owner’s representative prior to the continuation of the related repairs. The test area shall remain a part of the final conservation treatment.
PART 3 EXECUTION

3.1 GENERAL

A. Proper safety precautions are necessary prior to the beginning of the actual repair. Scaffolding shall be erected and secured where access to repair area by scaffolding is required. All workmen shall have appropriate eye, head, foot and hand protection. Protection from falling debris shall also be in place prior to the crack repair. Persons that are not part of the conservation team shall not approach to within 20 meters of the work areas.

B. The use of additives for the basic soil mix shall be used only if required to enhance flow characteristics and shrinkage.

C. Cracks and holes may have to be further cleared by drilling into the crack or void with a hand operated brace and bit or a power drill and augur bit.

D. The removal and the loss of original fabric shall be minimized during the repair.

E. The effect of the repair shall not distract from the existing visual character of the wall where the repair takes place unless the crack repair is to be hidden behind other subsequent repair.

3.2 PREPARATION

A. Select site location for conducting the testing of the grout mixes.

B. Test grout mixes prior to actual use for shrinkage and flow characteristics.
   1. Pour grout samples in a series of molds of equal size and allow sample to dry. Sections of pipes of approximately 10 cm diameter or cans with the tops and bottoms removed can be used for the molds.
   2. Allow the samples to dry thoroughly. Evaluate each sample for relative strength and shrinkage.
   3. Place grout between two mud bricks as a bed mortar and allow to dry thoroughly. Compare the relative adhesive quality of the various grouts by the force required to pull the two mud bricks... of the mud brick that are in contact with the grout prior to placement of the grout and shade to prevent rapid drying.
   4. Test the flow characteristics in use demonstration of both the grout bags and the gravity flow systems.
   5. The characteristics of each grout shall be determined at least 24 hours prior to the actual use on the structure.
   6. Pressure grouting is not approved unless it is demonstrated that very low pressures can be effectively controlled. Pressures should be restricted to the 10-15 pounds-per-square-inch range (30-45 kilograms/cm²).

C. Remove loose and deteriorated materials prior to the new repair by scraping, brushing, probing and blowing the voids and cracks where the grouting is used.

D. Prepare lime putty, if required, prior to addition to basic mud mix.
   1. Fill plastic barrel 1/3 full of potable water, and then slowly add lime (calcium hydroxide) to the water slowly mixing until the mix is the consistency of thick pudding.
   2. Continue slowly adding water and lime and mixing thoroughly until the barrel is 2/3 full. Seal barrel and allow to stand a minimum of 48 hours prior to use.
   3. Keep barrels sealed. Add water to ensure that there is a minimum of 5 cm of water standing on the top of the putty at all times.

E. Mix soil and water (potable) prior to use. Mix with heavy clay soil should be soaked overnight prior to application. Additives such as lime or cement shall not be mixed into the basic mud grout until immediate before use. Mix only amount that can be used for any specific application in amounts that can be used prior to initial dehydration of the mix. The actual time that the grout can stand before being discarded shall be determined in the field based on temperature, exposure, relative humidity and wind.

F. There is no restriction on the re-tempering or time limit on the use of unamended mud or lime grouts.

G. When lime is added for workability the approximate lime to be added to the mix is approximately 3-5% by volume, if required.

3.3 GROUT REPAIR

A. Mist materials that will be in contact with the new grout with water; repeat misting or dashing water into cracks or voids with brushes and brooms. Do not apply water spray to the extent that it results in the formation of mud drops.

B. Voids to be filled with lime grout spray with lime wash.

C. Lime wash mixed to the consistency of thin milk. If lime wash leaves a film of lime, reduce the amount of lime in the mix.

D. When grouting is done in association with crack repair, Section 04230, the sequencing shall be determined for each specific case.

E. When using a gravity grouting system the pressure of flow is directly related to the height of the grout pan above the area grouted. A pressure of approximately
Atturaif Quarter, Dirriyah, Saudi Arabia  Conservation Specifications
SECTION 04240  MUD GROUTING

10-15 psi results from the placement of the pan approximately 3 – 5 meters above.
All grouting shall be done with relatively low pressures.

D. Pressure using grout bags is individually controlled.

E. Depending on the position and the specifics of the cracks and voids to be grouted, prevent overflow by packing lower areas with wet newspapers, burlap strips, mortar or similar materials.

F. Protect wall surfaces from grout drips. Clean drips from wall surface immediately.

G. Repair holes that remain as described in Part 3, 3.4 of Section 04230.

H. Horizontal cracks:
   1. Support brick courses prior to grouting.
   2. Temporary shoring and bracing may be required.
   3. In a series of horizontal cracks, begin with the lower one and work toward the upper cracks (Figure 3).
   4. The horizontal cracks are at mortar joints.
   5. Grout the deepest voids first and then proceed toward the surface after initial curing of the deeper grout.
   6. Extensions on the grout nozzles may be required.
   7. Extreme care shall be taken in “packing” the grout.
   8. Temporary supports shall be left in place until the grout is fully cured.

F. Vertical cracks and voids:
   1. The same general descriptions apply as to H. above with the following additions.
   2. Vertical cracks can exist along vertical “stacked” mortar joints, end joints of headers, and through mud bricks.
   3. Grouting will be in association with other structural crack repair methods specified in Section 4230. Grouting is a supplement of more structural crack repair methods.

G. Holes and voids, missing mortar:
   1. Structural support is probably not required, as the voids do not reflect structural damage, but each case must be evaluated.
   2. Prepare as with other grouting methods.
   3. Complete filing of identified voids is not as critical as with the horizontal and vertical cracks (E. and F. above).

H. Use of both grout bags and gravity grouting in combination for the repair of most cracks and voids is expected.

I. Grout Bags:
   1. Wet grout bags with water prior to filling with grout.
   2. Clean grout bags regularly during use. Often the grout will have to be removed and re-tempered with water for continuing use.
   3. Clean grout bags thoroughly after use and set aside to dry.
   4. Fill grout bags approximately half full when grouting.
   5. Pressure is applied by continually rolling the open end of the bag.

J. Gravity Grouting:
   1. Wet group pans and hoses and nozzles prior to filling with grout.
   2. Clean all apparatus regularly during use.
   3. Clean apparatus thoroughly after use or at the end of the day.
   4. Grout pan and apparatus are located at a level above the point of introduction of grout into the wall. See Figure 4 for schematic sketch of operation.
   5. Two men located at the grout pan to regulate flow and to mix grout for continuous operation.
   6. Nozzle operator will be able to control the flow at the nozzle with a cut off valve or plunger.

Figure 1: Detail of deep void in a room of the Abdallah Palace caused both by basal erosion and rodents.

Anthony Crosby, Architectural Conservation
04240-5
September 2007

Anthony Crosby, Architectural Conservation
04240-6
September 2007
Figure 2: A large structural crack at a wall intersection that will require deep grouting to tighten the connection.

Figure 3: Sketch of wall section with multiple horizontal cracks showing sequence of crack repair.

Figure 4: Schematic sketch showing the basic process of the gravity grout system.

END OF SECTION 04240
MUD BRICK CONSTRUCTION
SEPTEMBER 2007

PART 1  GENERAL

1.1 DESCRIPTION: This is the primary section for the actual construction or restoration of missing elements of the structural and architectural systems. It includes the basic principles that the following sections, 04260 Wall Base Repair, 04270 Void and Hole Repair, and 04280 Mud Brick Capping adhere to with the more specific details included in those sections. It is also closely related to parts of Section 04230 Crack Repair, which involves the bridging of severe structural cracks. Figures 1 – 3 are examples of areas where mud brick construction will be required to stabilize existing walls.

The intent of this conservation intervention is to provide structural integrity to portions of the walls that lack that integrity. Portions of missing architectural elements or features shall not be constructed except for that purpose. Guidelines that allow the construction of missing features for interpretive purposes only and that activity is beyond the scope of this phase of this project.

1.2 RELATED WORK

A. SECTION 04200 – MUD BRICK CONSERVATION
B. SECTION 04210 – MUD BRICK MANUFACTURING
C. SECTION 04220 – SURFACE RENDERING
D. SECTION 04230 – CRACK REPAIR
E. SECTION 04240 – MUD GROUTING
F. SECTION 04260 – WALL BASE VOID REPAIR
G. SECTION 04270 – VOID AND HOLE REPAIR
H. SECTION 04297 – SAND BAG PROTECTION

1.3 SUBMITTALS

A. Submittals for the basic materials of mud brick and mortar shall conform to Part 1, 1.3, Section 04210.

1.4 QUALITY ASSURANCE

A. See Section 04200 Part 1, 1.6 for the general requirements of the conservation project and the specific requirements related to the selection of materials and the
SECTION 04250 MUD BRICK CONSTRUCTION

handling of the materials for general conservation requirements in Sections 04210 and 04230.

B. All repairs as specified in this section shall be tested on site to ensure that the specifics of this section are compatible with the site conditions and the materials that are utilized in the repairs. The owner’s representative shall approve modifications and/or changes to the specifics of this section. No modifications or changes shall be made to the general intent of this section and all modifications and/or changes shall be consistent with the general intent as stated in Section 04200, Part 1, 1.6 and to this section, Part 1, 1.1 above.

1.5 ENVIRONMENT CONDITIONS

A. Do not repair at temperatures less than 5 degrees Celsius, or if temperatures are expected to be less than 0 degrees Celsius within 24 hours.

B. Protect drying mortar from direct rainfall during the curing process.

C. Protect mortar from rapid drying from temperature, sun, and wind by shades and wind breaks.

D. See Section 04200, Part 1, 1.7 Environmental Conditions for general restrictions.

1.6 TEST PANELS (MOCK UPS)

A. Specific coursing of mud bricks shall be developed for each specific application location and approved prior to the continuation of the work. The actual integration of the new masonry and the existing shall also be developed and approved prior to continuing. The sections constructed for approval by the owner’s representative shall be part of the final work when approved.

PART 2 PRODUCTS

2.1 MATERIALS

A. Soils for preparation of mortar shall be consistent with Section 04200, Part 2, 2.1, D., 1. and 2.

B. Mud bricks for mud brick masonry construction shall be consistent with Section 04200, Part 2, 2.1, A., 1., 2 and 3.

C. Water: Potable, free from injurious amounts of oil, soluble salts, alkali, and acids, organic impurities and other deleterious materials, which might impair bond or strength.

D. Earth anchors, Foresight Products, Commerce City Colorado; #40 and #68.

E. Tensar Biaxial Geogrid; BX 1100 (Figure 1)

F. Tensar Boykin rods.

PART 3 EXECUTION

3.1 GENERAL

A. Proper safety precautions are necessary prior to the beginning of the actual repair. Scaffolding shall be erected and secured where access to repair area by scaffolding is required. Protection from falling debris shall also be in place prior to any construction repair. Persons that are not part of the conservation team shall not approach to within 20 meters of the work areas.

B. The removal and the loss of original fabric shall be minimized during the repair, although some existing materials will have to be removed in order to execute a satisfactory and integrated repair.

C. Repairs are to be structurally integrated with the existing mass of mud brick masonry to the greatest extent possible by excavating unsound material and establishing a sound base for the new material.

D. Use Tensar Geogrid and mechanical ties (Earthanchors) to integrate new construction with original.

E. The effect of the construction repair shall not distract from the existing visual character of the wall where the repair takes place.

F. Utilize tools and equipment that are most appropriate to limit the degree of intervention and loss of existing fabric.

3.2 PREPARATION

A. Determine the specific extent of the construction prior to beginning the repair and the amount of original materials that will have to be removed. The specific details of the construction repair shall be determined after loose materials have been removed.

B. Remove loose and deteriorated materials prior to the new repair by removal of existing mud bricks, scraping, brushing, probing and blowing the areas where the repair will take place.
SECTION 04250 MUD BRICK CONSTRUCTION

C. Prepare mortar joints for installation of Tensar Geogrid for horizontal reinforcement. Use thin steel bars to clean joints to maximum depth possible. Remove loose mortar.

D. Prepare a flat, horizontal base on the existing mud brick construction for the first courses of new mud brick. The base may be flat or stepped in areas where mud bricks are sound (Figure 4). The example given here is for the purpose of providing clarity of the process.

E. Dampen contact areas of existing and new mud brick masonry prior to setting new mud bricks and mortar.

F. Mix soil and water (potable) prior to use. Mix with clay soil should be soaked overnight prior to application.

G. There is no restriction on the re-tempering or time limit on the use of unamended mortars.

3.3 CONSTRUCTION REPAIR

A. Re-dampen materials according to 3.2, E. above of this section if required. Misting or spraying is allowed, but the water spray shall not be applied to the extent that it results in the formation of puddles.

B. Key new material to existing by setting new mud bricks in a “toothed” pattern keyed into the original mud brick masonry or with mechanical ties as determined in the field (Figure 5).

C. Replicate the coursing pattern of the existing exposed surface including the thickness of the mortar bed joints.

D. Vary bed mortar joint thickness only to ensure level mud bricks.

E. Set bricks on bed mortar and place bricks with some head joint mortar as well. Every approximately 6-9 courses, or at the end of each day, or when the horizontal reinforcement is to be placed, point all joints completely (Figure 6).

F. Construct the new mud brick masonry in complete horizontal courses where possible. Do not construct more than 10 – 12 courses before allowing masonry to dry. Allow minimum of 7 – 10 days for drying between 10 – 12 course lifts. Lay subsequent mud brick courses on fresh wet mortar.

G. Large voids shall be repaired with the standard mud brick construction.

H. Place horizontal reinforcement every approximate 6-9 courses. Geogrid can be laid in one contiguous piece or in pieces connected by Boykin rods (Figure 7).

I. Remove all tool marks from mortar by brushing, or other means to achieve the effect necessary to reflect the character of the surrounding wall surfaces. This may include but not be limited to the additional texturing of the surface, tuckpointing, the removal of some mortar joints and the application of a mud wash on the exposed surface.

J. The finished wall surface shall evoke the texture of the adjacent wall surface (Figure 9).

K. Use mechanical ties with Tensar Geogrid reinforcement when horizontal stress between existing and new masonry is excessive. See Section 04253 for details.

Figure 1: The missing portion of a wall on the east side of Block 3 will have to be reconstructed to provide stability.
Figure 2: A wall section in the Abdallah Palace showing an unsupported corner and how it could be supported by the partial restoration of a missing corner intersection.

Figure 3: Another section of wall in the Abdallah Palace showing how the tall wall on the left could be supported by the partial restoration of intersecting walls.

Figure 4: Preparation of mud brick base has been completed for new construction.

Figure 5: Integration of existing mud brick construction with new construction by the creation of a "toothing" pattern.
Figure 6: Comprehensive pointing of a course of mud bricks prior to the installation of horizontal reinforcement.

Figure 7: Geogrid horizontal reinforcement installed.

Figure 8: The placement of the horizontal reinforcement prior to mechanically attaching the grid to the adjacent wall mass.
Figure 9: An example of a section of new mud bricks that has been textured to blend with the surrounding wall surface.

END OF SECTION 04250
MECHANICAL TIES
SEPTEMBER 2007

PART 1 GENERAL

1.1 DESCRIPTION: The work of this section includes mechanical ties used to attach the new mud brick masonry to the existing mass mud brick masonry of the Atturaif structures. The mechanical ties actually connect to the Tensar Biaxial geogrid, which is used as horizontal reinforcement in the new mud brick masonry construction. The sections attached are usually relatively thin sections of new masonry. The ties shall be used only in cases where additional attachment is necessary and when it cannot be achieved by conventional masonry coursing approaches.

There are two types of mechanical tie, although is a later revision and is preferred. It is provided here as an alternative as the materials are more standard. This earlier version consists of a threaded steel rod attached to a spring loaded toggle that opens, when not compressed. The steel rod is attached by a couple to a steel eye bolt. The second type consists of a steel wedge on the end of a steel cable that is driven into a drilled hole with a driving rod. When the steel cable is pulled tight, the steel rod rotates from being in line with the drill hole to perpendicular to the hole. In both cases, the rod and the cable cannot be pulled from the drill hole. Both devices can be connected directly to the geogrid horizontal reinforcement by the eye bolt in one case and a loop in the steel cable in the other case (Figures 1 and 2).

The work of this section is closely associated with the work of Sections 04250 Mud Brick Construction. It is also closely related to parts of Section 04230 Crack Repair that involve the bridging of severe structural cracks. This section does not replace any other specification and is limited to the mechanical ties alone.

1.2 RELATED WORK
A. SECTION 04200 – MUD BRICK CONSERVATION
B. SECTION 04230 – CRACK REPAIR
C. SECTION 04250 – MUD BRICK CONSTRUCTION

1.3 QUALITY ASSURANCE
A. See Section 04200 Part 1, 1.6 for the general requirements of the conservation project and the specific requirements related to the selection of materials and the handling of the materials for general conservation requirements in Sections 04210 and 04230.
SECTION 04253  MECHANICAL TIES

B. All repairs as specified in this section shall be tested on site to ensure that the specifics of this section are compatible with the site conditions and the materials that are utilized in the repairs. The owner’s representative shall approve modifications and/or changes to the specifics of this section. No modifications or changes shall be made to the general intent of this section and all modifications and/or changes shall be consistent with the general intent as stated in Section 04200.

C. Safety conditions are specified in Sections 4250, Mud Brick Construction.

1.4 ENVIRONMENT CONDITIONS

A. Do not install mechanical ties at ambient temperatures less than 5 degrees Celsius, or if temperatures are expected to be less than 0 degrees Celsius within 24 hours. If the location is well protected from winds and the actual temperature of the mud brick mass where the repair will take place is greater than 10 degrees Celsius, the repair can continue.

B. Protect drying mortar and mud bricks from direct rainfall during the curing process.

C. Protect materials from rainfall or night humidity.

1.5 TEST PANELS (MOCK UPS)

A. There are no “test panels” or mock ups as such as the repair is completely covered by mud brick masonry as soon as the mechanical ties have been installed.

PART 2 PRODUCTS

2.1 MATERIALS AND TOOLS

A. Soils for preparation of mortar shall be consistent with Section 04200, Part 2, 2.1, D., 1. and 2.

B. Gravel collected locally.

C. Water: Potable, free from injurious amounts of oil, soluble salts, alkali, and acids, organic impurities and other deleterious materials, which might impair bond or strength.

D. Steel rods, threaded, stainless ¼ inch diameter, 24 inches long, nuts, eye bolts and couples.

E. Stainless steel toggle bolts, ¼ inch.

F. Earth anchors, Foresight Products, Commerce City Colorado; #40 and #68 and associated clamps and connectors.

G. Tensar Biaxial Geogrid and Tensar Boykin rods.

H. Brace and bit (hand operated); Hammer drill (non-battery powered) and ½”, 18 inch long masonry bits.

I. Portable generator, transformer and electrical extension cords.

J. Assorted steel and wood probes, pliers, wrenches, and a masonry hammer.

PART 3 EXECUTION

3.1 GENERAL

A. The removal and the loss of original fabric shall be minimized during the repair, although some existing materials will have to be removed in order to execute a satisfactory and integrated repair.

B. Utilize tools and equipment that are most appropriate to limit the degree of intervention and loss of existing fabric.

3.2 PREPARATION

A. Remove loose construction materials, debris, and deteriorated materials prior to selecting the exact locations for the ties.

B. Mix soil and water (potable) prior to use. Mix with clay soil should be soaked overnight prior to application.

C. There is no restriction on the re-tempering or time limit on the use of unamended mortars.

3.3 INSTALLATION OF MECHANICAL TIES

A. Locate where holes will be drilled for the installation of the ties along the entire length of the section of wall that will be mechanically attached to the existing mud brick masonry.
B. Drill hole to a depth of approximately 30 - 40 cm or equal to the length of the steel rod or steel cable. The holes are drilled at an angle of 30-45% from horizontal. Holes should be between ½ inch and 1 inch in diameter (12 -25 mm) (Figure 3).

C. Clean loose debris and soil from drilled hole by scooping, brushing, backward drilling with brace and bit. It may be necessary to add water to the hole to aid in the extraction. The cleaning of the hole is necessary with the steel threaded rods and toggles, but not for the cables and wedges (earth anchors).

D. Insert steel rods or earth anchors into the holes. The earth anchors are simply driven to resistance and to maximum depth. The steel rods and toggles are inserted and maneuvered until the toggle opens. Both devices are then pulled to resistance.

E. The drilled holes are filled with mud mortar. The moisture content of the mortar will vary but should be as dry as possible. The mud, along with large gravel is placed into the holes in small quantities and packed as tightly as possible with steel and wood rods. The process is repeated until no more mortar can be forced into the holes. The only part of the tie that remains visible is the steel eye bolt or the steel cable loop, which will connect to the geogrid (Figures 5 and 6 show the installation of the steel rods and Figures 7 – 11 show the installation of the steel cables).

F. The geogrid is cut and put in place. The connecting Boykin rod is woven through the geogrid and the eye bolt or cable loop (Figures 6 and 11).
SECTION 04253 MECHANICAL TIES

Figure 4: Field sketch of section detail at wall showing steel rod and toggle assemblage set into the mud brick wall. The earth anchors are installed similarly.

Figure 5: Eye bolts are the only part of the mechanical tie that is visible after set in the wall. These are set approximately 1 meter apart.

Figure 6: The mechanical ties connected to the geogrid.

Figure 7: Detail of the steel cable and rotating head in which a driving rod is inserted.
Figure 8: Head being inserted into drilled hole.

Figure 9: Cable extended as head is being driven into hole.

Figure 10: Cable with loop is pulled once desired depth is reached.

Figure 11: Boykin rod is attached to the cable loop, which is woven through the geogrid.

END OF SECTION 04253
WALL BASE REPAIR
SEPTEMBER 2007

PART 1 GENERAL

1.1 DESCRIPTION: The work of this section includes the structural repair of the bases of walls for which the structural integrity has been compromised by the removal of significant portions of the walls. This may include additional foundation stabilization if required. It includes the extensive voids caused by mechanical erosion and the effects of rising damp, which is pervasive at the site. Figures 1, 2, 3 and 4 show examples of the conditions for which this specification is applicable.

The work of this section is closely associated with the work of Sections 04250 Mud Brick Construction and Section 04270 Void and Hole Repair. It is also closely related to parts of Section 04230 Crack Repair that involve the bridging of severe structural cracks.

The intent of the construction is only for the purpose of providing structural integrity to the lower walls. Portions of missing architectural elements or features shall not be constructed except for that purpose.

1.2 RELATED WORK

A. SECTION 04200 – MUD BRICK CONSERVATION
B. SECTION 04230 – CRACK REPAIR
C. SECTION 04250 – MUD BRICK CONSTRUCTION
D. SECTION 04270 – VOID AND HOLE REPAIR
E. SECTION 04297 – SAND BAG PROTECTION
F. SECTION 04500 – STONE MASONRY

1.3 SUBMITTALS

A. Submittals for the basic materials of mud brick and mortar shall conform to Part 1, 1.3, Section 04210.

1.4 QUALITY ASSURANCE

A. See Section 04200 Part 1, 1.6 for the general requirements of the conservation project and the specific requirements related to the selection of materials and the handling of the materials for general conservation requirements in Sections 04210 and 04230.
B. All repairs as specified in this section shall be tested on site to ensure that the specifics of this section are compatible with the site conditions and the materials that are utilized in the repairs. The owner’s representative shall directly approve the specific work details in each of these critical wall bases and modifications and/or changes to the specifics of this section.

C. Prior to any removal of the existing debris and unstable mud bricks each specific area shall be inspected for its safety and steps taken to provide a safe work environment. This includes, but not limited to the construction of sand bag buttresses and supports, temporary bracing and shoring, and personal safety equipment.

1.5 ENVIRONMENT CONDITIONS

A. Do not repair at ambient temperatures less than 5 degrees Celsius, or if temperatures are expected to be less than 0 degrees Celsius within 24 hours. If the location is well protected from winds and the actual temperature of the mud brick mass where the repair will take place is greater than 10 degrees Celsius, the repair can continue.

B. Protect drying mortar and mud bricks from direct rainfall during the curing process.

C. Protect mortar from rapid drying from temperature, sun, and wind by shades and wind breaks.

D. Protect repair area during the night by covering previous work and protecting from low night temperatures and night winds.

E. See Section 04200, Part 1, 1.7 Environmental Conditions for general restrictions.

1.6 TEST PANELS (MOCK UPS)

A. Specific coursing of mud bricks shall be developed for each specific application location and approved prior to the continuation of the work. The actual integration of the new masonry and the existing shall also be developed and approved prior to continuing. The sections constructed for approval by the owner’s representative shall be part of the final work when approved.

PART 2 PRODUCTS

2.1 MATERIALS

A. Soils for preparation of mortar shall be consistent with Section 04200, Part 2, 2.1, D., 1. and 2.
C. Place horizontal and vertical string lines in section of new mud brick masonry after removal of any damaged existing mud bricks to ensure that the repair is consistent with the form and mass of the existing masonry.

D. Mix soil and water (potable) prior to use. Mix with clay soil should be soaked overnight prior to application.

3.3 WALL BASE WALL REPAIR

A. Key new material to existing by setting new mud bricks in a “toothed” pattern keyed into the original mud brick masonry. Pack new mud bricks and mortar to the maximum extent possible (Figure 5).

B. Replicate the coursing pattern of the existing exposed surface including the thickness of the mortar bed joints.

C. Construct the new mud brick masonry in complete horizontal courses where possible. Set new bricks with head joint mortar as well as bed mortar.

D. New mud brick repair shall not appear as new construction, but shall replicate the general character of surrounding wall surfaces.

E. Mortar should be thoroughly wet and in a plastic state but as dry as possible. The specific moisture content of the mortar will vary depending on the specific use.

F. If basal erosion void is wider than one withe of mud bricks, set interior courses, allow to cure for minimum of 72 hours before continuing with exterior withe.

G. Protect the repairs from rapid drying by misting, shading and protection from dry winds.

H. Figures 6 and 7 show the completed construction of a wall base.
Figure 3: Another example of severe basal erosion immediately above a cut stone and rubble stone masonry foundation.

Figure 4: Severe basal erosion in the east unit of Block 1 of the Salwa Palace.

Figure 5: Sketch of typical wall base showing the construction of a new base, which projects beyond the wall face.

Figure 6: The wall base is being completed masonry packed and wedged in as much as possible. Note small white rocks used to reduce settlement as mortar dries.
Figure 7: The completed construction of a wall base. The lower part of the wall will be covered with fill sand.

END OF SECTION 04260
PART 1 GENERAL

1.1 DESCRIPTION: The work of this section includes the repair of voids and holes in the mud brick walls that are not included in the structural repairs specified in Sections 04250 and 04260. The voids and holes repair in the stone masonry walls are included in Section 04500 of these specifications. The repairs of this section are structural, but the intent of the repair is also to eliminate holes and voids that provide habitat for animals and insects and possible access to the mud brick mass of water and wind that further erode these same holes and voids.

1.2 The repair of this section will result in undulations in the wall surface similar to that which exists. The repaired sections shall not be flat, but rather set to create the textures and shadows consistent with the texture and character of the original mud brick walls. The repairs shall also replicate the courting patterns as much as possible. Figures 1 and 2 show some of the typical areas of voids that are the subjects of the work covered by this specification.

1.3 RELATED WORK
   A. SECTION 04200 – MUD BRICK CONSERVATION
   B. SECTION 04210 – MUD BRICK MANUFACTURING
   C. SECTION 04220 – SURFACE RENDERING
   D. SECTION 04240 – MUD GROUTING
   E. SECTION 04250 – MUD BRICK CONSTRUCTION
   F. SECTION 04500 – STONE MASONRY

1.4 SUBMITTALS
   A. Submittals for the basic materials of mud brick and mortar shall conform to Part 1, 1.3, Section 04210.

1.5 QUALITY ASSURANCE
   A. See Section 04200 Part 1, 1.6 for the general requirements of the conservation project and the specific requirements related to the selection of materials and the handling of the materials for general conservation requirements in Sections 04210 and 04250.

PART 2 PRODUCTS

2.1 MATERIALS
   A. Soils for preparation of mortar shall be consistent with Section 04200, Part 2, 2.1, D., 1. and 2.
   B. Mud bricks for mud brick masonry construction shall be consistent with Section 04200, Part 2, 2.1, A., 1., 2 and 3.
   C. Water: Potable, free from injurious amounts of oil, soluble salts, alkali, and acids, organic impurities and other deleterious materials, which might impair bond or strength.
   D. Tensar Biaxial Geogrid.

PART 3 EXECUTION

3.1 GENERAL
   A. Proper safety precautions are necessary prior to the beginning of the actual repair. Scaffolding shall be erected and secured where access to repair area by scaffolding is required. Protection from falling debris shall also be in place prior
to any construction repair. Proper safety precautions are necessary prior to the beginning of the actual work. Persons that are not part of the conservation team shall not approach to within 20 meters of the work areas.

B. The removal and the loss of original fabric shall be minimized during the repair, although some existing materials will have to be removed in order to execute a satisfactory repair.

C. Utilize tools and equipment that are most appropriate to limit the degree of intervention and loss of existing fabric.

3.2 PREPARATION

A. Determine the specific extent of repair prior to beginning the work. The specific details of the repair shall be determined after loose materials have been removed.

B. Each area shall be documented photographically by the project documentation team prior to any preparations of the specific areas. After preparation the areas shall be re-documented prior to the undertaking of the actual repair.

C. Check for the presence of insects and treat with an approved insecticide if necessary.

D. Remove loose and deteriorated materials prior to the new repair by removal of loose debris, sand, soil, and insects nests. Loose mud bricks can be removed to reset later, but removal is not necessary. Report all cultural materials and objects and report to archeological representative. Remove loose materials by scraping, brushing, probing and blowing the voids and holes where the repair will take place.

E. Establish the overall repair approach and the final surface plane of the repair prior to the work. Temporary placement of dry laid mud bricks in the larger holes and repairs can be used to approximate the visual effect of the final repair.

F. Use thin steel bars to clean joints to maximum depth possible. Remove loose mortar.

G. Dampen contact areas of existing and new mud brick masonry prior to setting new mud bricks and mortar. The depth of the dampening shall be between approximately 2-3 mm and 6 mm deep: it shall not exceed 6 mm deep.

H. Mix soil and water (potable) prior to use. Do not use the clay rich soil.

I. There is no restriction on the re-tempering or time limit on the use of unamended mortars.

3.3 VOID AND HOLE REPAIR

A. Re-dampen materials according to 3.2, E. above of this section if required. Misting or spraying is allowed, but the water spray shall not be applied to the extent that it results in the formation of mud drips.

B. Place full size mud bricks in the holes and voids where possible. Fill voids around the placed mud bricks with mud brick bats and mud mortar. Particularly deep voids may require the use grouting as specified in Section 04240.

C. Replicate the coursing pattern of the existing exposed surface including the thickness of the mortar bed joints where the voids and holes have the required surface area. The actual coursing pattern of the new mud bricks is not important except at the finish surface of the repair.

D. Set new bricks with head joint mortar as well as bed mortar.

E. Fill all voids by throwing mortar into the voids. The new mud bricks and mud brick bats shall be placed into the voids with as much pressure as possible.

F. Mortar should be dry as possible but the mortar for grouting will be quite wet. Grout shall be restricted to the filling of only small voids in the actual repair after the repair material has initially set. The mud grout shall set completely (thumbprint dry) prior to the subsequent step of repair. Grouting shall be limited.

G. Specific depth of each repair step shall be determined in the field for each specific case. In some cases where deep and large voids exist, it may be necessary to complete the repairs in a series of steps. See Figure 4.

H. Use Tensar Biaxial Geogrid in particular large voids to provide horizontal reinforcement. In rare cases it may also be necessary to mechanically connect the geogrid to the existing wall mass. See Section 04253 of these specifications.

I. New mud bricks shall not extend beyond the existing surface of the mud brick walls. In some cases it will be necessary to corbel out mud bricks to establish a base for repairs higher in the wall.

J. Holes that represent an architectural feature such as beam pockets should not be filled within ca. 10 cm of the wall surface plane so that the evidence is retained.

K. The repair shall replicate the general texture of the surrounding mud brick wall surface.

L. Remove all tool marks from mortar.
Figure 1: A ruined wall in the Abdallah Palace with deep holes that are subject to the work of this spec.

Figure 2: Large holes that may have been for beam pockets. They should be filled, but held back from the surface so as not to obscure architectural features.

Figure 3: Sketch partial section through a typical void showing basic repair with mud bricks and mud brick bats. Same deep repair can be made with stone.
MUD BRICK CAPPING
SEPTEMBER 2007

1.1 DESCRIPTION: The work of this section includes the protection of the tops of walls by the installation of mud brick caps. It is the intent of the work of this section to install caps to the tops of all walls to protect the existing (original) fabric. The new mud brick caps will compose a sacrificial layer and are expected to erode. Over time the cap will be replaced by other mud bricks to continue the protection of the tops of walls. Protection is necessary as decayed mud bricks no longer withstand even the most minor decay mechanisms. It includes the basic principles that the Section 04250 Mud Brick Construction. It is also closely related to parts of Section 04230 Crack Repair that involve the bridging of severe structural cracks.

The intent of the mud brick capping is only for the purpose of providing a sacrificial layer to protect underlying fabric. It shall not significantly change the overall massing of the existing walls and shall follow the existing wall undulations to the degree possible by adding one to two courses to every exposed brick. Rubble stone masonry wall shall be capped with a mud cap, similar to cob, or puddled mud. The thickness shall be based on field conditions.

1.2 RELATED WORK
A. SECTION 04200 – MUD BRICK CONSERVATION
B. SECTION 04210 – MUD BRICK MANUFACTURING
C. SECTION 04230 – CRACK REPAIR
D. SECTION 04240 – MUD GROUTING

1.3 SUBMITTALS
A. Submittals for the basic materials of mud brick and mortar shall conform to Part 1, 1.3, Section 04210.

1.4 QUALITY ASSURANCE
A. See Section 04200 Part 1. 1.6 for the general requirements of the conservation project and the specific requirements related to the selection of materials and the handling of the materials for general conservation requirements in Sections 04210 and 04230.

B. All repairs as specified in this section shall be tested on site to ensure that the specifics of this section are compatible with the site conditions and the materials that are utilized in the repairs. The owner’s representative shall approve modifications and/or changes to the specifics of this section. No modifications or
changes shall be made to the general intent of this section and all modifications and/or changes shall be consistent with the general intent as stated in Section 04200, Part 1, 1.6 and to this section, Part 1, 1.1 above.

1.5 ENVIRONMENT CONDITIONS
A. Do not repair at temperatures less than 5 degrees Celsius, or if temperatures are expected to be less than 0 degrees Celsius within 24 hours.
B. Protect drying mortar from direct rainfall during the curing process.
C. See Section 04200, Part 1, 1.7 Environmental Conditions for general restrictions.

1.6 TEST PANELS (MOCK UPS)
A. Mock ups shall be developed for each type of wall that is to be capped and they shall be approved by the owner’s representative. Additional mock ups shall be developed if field conditions change significantly. The mock ups shall become part of the actual repair. The sections constructed and approved shall be part of the final work and shall serve as the standard until the work of this section is complete.

PART 2 PRODUCTS

2.1 MATERIALS
A. Soils for preparation of mortar shall be consistent with Section 04200, Part 2, 2.1, D., 1. and 2.
B. Soil for mud caps shall be same as for mud mortar. Small stones may be incorporated in the mud mix if necessary for visual effects.
C. Mud bricks for mud brick masonry construction shall be consistent with Section 04200, Part 2, 2.1, A., 1., 2 and 3.
D. Water: Potable, free from injurious amounts of oil, soluble salts, alkali, and acids, organic impurities and other deleterious materials, which might impair strength.

PART 3 EXECUTION

3.1 GENERAL
A. Proper safety precautions are necessary prior to the beginning of the actual work. Persons that are not part of the conservation team shall not approach to within 20 meters of the work areas.
B. The removal and the loss of original fabric shall be minimized during the repair, although some existing materials will have to be removed in order to execute a satisfactory and integrated cap.
C. The mud brick caps are to be integrated with the existing mass of mud brick masonry to the greatest extent possible, but the complete removal of all unsound materials is not normally required.
D. Rubble stone masonry often cannot be protected with a mud brick cap, or it may be visually inappropriate. In these cases a puddle mud brick cap shall be used.
E. The effect of the mud brick cap or the mud cap shall not distract from the existing visual character of the wall where the repair takes place.
F. Utilize tools and equipment that are most appropriate to limit the degree of intervention and loss of existing fabric.

3.2 PREPARATION
A. Determine the specific extent of the construction prior to beginning the repair and the amount of original materials that will have to be removed. Do not remove loose material from the top of a wall if the mud cap is not to be installed within 5 workdays.
B. Remove loose and deteriorated materials in the form of friable and powdery surface prior to the new repair by scraping, and brushing the areas where the repair will take place. Remove loose mortar and repoint prior to the installation of the mud brick cap. See Figure 1.
C. Dampen contact areas of existing and new mud bricks prior to setting new mud bricks and mortar cap. The depth of the dampening shall be between approximately 2-3 mm and 6 mm deep; it shall not exceed 6 mm deep.
D. Mix soil and water (potable) prior to use. Mix with clay soil should be soaked overnight prior to application.
E. There is no restriction on the re-tempering or time limit on the use of unamended mortars.
F. Mud for mud caps shall be applied well mixed, but as dry as possible to prevent slumping.
G. Mixing of mud for mud plaster and mud washes shall be as specified in Section 04220.
3.3 CONSTRUCTION REPAIR

A. Re-dampen materials according to 3.2, D. above of this section if required.
Misting or spraying is allowed, but the water spray shall not be applied to the extent that it results in the formation of mud drips.

B. In most cases the mud brick cap shall be two courses thick, although there may be some conditions that require only one course of mud bricks (Figures 2 and 3).

C. Coursing pattern shall replicate the existing bonding pattern when possible. Alternate patterns and the use of partial mud bricks will be necessary to cover the original bricks most efficiently (Figure 3).

D. New mud bricks shall be set in bed mortar following the basic existing contour. Thickness of bed mortar shall be approximately 15-25 mm thick.

E. Do not allow bed mortar to dry prior to setting mud bricks. Mud bricks shall be placed on mud mortar immediately after placement of mortar.

F. Second course can be added immediately with no time allowed for the drying of the first course.

G. Mud brick cap shall follow the general wall surface profile or step back several cm if the wall surface is plumb (Figures 2 and 3).

H. Remove sharp edges from the new mud bricks prior to setting. Additional removal of sharp edges may be necessary during the final treatment.

I. Remove all tool marks from mortar by brushing and by stippling mortar joints with stiff bristle brush.

J. Allow 1-2 days for drying after placement of second course of mud bricks. Repoint mortar joints to ensure complete closure where necessary.

K. Dampen surface and brush with a wire brush to further blend with original material.

L. A very light mud wash shall be added if the color contrast between the new and the original mud bricks is objectionable.

M. Field dirt may also be applied to the finished capping to further reduce strong shadow lines and sharp edges.

N. See Figure 1 and 2 for a before and after comparison.
Figure 3: Sketch section of a mud brick wall showing the schematic treatment of providing a wall cap.

Figure 4: A sketch of a stone masonry wall

END OF SECTION 04280
SECTION 04296 PROTECTIVE BRACING-SHORING

PART 1 GENERAL

1.1 DESCRIPTION: The work of this section includes the structural bracing and shoring during archeological excavations. The system utilizes existing supplies and materials that should be found on the site, primarily based on the scaffolding system. The scaffolding is very versatile as various parts of the systems can be used in a multitude of ways to create support for both vertical and lateral loading. One particular use is described here, supporting vertical walls and partial vaults from collapsing during excavations, but it also demonstrates how adaptable the system is.

The intent of the bracing system is to provide temporary support during the excavation process, or to meet emergency needs. The following sections of the conservation specifications are only related as they may address directly some of the repairs associated with the structural failures that lead to the need for the shoring and bracing.

1.2 RELATED WORK

A. SECTION 04230 – CRACK REPAIR
B. SECTION 04270 – VOID AND HOLE REPAIR
C. SECTION 04295 – SAND BAG BUTTRESS CONSTRUCTION
D. SECTION 04297 – SAND BAG PROTECTION

1.3 QUALITY ASSURANCE

A. See Section 04200 Part 1, 1.6 for the general requirements of the conservation project and the specific requirements related to the selection of materials and the handling of the materials for general conservation requirements in Sections 04210 and 04230.

B. The specific use of the bracing and shoring system should be reviewed prior to and during its use by the owner’s representative and that person shall approve modifications and/or changes to the specifics of this section.

C. The owner’s representative, or the person responsible for installing the system shall work directly with the site archeologist in charge so that the system responds best to the archeological needs as well as protecting both the archeological features and the health of the archeological crew members.

PART 2 PRODUCTS

2.1 MATERIALS AND TOOLS

A. Steel pipes of approximately 2 inches or 50 cm in diameter to fit the multi directional couples that connect the various parts of the system. The actual lengths will be determined by the specifics of the support needs, but shall consist of a minimal of two pipes that are 4 – 5 meters long and 6 pieces that are 2 – 3 meters long.

B. Multi-directional couples – minimal of 6 couples for each section of bracing.

C. Adjustable scaffolding feet, a minimum of two for each section of bracing.

D. Wedges and shims of various thicknesses and lengths.

E. Lumber of various lengths, 2 inches, 50 cm, and 25 cm thickness

F. Nails and a hammer

G. 19 mm crescent wrench

H. Pipe cutter (hack saw, etc.)

I. Tie wire and pliers and wire cutters.

J. Sand bags and fill sand.

PART 3 EXECUTION

3.1 GENERAL

A. Proper safety precautions are necessary prior to the beginning of the actual installation. Sand bags and temporary bracing may be needed to safely install the system. Protection from falling debris may also be necessary.

B. The removal and the loss of original fabric shall be minimized during the installation.
C. Utilize tools and equipment that are most appropriate to limit the degree of intervention and loss of existing fabric.

D. Figure 1 shows the general condition where this example of the brace is necessary.

3.2 PREPARATION

A. Determine the specific extent of the problem and develop a preliminary design that addresses the problem. Collect the needed materials as need for the bracing design.

B. Plan access and working conditions that minimizes damage to the site features.

C. Install sand bags or temporary bracing as needed.

3.3 EMERGENCY BRACING AND SHORING

A. Collect system components and adjust sizes and lengths as necessary for the specifics of the task (Figure 2).

B. Set horizontal steel pipes in place, which will support the system components, connect securely and secure in place with sand bags (Figure 3).

C. Connect vertical members with the support pipes with couples and tighten temporarily.

D. Arrange horizontal pipes with adjustable feet (screw jacks) that will supply the bracing for the lateral loading of the walls. Continue to add to the basic system as needed to supply the support necessary.

E. Add pressure plate against the walls to be supported and snug in place with screw jacks (Figure 4).

F. As the system is designed to allow excavations beneath, the components are supported from above leaving the floor free.

G. One support will require lateral support perpendicular to the brace. This support can be removed when the second and subsequent braces are installed and connected to each other.
Figure 3: System supported from above by the horizontal pipe that bears on a stable area outside the vaulted area.

Figure 4: Field sketch of the adjustable compression feature that supports the side walls.

Figure 5: One brace or one bay of the system installed. Additional bays can be added as needed as the excavation continues. Note that the system is supported from above leaving the floor clear for continuing the excavations.

END OF SECTION 04296
SAND BAG PROTECTION
SEPTEMBER 2007

PART 1 GENERAL

DESCRIPTION: The work of this section is the placement of sand bags to protect the low walls and features that are exposed to accelerated deterioration primarily because of foot traffic on the site. The deterioration is particularly bad when there is a lot of activity on the site such as construction activities. The sand bags are intended to cover the areas that are susceptible to wear and take the actual force of the traffic. Sand bag protection represents the least amount of resource investment and technical skill and is considered an important part of the protection of the resources during the process of conservation as well as during the archeological investigations. Sand bags shall be available on the site at all times.

Specific areas where sand bags can be used are on steps, stairs, low walls, extant column bases, and original floor surfaces (Figures 1 and 2).

1.1 RELATED WORK

A. SECTION 04200 – MUD BRICK CONSERVATION

B. SECTION 04296 – PROTECTIVE SHORING AND BRACING

1.2 SUBMITTALS

A. Sand bags shall be submitted for approval in advance of any specific project. Material can vary, but for relatively long-term use (greater than one year) they should be constructed of burlap. Bags of non-natural fiber, such as polypropylene, can be used for emergency and short-term use and where they are not exposed to sunlight.

B. Sample sandbags in the required size and fabric shall be approved by the owner’s representative prior to the placement of a substantial order well in advance of a specific need and a proposed field season.

1.3 QUALITY ASSURANCE

A. See Section 04200 Part 1, 1.6 for the general requirements of the conservation project and the specific requirements related to the selection of materials and the handling of the materials for general conservation requirements in Sections 04210 and 04230.

B. The owner’s representative shall approve modifications and/or changes to the specifics of this section. No modifications or changes shall be made to the general intent of this section.
1.4 ENVIRONMENT CONDITIONS
A. There are no restrictions on the manufacturing/filing of the bags and the construction of the buttresses, except those that might affect human health and safety.

1.5 TEST PANELS (MOCK UPS)
A. There are no mock ups for the work of this specification.

PART 2 PRODUCTS

2.1 MATERIALS
A. Sand for the sand bags shall be the archeologically cleared sand from excavations with the addition of local loam. The best material for the sand bags is a sandy loam. If sand bags are fabricated separate from an excavation, site sand can be used as well, if it is archeologically cleared. Final material selection shall be approved by the owner’s representative.

B. Sand bags shall be constructed of untreated burlap, approximately 35-45 cm wide (14-18”) and 75-90 cm long (30-36”). Larger bags are too large to handle.

C. Polypropylene sand bags can be used in emergency, for short-term use (less than one year) and for bulk areas where they are not exposed to sunlight. They should be the same approximate size as the burlap bags.

D. Natural fiber sand bags with tighter weave than the burlap can also be used for small-scale application. Light cotton or similar natural fiber material can be used for smaller bags. The size should be approximately 25-30 cm wide (10-12”) and 40-45 cm long (16-18”).

PART 3 EXECUTION

3.1 GENERAL
A. Proper safety precautions are necessary prior to the beginning of the actual placement of the sand bags. Protection from falling debris shall also be in place prior to any work. All personnel not part of the conservation team shall not approach to within 20 meters of the work areas.

B. The removal and the loss of original fabric shall be minimized during the placement of the bags. Little removal is anticipated.

C. There shall be a minimum number for emergency use of 100 filled burlap bags and 100 smaller filled bags.

3.2 PREPARATION
A. Determine the specific extent of the need and establish a priority for sand bag protection; the highest priorities should be in the area of the greatest amount of human foot traffic. The specific details of the bag placement shall be determined prior to the beginning of construction.

B. Filling sandbags: Filling sand bags is a two-person operation, one holding the bag and the other filling. The most effective way is to use a rounded point shovel to fill the bags. The bags should be filled approximately 1/3 full. The method of tying the bags will determine if the bags can be filled more than 1/3.

C. Tying sand bags: Sandbags shall be tied or sealed by either tying with steel wire, with heavy cord, or by stitching the open end. The most effect is tying with wire.

D. It is not necessary to clean area of loose sand before the sand bags can be placed.

3.3 PLACE SAND BAGS
A. Place sand bags to prevent food traffic abrasion as well as to prevent the force of people walking dislodging walls, mud bricks or features. It is difficult to use too many sand bags. Sand bags should be a minimal of two bags thick in heavy traffic areas. Figures 1 and 2 are typical areas where sand bags should be placed.

B. Place the sand bags 5-10 cm from the wall surfaces. Fill the space between the sand bags and the feature with sand to serve as a separation (Figure 3).

C. Place the bags parallel to the wall or feature being supported; place succeeding bags on top, offsetting by one-half (½) the length of the previous bag. It may be necessary to form steps of the bags for easier human access.

D. Place bags level or slightly inclined toward the wall. Stamp each individual bag in place once it is placed.

E. It may be necessary to place the sand bags so that human access is restricted by making it difficult to step over the bags.

F. Monitor the effectiveness of sand bags and replace and add additional ones as necessary.

G. Sand bag protection should be supplemented by restricting use to some areas by the installation of stakes and construction tape, or construction fencing.
Figure 1: A typical room in the Abdallah Palace with the remains of a low patrician wall that should be protected during human access.

Figure 2: Another typical room with multiple surfaces, low walls, column bases that should be protected with sand bags.

Figure 3: A sketch of a low wall showing the use of sand bags to protect it. This wall would be similar to the walls of Figure 1.

END OF SECTION 04297
SECTION 04500 STONE MASONRY

PART 1 GENERAL

1.1 DESCRIPTION: The work of this section includes repair stone masonry of the Atturaif structures. Figures 1-4 are examples of the stone masonry that are the subjects of this specification.

1.2 RELATED WORK
A. SECTION 04200 – MUD BRICK CONSERVATION
B. SECTION 04220 – SURFACE RENDERING
C. SECTION 04240 – MUD GROUTING
D. SECTION 04250 – MUD BRICK CONSTRUCTION
E. SECTION 04280 – MUD BRICK CAPPING

1.3 SUBMITTALS
A. Any substitute materials submitted for the repair of the stone masonry shall be approved by the owner’s representative prior to their use in any of the crack repair procedures. In addition, the specific use of substitute materials shall be demonstrated in test panels prior to approval.

1.4 QUALITY ASSURANCE
A. See Section 04200 Part 1, 1.6 for the general requirements of the conservation project and the specific requirements related to the selection of materials and the handling of the materials for general conservation requirements.
B. All repairs as specified in this section shall be tested on site to ensure that the specifics of this section are compatible with the site conditions and the materials that are utilized in the repairs. The owner’s representative shall approve modifications and/or changes to the specifics of this section. No modifications or changes shall be made to the general intent of this section and all modifications and/or changes shall be consistent with the general intent as stated in Section 04200, Part 1, 1.6 and to this section, Part 1, 1.1 above.
C. Patching material to have characteristics similar to the most masonry.

1.5 ENVIRONMENT CONDITIONS
SECTION 04500 STONE MASONRY

A. Do not repair at temperatures less than 5 degrees Celsius, or if temperatures are expected to be less than 0 degrees Celsius within 24 hours.

B. Protect drying stone masonry from direct rainfall during the curing process. Mist curing masonry to prevent cracking and rapid drying.

C. See Section 04200, Part 1, 1.7 Environmental Conditions for general restrictions.

1.6 TEST PANELS (MOCK UPS)

A. Mockups will be produced, until the owner’s representative is completely satisfied of the results. Mockups should include several of the other conditions such as the different types of foundation stones and the different masonry systems on the site.

B. Mockups for the repair of coursed rubble masonry shall be prepared and approved by the owner's representative prior to the continuation of the repair. The test panel shall be part of the original structure and shall remain after approval as the standard for that part of the work. It shall also remain a part of the final conservation treatment.

C. All repairs as specified in this section shall be tested on site to ensure that the specifics of this section are compatible with the site conditions and the materials that are utilized in the repairs. The owner’s representative shall approve modifications and/or changes to the specifics of this section.

PART 2 PRODUCTS

2.1 MATERIALS


B. Sand:
   a. Choose well graded sands (#6(3mm):#200(75microns)).
   b. Choosing the correct sand when making a mortar is of extreme importance.
   c. Sands should be clean and uncontaminated by clay/silt. These occur in the range from #300 (0.04mm) and below and the most effective method to establish their presence is the wet sieve analysis. Normal dry sieve analysis does not accurately reveal the presence of clay or silt (particles passing #200 (0.075) sieve). This is due to the fact that when the sand is dried before sieving,
B. The removal and the loss of original fabric shall be minimized during the repair.

C. The effect of the repair shall not distract from the existing visual character of the wall where the repair takes place unless the crack repair is to be hidden behind other subsequent repair.

D. Place horizontal and vertical string lines in section of new mud brick repair after the removal of the existing mud bricks to ensure that the repair is consistent with the existing form and mass of the existing masonry.

E. Selection of stones for masonry repair: Stockpile sandstone similar in character to that used in existing masonry utilizing stones secured from building as well as supply from local sources.

F. Preparation of stones: Have adequate supply of sandstone on hand for repair of a wide range of sizes.

a. Brush soil, deposition from surface of stone. C. Wash stones in water if necessary to further clean. Stones used in masonry shall be clean and free of contaminants.

b. Soak stones in water containers; remove adequate supply for one day’s work the day before use and store in dry container, covered with tarp or equivalent to reduce drying rate. Water containers shall be clean and contain no contaminants or residue from previous uses.

c. Dip in lime water immediately prior to use.

d. Shape as needed and dip again as necessary; if lime begins to form on surface on drying, brush surface with stiff bristle brush and rewet with potable water.

G. Preparation of masonry surface for repair:

a. Brush surface of all loose materials and depositions.

b. Rate mud mortar joints to minimum depth of approximately 1 inch for pointing.

c. Remove loose stones and clean remaining voids.

d. Continually brush surface to remove dry deposition and loose friable materials.

e. Remove soft friable stone surfaces that continue to powder with trowels until sound materials or for additional depth of maximum of two inches (2”).

f. Replace or reset small stones if they are loose or dislodged.

g. Reset large stone if they are loose.

h. Dampen surface with potable water from spritzer (spray bottle). Stones will absorb water immediately; continue to spray stones until rate of absorption slows. Do not overspray that results in water running freely down surface of existing wall surface.

i. Restrict amount of water applied to mud mortar. Do not spray directly.

j. After initial wetting of surface spray with lime water. Repeat wetting with lime water in soft friable areas; spraying shall include lime and mud mortar. Lime water mixed to consistency of non-fat milk. If lime accumulated and forms surface on stone after one application, further dilute lime wash.

k. Brush surface immediately prior to repair. Brush any lime that has accumulated on surface of stone and rewet with potable water.

H. Preparation of lime mortar

a. Dry mix mortar and ½ amount of sand; continue to mix while adding the remainder of the sand.

b. Add water and mix for minimum of 10 minutes. Mortar shall be mixed prior to use, covered to prevent excessive evaporation of water and remixed immediately before use adding only a minimal amount of water.

c. Mortar mix should be as dry as possible for the intended use.

d. Hydraulic lime does not need to be slaked prior to mixing. Non hydraulic lime does require re-slaking. See Section 04240; 3.2, of these specifications.

I. Pointing of Existing Masonry

a. Brush overall surface immediately prior to pointing and repair.

b. Masonry should be rewetted continually with hand water sprayer containing lime water. Wet existing mud mortar as well as stone.

c. Brush stone of lime film in contact with mortar.

d. Spray lightly with potable water prior to application of mortar.

e. Pack mortar in voids and joints as tightly as possible. If mortar is too wet to pack, wait several minutes until mortar is drier and can be compacted.

f. Grout deep cracks that can not be pointed effectively.

g. Wedge all stones into voids and holes where possible.

h. Work the joints and the mortar quickly and do not overwork.

i. Repaired areas shall have a predominance of stone visible rather than mortar if that is the character of the original material. Match the original texture as much as possible.

j. Set all stones with bedding planes flat or match the existing character where the stone masonry systems remain exposed.

J. Stone Replacement

a. Stones that are completely fractures and either come apart or become loose when preparing the surface should be reset or replaced with similar stone. Some shaping will be necessary.
SECTION 04500 STONE MASONRY

b. Prepare voids as described previously by cleaning and brushing exposed voids and applying water and lime water. Reset stone with stiff mortar and force stones in mortar.

K. Repair of Large Holes and Voids

a. Prepare holes and voids as described previously by brushing and cleaning loose and friable materials. Apply water and lime water until prior to actual repair. Rewet with lime water, brush surface lime by brushing and apply final application of potable water prior to application of mortar.
b. Fill voids with the largest stone possible with sufficient mortar to set stones. With deep voids, greater than 6 inches, fill in two applications allowing one day (24 hours) between applications.

L. Curing. Work in the shade; drape wall repaired with burlap or equal and keep damp during day until dehydrated.

Figure 1: Stone wall in the archeological zone – weathered side.

Figure 2: Detail of slab stone masonry wall.

Figure 3: Coursed rubble masonry wall in archeological zone.
Figure 4: Mixed stone and mud mortar wall.

END OF SECTION 04230

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PHASING & GENERAL SPECIFICATIONS

1. SIGNS AND SECURITY
2. PROPPING AND REINFORCEMENT
3. CLEARING AND TRANSPORTATION OF RUBBLE
4. ROOF REMOVAL
5. WOOD TREATMENT
6. INTERVENTIONS ON FOUNDATIONS
7. CONSTRUCTION OF NEW DOUBLE WALLS
8. ROOF RECONSTRUCTION
9. RESTORATION OF ANCIENT WALLS
10. PLASTERS / FINISHINGS
11. FLOORS
12. CLEANING
Construction sites where the conservation of earthen cultural heritage monuments takes place are different from other construction sites, due to the fact that the fragility of the structures may increase the risk of accidents. Thus, the active participation of all stakeholders in security-related activities (prevention and awareness) is instrumental. These actions concern both the site workers and the visitors.

A construction site where conservation and restoration activities take place involves a large number of stakeholders, who usually do not know each other very well and do not share direct contractual relations. The general coordination of all stakeholders is required before the launching of the construction works takes place.

For this, the following should be considered:
- Refer to the Saudi regulation;
- Naming a coordinator of security and protection;
- Training and informing workers, entrepreneurs and other stakeholders on the specificities of the site;
- Ensuring that all stakeholders are involved in the prevention of risks;
- The project managers in collaboration with the security coordinator must implement a general organisation of all activities related to the construction works.

Before the launching of conservation works, it is advisable to install security signs near the entrances to the construction site in order to limit the access to the site, granting it only to people who work there. The security signs will also inform visitors and other people of the risks and dangers they may encounter when approaching the area where the construction works take place. Access to the construction site should be monitored. To that end, project management officials should issue a special permit to all workers.
The state of conservation of the structures in the intervention area ranges from average to poor and the risk of wall and roof collapse is always present. Both exterior and interior walls and roofs are weakened by various pathologies and might not be able to withstand an intervention without being propped up and secured. Thus, to ensure ongoing work stability of old structures and ensure the security of workers and visitors it is essential to treat the walls and roofs through propping and scaffolding while allowing free access to the structure portions where work must be undertaken.

The placement of props inside the houses must be studied beforehand (propping plan) to ensure maximum safety and facilitate/ensure the movement of workers, allow the smooth transportation of tools and construction materials and the accessibility to areas requiring an intervention.

The scaffolding must be installed on the outside of the structures. In some cases, it could be used to support the exterior walls while facilitating access to the roof and upper walls. The stability of such a buttressing scaffolding needs however to be carefully studied.
This phase will take place once the site is secured. It implies the transportation, over the whole site, of all the rubble and debris. The cleaning and removal of rubble must be done with adapted tools (shovels, picks, wheelbarrows). Vibration-producing tools are not recommended because they may be dangerous to the fragile structures and increase the risk of collapse.

It is also recommended to prepare in advance a plan to handle the rubble and debris of the site, and to organize their transport and evacuation away from the construction zone onto outside locations chosen for this purpose. If only small vehicles like the bobcat are allowed to move near construction work areas, various types of vehicles could be used at other stages.
This layer of 20 to 40 cm constitutes a considerable weight which represents a potential threat in case of collapse. To reduce this threat on the structures (walls, columns, beams) and to limit the potential damage in case of collapse, it is recommended to remove the layer of soil until the first wooden joists (Ethi) become visible. Afterwards, the structural elements (joist) which are in bad state will be removed one by one. The joists that are in a good state of conservation can be reused while those attacked by termites or in poor condition must be disposed of. If no special structures is to be installed under the roof structure, joists in good condition can be kept in place. This operation is very difficult because in most cases the joists are well anchored into the walls and sometimes they even go through the walls. If this is the case, the joists must be cut with a saw tangent to the surface of the wall. The detachment of joists from the walls through digging with vibrating tools is not allowed for it could cause additional damage to the walls.

For unstable walls or walls without bracing, it is recommended to leave some of the joists as a way to maintain the stability of the sidewalls. One solid joist every metre is sufficient for this purpose. Once the placement of new joists is completed, the old ones can be cut and replaced. Finally, the beams, being structural elements, must be maintained in place through the restoration process.
**WOOD TREATMENT**

The condition survey revealed the existence of termites that attack wood and all materials of vegetal origin that are used in the construction of the roofs and the woodwork. Termites are also present in walls and floors. The types of wood used in Atturaf (Tamarisk, Ethe and also palm wood) are sensitive to biological attacks from insects (termites, Capricorn beetles) or fungi.

Today, insecticides and antifungal substances and also cocktails of chromium, copper and arsenic (known as CCA) are used as a means to counteract these damaging factors. These toxic products will soon be banned. The products used for the treatment of wood include:

- Products for the preservation of wood. They contain at least one active biocide agent (pesticide) to protect the wood against the attack of lignivorous fungi and some so-called xylophagous insects, which are considered as biological attacks.

  The first may contain ingredients used as paint; the latter may contain biocide agents intended to preserve the wood. Only products that are safe and environmentally friendly will be used.

  All wood to be used in the restoration of the roof structures will be treated beforehand against termites and against moisture. The anti-termite treatment must take place outside of the site.

  The ends of the wooden elements to be sealed into the walls must be treated against moisture with a layer of asphalt. The main function of this type of treatment is to prevent the infiltration of water into the wood and ensure its waterproofing.

  For the in situ treatment of decorated beams against xylophagous insect larvae, professional know-how is required in order to avoid the degradation of the decorative motifs. The suggested method is as follows:

  - Brush and remove dust in order to allow a better penetration of the products on the wood;
  - Remove the portions that are highly eroded and infested and determine the sources of the attacks
  - Make holes in the wood to receive the injections
  - Inject under pressure the wood treatments for large-section beams
  - Finally, spray the product on the surface until a saturation of the wood is noticed.
The stages of intervention
For the implementation of works to consolidate the foundations of the walls, it is advisable to carry out the work one side at a time and to intervene as follows:

1. External surface
   - Start with the external surface;
   - Dig a foundation trench, 50cm-wide and as deep as needed to reach the bedrock;
   - Clean the old stone masonry, clear joints;
   - Build the new foundation, 30cm wide with drainage and 50cm without drainage) by creating a junction between the stones of the old and new masonries;
   - Use a mortar made of sand and gypsum;
   - Give particular attention to the achievement of the last layers of the foundation by shaping a sloping wall to the streets to ensure an optimal evacuation of water into the street drainage system;
   - For the foundation with peripheral drainage, the rest of the trench will be refilled with gravel, 2 to 5 cm in diameter, separated from the ground by a geo-textile. Make sure to fully compact the gravel.
   - For foundation without peripheral drainage the trench shall be completely filled with stone masonry;
   - The installation of drain will depend on the results of the studies carried out by Buro Happold about the infrastructure and drainage of streets and alleys.

2. Internal surface
   - Dig a foundation trench, 50cm-wide and as deep as needed to reach the bedrock;
   - Clean the old stone masonry, clear joints;
   - Build the new foundation, 30cm-wide by creating a junction between the stones of the old and new masonries;
   - Continue the stone foundation masonry (20-cm thick) up to 50 cm from the ground level of the interior rooms;
   - Ensure that the level of the last layer of stone masonry is horizontal in order to serve as a proper base for the construction of the mud brick “adobe” wall;
   - Use a mortar similar to the mud brick mixture.

For the partial reconstruction of the old walls, it is recommended that an underpinning of the foundation is made, up to 50 cm from the ground level.

This type of intervention only concerns the peripheral walls of the housing units. The goal is to strengthen structural resistance of the foundations and to create a resistant base against ground humidity and water infiltration. This new foundation backed against the wall will also serve as some sort of bench following the slope of the street and will protect the wall base against water flowing. The walls in this area are quite thin (32 to 38 cm-thick in most cases) and can be quite fragile as they are not connected to perpendicular cross walls and cannot bear the weight of a new roof on their own. Thus, to compensate for the lack of connection between the masonry walls on the facade and the orthogonal walls, and also in order to ensure their stability, a cross wall will be built providing a link between the old wall and the new walls through the use of tie-rods.

Before the launching of underpinning works it is necessary to strengthen the preserved ancient facades, through propping done externally and not on the internal parts of the building where work needs to be carried out.
PHASING & GENERAL SPECIFICATIONS

CONSTRUCTION OF NEW DOUBLE WALLS (WALL DOUBLING)

Prior to building the adobe masonry wall (30x20x10) that will serve as a furring wall (20 cm thick), all walls perpendicular to the angle of crossing should be carved out over their full height, forming a narrow gradient trail at the level of the base of the wall and wide at the top (see detail N° ...). This opening will allow for the crossing of layers of bricks between the new furrowing wall and the ancient walls to be preserved.

To achieve this, the contractor should ensure that the walls are well shored up. The tool best suited to accomplish this task is a circular saw because it causes only few vibrations. The instructions are the following:
- With chalk and a ruler, trace out the portions of the wall to be removed
- Saw a 5cm deep cut along the tracing
- Saw deeper to 10cm and then to 15cm by adjusting the depth of the circular disk

The adobe masonry is launched once the stone foundations are completely dry. It takes at least one week for the drying and settling to be completed. The contractor shall proceed as follows:
- Provide special care to the first base of adobe bricks to maintain a horizontal level along the entire length of the wall;
- The bricks are set in successive layers with crossed joints;
- The bricks are assembled with a mortar made of earth mixture in a plastic state;
- The thickness of horizontal and vertical joints should not exceed 2cm;
- Work carried out in one day should never exceed 5 layers; and the new courses will be added only after two days drying;
- Be careful with the brick bonds when dealing with connections with perpendicular walls;

Mari-Syria
Dealing with the bases of walls and their renovation:

Intervention at the base of the walls is a most delicate operation to achieve as special procedures need to be taken. The walls are generally quite degraded at the base, which in turn makes them very fragile. Moreover, the fact that the walls are not quite thick complicates matters even further. This procedure should be taken care of by skilled personnel, trained in restoration techniques.

For the treatment of profound and continuing undercut, the contractor shall proceed as follows:
- Install propping of the wall on both sides;
- Divide the wall into several lengths (for a 3m wall, it will be divided into 3 lengths of 1m each: A, B and C);
- Create an opening A in the wall;
- Install wooden supports to support the opening section;
- Padding of section A and then continue with C and finally B;
- For thick walls whose thickness is greater than 40cm, intervention is done on both sides. The principle of intervention is the same except that work cannot be carried out on both sides at the same time;
- The first layers of masonry padding should be made of stone, forming a plinth with a minimum height of 30cm;
- The last layer, which provides contact between the repaired portion and the wall, must be implemented after the settling and drying of the padding;
- The last layer is to be completed with flat stone elements.

Treatment of gullies

The infiltration of rainwater from the roof produces deep gashes in vertical walls. The technique proposed for repair is to cut in a "V" shape the portions of the wall that are damaged by water, and to replace them with adobe brick masonry as follows:

- Trace the area to be cut in the shape of a reverse stair pyramid;
- Follow the same technique of cutting explained above;
- Work from top to bottom to empty the chosen portion of the wall;
- Implement adobe masonry. Work is to be done slowly, with daily not more than 5 courses of adobe blocks, and allowing a one day drying before masonry work is continued.

Treatment of structural cracks

Before a crack is repaired, one has to check if the works needed to eradicate its cause has been treated. (The causes can be found far from the crack itself, at the base of the building for example. The deformation is usually due to a stagnation of water at the base of the building after an accidental change of topography : collapsed wall, accumulation materials or rubble, etc.).
Once the cause is eradicated, the crack can be treated. It is then possible to proceed as follows:
- Clean the crack to remove dust.
- Insert wooden elements in masonry, sealing them inside the mud or lime or gypsum mortar at least 15 cm deep;
- Cap and seal the rest of the crack with an earth plaster.

Dismantling the walls
Very few walls need to be dismantled. For portions of walls that need to be torn down, this should be done as described in the treatment of gullies.

Mounting walls
The reconstruction of collapsed walls must be made starting from the foundations (the same procedure as for wall doubling).

Columns
In some cases, the columns need to be strengthened at their base. The strengthening of the foundations is carried out after the columns are proped. It is then possible to proceed as follows:
- Dig a foundation trench 50cm wide around the column;
- Fill the trench with stone masonry up to the base;
- Strip layers of plaster;
- Strengthen drums' stone structure with chicken wire (detail N°…);
- Apply a lime or gypsum based coating (sand and lime);
- Treatment of ancient openings (doors and windows)
  For existing doors, two types of intervention are possible:
  - An intervention on door jambs - to repair door jambs, it is recommended to use a stone masonry to strengthen angles which are often very exposed to human contact (see detail N°…)
  - An intervention on the lintels and the area above the lintels (see detail N°…)
- For existing windows, a custom-made wooden frame is inserted into the opening and then sealed with plaster (see detail N°…)

Treatment of new openings (doors)
For expansions and new doors, the insertion of a lintel to strengthen the structure of the wall is needed. We must proceed as follows:
- Draw placement where opening in the wall is to be made (see detail N°…);
- Insert on each side of the wall a wooden lintel of sufficient length to ensure a proper placement on the jambs. Insert a piece of flat wood to allow the insertion of the lintel on the wall and a better distribution of loads;
- Fill empty areas above the lintel (using flat stones and plaster);
- Saw the contours of the parts to be emptied out;
- Gently remove the adobes bricks;
- Build the door jambs (stone plates assembled with a lime and earth plaster);
- Install at the threshold of the door slab of prefabricated concrete;
- Insert wooden frame;
- Screw in the lintel and in the concrete slab on the ground (threshold);
- Fill in gaps around the wooden frame.

Doors and stair steps
In some cases, creating openings for the passage from one unit to another may require the installation of one or several steps depending on the level difference between the two units. These stair steps should be made of stone masonry, with a foundation reaching bedrock level (see detail N°…).
The implementation of roof terraces deserves careful attention and continuous maintenance as they ensure the protection and durability of the building. Very often occupied, they wear faster than the rest of the building. Once a roof is neglected, serious damage caused by water infiltration starts to take place.

Important factors ensuring the proper functioning of the roof are:
- A sound main wooden structure;
- The resistance to water of the roof;
- The slopes that provide water flow directed towards the gargoyle.

- The thermal mass of the earth that provides a good insulation of the building;
- The good design and realization of gargoyle that ensure the proper evacuation of rainwater;
- The parapets that protect the tops of walls.

Production

Once the restoration work on walls and other vertical elements is completed, the reconstruction of the roof may start as follows:
- Installation of wooden chaining (when specified in the restoration project);
- Installation of joists (on chaining if applying) at regular intervals (25cm max);
- Fixing of joists in the walls;
- Installation of steel tie-rods between the joists and the walls outside;
- Stone furring of parapet wall;
- Pose of palm mats and branches (treated against termites);
**ROOF RECONSTRUCTION**

- Pose of palm leaves;
- Pose of a layer of geotextile to protect from dust;
- Pose of a layer of compacted earth of 15 cm;
- Laying of mud-straw bricks to ensure a better thermal insulation;
- The laying of bricks is done with an earth-based mortar to create slopes on the roof;
- Construction of gargoyles where indicated on the drawings (detail N°...);
- Installation of a sealing;
- Laying of fired brick tiles (40x40x04) on a sand-lime mortar;
- Pose of fired earth tiles as a plinths;
- Finishing with a thin layer of earth-sand-lime mortar (tests to be made to adjust the composition);
- Capping of the parapet with a mud mortar.

Maintenance of roof terraces and parapet walls

The maintenance of the roofs and parapet walls ensures the sustainability of the buildings. After each rainy season, the roof must be checked, the surface cleaned, the gargoyles cleared, the cracks sealed, and the slopes corrected where there have been settlements, to avoid water stagnation. The partial repair of eroded parts is resumed after every rainy season.
Exterior earthen plasters
The application of earthen plasters is done in five steps:
- Cleaning the wall: walls should be scratched, dusted and thoroughly soaked with water before applying the coating to remove brittle pieces and dust particles clinging to the surface.
- Preparation of the earth: the mud-straw mixture is prepared several days in advance, brought to a plastic state and then mixed again before application.
- Preparation of the wall surface: a good surface preparation is essential to avoid problems such as cracks, and surface detachment. Heavily eroded walls require a preliminary straightening, the gaps should be filled and a flat surface restored on which the main coating will be applied evenly. This surface will remain rough to allow the adhesion of the following layers. The layers must remain thin (15 mm maximum), because these fragile walls cannot stand heavy coatings.
- Application of the plaster: it is done by strongly throwing balls of mud against the wall hand and smoothen with a wooden flattener, on a pre-wetted surface. To avoid cracking linked to fast drying, it is preferable to coat the walls while they are in the shade.
- Finish: When the main coating is dry, a light coat of earth (mixed with fine chopped straw) and water (high water content) will be applied with a brush to fill-in the micro-cracks and get a regular surface.

Selection of suitable soil for mud plaster: testing In order to select the suitable soil for the mud plaster a simple test can be done to check the performance of available soil, and find the best mixture of mud-sand, or mud-chopped straw if the soil is too clayey.

Implementation of the test:
- Wet samples of earth to obtain a plastic mixture. This will preferably be done a few days in advance.
- If the soil is very clayey, prepare samples of soil + sand with different proportions
- Apply the earth plaster on a wall, cleaned and moistened, on 40 x 40 cm squares
- Mark the reference samples
- Observe the results after the drying cycle is completed.

Results:
• The mixture selected must adhere to the wall
• The plaster should crack only slightly
• The colour should match the buildings around.

External coatings, stabilized with lime
Lime is primarily used to stabilize the external surfaces on walls, patios and parapets, as a way to increase their resistance to erosion. Tests need to be carried out to check compatibility and define correct mixture.

Implementation:
The outer coating is composed of three layers:
- Base coat (1 to 1.5 cm): this layer is made of mud or a mix of mud + sand. It will provide a better grip if it contains chopped straw.
- Main layer: thick layer of 0.5 to 1 cm. It is composed of 3 parts earth / 2 parts sand / 1 part lime.
- Finish plaster: applied on an almost dry main layer, it allows the filling of any small cracks in the wall. The finish plaster must be very fine (2 to 3 mm). Its composition is richer than the main layer coating: 1 part earth / 1 part sand / 1 part lime.

Interior plasters:
Interior plasters can be made with mud-straw mixture only, or with stabilized earth. The stabilization will make the surface more resistant to abrasion, but this is not essential in dry areas. An interesting and inexpensive solution is to stabilize only the finish plaster, to be applied over the main layer.

Base coat:
As for external coatings, it is best to prepare the walls by cleaning and applying a base coat, to homogenize the wall surface. This layer provides a better grip if it contains chopped straw.

Finish plaster stabilized with slacked lime:
To reduce the costs of stabilizing, only a thin layer on the surface may be stabilized. This layer is applied over the main layer made of earth or of a mixture of earth and sand. The recipe given here should be tested and adapted based on the characteristics of the earth. The usual proportions for a thin layer of finish plaster inside stabilized are:
• 1 part earth
• 1 part sand
• 1 part lime

This recipe needs to be checked with preparing samples with varying proportions that will be tested.
The treatment of floors is done as follows:
- Removal of at least 30 cm of mud floor layer inside the rooms and in the courtyards;
- Treatment of the soil against termites (spraying);
- Installation of drainage system in the courtyards;
- Installation of drinking water and sewage networks;
- Installation of a bed of gravel to ensure protection against damp-rise;
- Installation of a layer of geotextile fabric to keep the gravel layer clean;
- Addition of a layer of well-compacted earth;
- Installation of electrical and plumbing network inside the compacted earth layer;
- Placing of stone paving or fired brick tiles on a sand-cement mortar (sloped);
- Installation of wet areas (bathrooms/toilets)

Installation of wet areas (bathrooms/toilets)
A leak can lead to serious damage. It is advisable to create a wall doubling to fix all the necessary facilities. It is also recommended to keep the pipeline apparent, as well as the power network that should be installed in chutes.
INTRODUCTION

It's recommended that repairs should be minimal and should only be implemented to reduce the risk of decay and to propose treatment for structural pathologies in a “passive” way, by using adapted solutions. The structures of the selected sector (area A, B, C, D) for re-use should be conserved as they exist, with minimal intervention. The re-use of part of the domestic residence quarter is compatible with UNESCO approach as it does contribute to the overall long-term sustainability of the development project. However, it is fundamental to find a balance between the environment of the site, the original characteristics of the buildings to be re-used and the concept of transformation required for their future function.

Past experiences have revealed that “active” conservation methods, aiming at changing the physical properties of the earthen material (waterproofing, introduction of intrusive materials like cement, chemical treatments...) are ineffective, or even irreversible. Therefore, all implemented conservation works should be minimal, and should respect the authenticity of the site by using the same types of local materials, the Najd architectural techniques (know-how and traditional techniques), and respect of the environmental development of the site.

In addition, the proposed solutions should also be designed to fit in the social, cultural and natural environment of the Wadi Hanifa region. They should make use of the existing materials, and be based on the techniques which were well mastered locally. The proposed conservation methods should be inspired by the architecture of the ruins, and should refer to the ancient know-how. All these features and characteristics should be properly preserved and adequately presented to visitors.

The historical background is necessary to understand the history of the site and the main constructive periods in order to obtain the definition of a comprehensive conservation and re-use concept respectful of the structures, and to act in accordance with international rules, ethics and standards to rehabilitate and revitalize this exceptional heritage.

The balance between maximum understanding and minimum intervention is an essential equation.
OVERALL RECOMMENDATIONS

All solutions suggested in this manual for the treatment of different pathologies are only based on field observation. This work should be imperatively completed in the future by a systematic monitoring focused on specific problems observed in the Atturaif site and fine tuned with the results and experience gathered at the occasion of the realization of the pilot phase.

Depending on the state of conservation and the origin of the degradation of each unit, different treatments and conservation techniques may be applied. This can include the following actions, which need to be more developed and more adapted during the "pilot conservation project":

- Treatment of the surrounding environment of the structure;
- Restoration of the wall base with intervention to solve drainage problems;
- Add anti-capillary treatment, structural reinforcement, and treatment of the undercut;
- Intervention on the top portions and vertical surfaces of the wall by stopping the causes of direct rain water erosion, after which an improved mud plaster is applied to the restored walls;
- Treatment of the roof to ensure a good flow of the rain waters for a better drainage and distribution towards the gargoyles. Intervention on the roof will consist by the removing of original materials, treatment of the wooden beams and joists, improvement of the roof drainage and the waterproof system to drain rainfall water outside the terraces. The gargoyles system also needs to be improved to avoid water-related pathologies;
- Strengthening and rebuilding the collapsed parts of the walls: The unstable or dangerous parts are to be carefully dismantled, cleaned and reconstructed, using the same techniques and materials. To reinforce the structural function of the walls, a wooden ring beam is recommended to channel and to tie the external walls to the perpendicular internal ones;
- Restoration and partial reconstruction of the parapets.

Conservation techniques

All solutions for treatment proposed in this manual to solve different pathologies are only based on field observation. This should be imperatively completed in the future by a systematic monitoring and the implementation of the "pilot conservation project".

Conservation techniques selected must be tested first before being applied on a large scale. The conservation techniques proposed for this type of monuments include:

a. For the wall base (The repair of the wall base should be integrated structurally with the existing system)
   - Treatment of the surrounding environment of the structure (cleanings and drainage)
   - Restoration of the wall base with structural reinforcement of the stone foundation
   - Peripheral drainage and improvement of the evaporation system
   - Reduction of the capillary section of the wall and treatment of the undercut

b. For the Vertical faces of walls:
   - Reconstruction of collapsed wall
   - Structural reinforcement of the walls (ring beam)
   - Treatment of guillies and gaps
   - Improvement of traditional plasters
   - Protective coating

c. For the top of walls and parapets:
   - Restoration and partial reconstruction of the parapets
   - Improvement of traditional plasters
   - Protective coating
   - Sacrificial capping

d. For the roof, terraces and wall junctions:
   - Treatment and replacement of the wooden beams and joists
   - New wooden ring beam to reinforce the junction between the external walls and the perpendicular internal walls
   - Improvement of the water-proofing and unsulating system of traditional roof
   - Improvement of the drainage system of the terraces (slopes)
   - Improvement of the gargoyles system

e. For the ground surface:
   - Drainage of the soil (gravel bed)
   - Surface treatment (pavement)
Project development for bloc A, B, C and D

The proposed Atturaif Traditional Demonstration Area, previously referred to as the Traditional Souk, has been divided into four zones:
- Zone A: located at the west end of the demonstration area extends from the Salwa Palace to the proposed Life Style area. It forms a coherent and contiguous block separated by the Salwa palace from the proposed extension to the east.
- Zone B: incorporates food related functions clustered around the open courtyard east of the palace of Abdullah and south of the Salwa Palace.
- Zone C: consists of buildings along the formerly designated Street of Senses to the east of the food court area.
- Zone D: incorporates buildings along the street extends north towards the Sabala of Moudhi and the Treasury Building.

The conservation and the reuse project propose two phases:
Phase 1 will include the restoration and rehabilitation of Zone A and Zone B for the reuse of the existing buildings.
Phase 2 will include the stabilization of Zones C and D without modification in order to retain flexibility, as they may be developed and used in different ways. These zones will be reserved for future development pending input from experience gained in operating the Phase One demonstration zone.

It was recommended that the buildings in Zones C and D will be renovated in a second stage of site development following the completion of Phase One development.

It was also recommended that future renovation and adaptive reuse of the buildings in these zones will be undertaken under the direction of conservation and management staff of the site and that the program of conservation and reconstruction will be part of the public demonstration program of the Museum. In keeping with internationally recognized standards of operation for programs to encourage the retention of traditional crafts and vernacular architecture, there will be opportunities to use the restoration program as both a training program to support traditional crafts and a demonstration program for public education.
Conservation options for bloc C and D

The concept of stabilization planned for bloc C and D consists to conserve the unit area as it is with minimal intervention. The objective is to establish a situation requiring minimum risk of further decay.

Two options were proposed:

Option 1: Stabilization and preventive conservation

This option suggests maintaining the original fabric of the units within this area. Blocs C and D should only be stabilized and conserved as they are to contribute to the understanding of the residential sector of the site. The main objective is to mitigate the rate of erosion and natural degradation by preventing decay and by proposing soft intervention and optimal conditions for the ruins. In this sector different preventive conservation techniques could be tested to provide for this project a complete spectrum of intervention showing for each case one concept, one approach and one nature of treatment.

Advantage:
- Less works with focus only on the reduction of risk of degradation
- Less cost
- No extent on conjecture in terms of interpretation
- Soft to guarantee the protection of the strict concept of authenticity and integrity
- Demonstrates existing state of this sector
- The development of practices and skills that will be useful for future preventive conservation needs in similar sectors on the site

Disadvantage:
- Limited accessibility of the stabilized area
- Periodic maintenance works
- Presented as a ruin

Option 2: Stabilization and Partial reconstruction of the facade walls

This option proposes a complete restoration with partial reconstruction of the external elevations. This approach is justifiable only with a reuse program. The stabilization of the elevations should include restoration of the outer walls, the roofs of adjacent rooms and internal lateral walls.

The stabilization of peripheral walls across the streets is similar to the intervention developed on bloc A and B. However, the adaptive reuse program proposed by ASG for this area is not definitive and should require in the future adaptation and changes of the fabric already stabilized.

The conservation of this area should be implemented during the first phase of the project and can be developed and followed in the future by an adaptive reuse project. This option proposes also different approach and would be an opportunity to develop the necessary expertise and skills by providing training and education programs for the technical site staff in the field of preventive conservation. The variety of approaches, methods and techniques of conservation is an essential issue according to the variety of situation on the site.

Advantage:
- Similar intervention as bloc A & B
- Potential reuse program for the future
- Accessible
- Total safety for visitors

Disadvantage:
- Large intervention
- Requires complete structural restoration of interior units
- More cost

After discussions and evaluation of the two options, option two has been identified by ADA to meet the conservation and stabilization goals. Only the Exterior Walls and Facades of the buildings across the street will be stabilized according to the technical drawings detailed in this manual. For the structures inside the units, preventive conservation techniques should be applied to maintain the walls and the roofs in the state and to slow down the erosion processes.
STABILIZATION: PREVENTIVE CONSERVATION TECHNIQUES

Existing elevation

After intervention

Original door

Treatment of the roof
Sacrificial coating
Restoration of collapsed walls
Sacrificial plaster
Emergency stabilization
Undercut repair
Structural repair of basal erosion foundation reinforcement
Shoring and bracing
Drainage system
Cleanings and removal of accumulated fill
Emergency stabilization
TRADITIONAL CULTURAL DEMONSTRATION ZONES
CONSERVATION MANUAL

OPTION 2

STABILIZATION AND PARTIAL RECONSTRUCTION

Existing elevation

After intervention
**FOUNDATION**

**NEW WALL FOUNDATION AND WALL MASONRY**

- **F2**
  - Exterior
    - Pavement
    - Cement-sand mortar
    - Compacted soil
    - Geotextil
    - Drainage
  - New wall
  - Stabilized plaster
  - Fired brick Plinth
  - Pavement
  - Cement-sand mortar
  - Compacted soil
  - Geotextil
  - Drainage
  - New foundation with stone masonry

- **F3**
  - Exterior
    - New wall
    - Old wall
    - Fired brick Plinth
    - Pavement
    - Geotextil
    - Drainage
    - Foundation reinforcement with stone masonry
    - New foundation for new walls

**DOUBLE WALL FOUNDATION AND WALL MASONRY**

- **F3**
  - Interior
    - Pavement
    - Cement-sand mortar
    - Compacted soil
    - Geotextil
    - Drainage
  - New wall
  - Old wall
  - Fired brick Plinth
  - Pavement
  - Geotextil
  - Drainage
  - New foundation for new walls

**Detail for addressing the new wall foundation**

**Detail for addressing the double wall foundation**
FOUNDATION

TREATMENT OF WALL FOUNDATION

Cleaning

Reinforcement with stone masonry

Finishing

COURTYARD

Stabilized Plaster

Plinth

Compacted gravelly soil

Geotextile

Drainage

Fondation and basal repairs

ROOM

Pavement

0.00

+0.15
WALL BASE

PROPPING

Temporary shoring and bracing of the old wall during conservation stage.

Wooden shoring and bracing on both sides.

SECTION

ELEVATION
WALL BASE

TREATMENT OF BASAL EROSION

1. Initial state
2. Preparation of the wall
3. Masonry

Undercut profile
Mud brick
Limestone masonry

Lime stone
Mud brick masonry
Stone masonry base

50 cm
WALL BASE

TEATMENT OF BASAL EROSION

PHASING FOR OLD WALL REINFORCEMENT
WALL FINISHING TREATMENT

WALL PLASTER TREATMENT

1. PREPARATION OF THE ERODED WALL SURFACE

2. CLEANING OF THE WALL SURFACE. THE WALL SHOULD BE SCRAPED, DUSTED AND ABSOLUTELY MOISTENED BEFORE COATING IS APPLIED

3. COATING APPLICATION

Leveling coat 10 to 15 mm max

Two coats
WALL TREATMENT

VERTICAL CRACK REPAIR

W2

Crack fill with pieces of stone then mortar cover.

5x7x80 cm Wood section
5x7x30 cm Wood section
Key connection

Detail for repairing vertical and oblic cracks at the wall faces.

CRACK REPAIR AT THE WALL CORNER

W3

Phasing and localizing of wood ties.

12x7x80 cm Wood section
7x5x60 cm Wood section
5x7x30 cm Wood section
Key connection

Detail for repairing vertical and oblic cracks at the corner of walls.
WALL TREATMENT

DEEP WATER GULLIES AND GAPS REPAIR

W4

1  ➔  2  ➔  2
WALL TREATMENT

NEW DOUBLE WALL CONSTRUCTION

The new wall masonry and join connection

Insertion of wooden pieces to fix electricity shaft

Corner connection between new and existing wall
WALL TREATMENT

NEW DOUBLE WALL CONSTRUCTION

W6

1. Initial state
2. Mud brick masonry construction
3. Installation of the ring beam and the connection between joist and old wall
4. Stone masonry parapet construction

Initial state Final state

Treatment of the corner connection between new and existing wall
DOORS AND OPENING

**OP1**

Repair of jambs of existing doors

Detail for addressing damaged existing opening
DOORS AND OPENING

NEW OPENING

OP2

1

2
DOORS AND OPENING

**OP2** NEW OPENING

1. 

2. 

Detail for addressing new opening under existing beam
DOORS AND OPENINGS

LINTEL REPAIR FOR EXISTING DOOR

Repair of the lintel zone for existing doors
DOORS AND OPENING

OP3

Repair of jambs of existing windows

- Wood lintel
- New mud plaster
- New wooden frame
- Windows frame
- Pieces of stone
- Adobe
- Niles
STAIRS AND STEPS

S4 NEW OPENING WITH STEPS

- New door lintel
- New wooden frame
- New opening
- Old foundation
- New base stone masonry
- Concrete base for door frame fixing
- Concrete base for Handrail fixing
- Stone or Tabouck tiles finishing

S5 NEW OPENING WITH STEPS INSIDE THE WALL
STAIRS AND STEPS

NEW STAIRS FONDATION

S2

NEW STEPS FONDATION

S3

Sand-lime mortar

Treatment against humidity

Wooden structure of stair case

Concrete base to fix the guardrail

Pavement

Cement mortar

Compacted soil

Geotextile

Drainage

Stone base masonry

Pavement

Cement-sand mortar

Compacted soil

Geotextile

Drainage
COLUMNS AND BEAMS

C1 REINFORCEMENT OF COLUMN BASE

- Lime plaster
- Base reinforcement
- Stone column drums
- Stone column
- Stone masonry
- Drainage
- Compacted soil
- Geotextile
- Pavement
- Silty clayey sand layer
- Limestone Rock base

C2 TREATMENT OF THE CONNECTION BETWEEN THE COLUMN AND THE PARAPET

- Mortar (cement-sand)
- Water-proof membrane
- Mud-Straw insulating brick (slope 1:100 to 2:100)
- Compacted mud layer
- Geotextile
- Plaited palm-leaf matting
- Stipped palm-leaf spines
- Athl Joist
- Mud brick masonry
- Athl girders
- Stone capital
- Column

Steel tie to connect wood structure of the roof to the old wall

Detail for addressing the connection between the parapet and column.
COLUMNS AND BEAMS

C4  REINFORCEMENT FOR STONE COLUMNS

1. Plaster removal  
2. Vertical reinforcement  
3. New lime plaster

C5  TREATMENT OF THE WOODEN BEAM

Steel tie connection

Traditional internal Beams treatment

Traditional external Beams treatment
NEW ROOF CONSTRUCTION

R3

SECTION

ELEVATION

STEEL TIE

TYPE 1

TYPE 2

SACRIFICIAL CAP

STONE PARAPET MASONRY

NEW WALL

EXISTING WALL

WOODEN RING BEAM

40.40.5 cm Pavement

5 cm Mortar (cement-sand)

Water-proof membrane

20.30.10 cm Mud-Straw insulating brick (slope 1:100 to 2:100)

15 cm Compacted Earth layer

Geotextile

Plaited palm-leaf matting

Stipped palm-leaf spines

Athl Joist

Steel tie to connect new roof structure to old wall
ROOF AND GARDEOYLE

P1 TOP OF WALL EROSION TREATMENT

1. Initial state

2. Removal of the old plaster

3. Stone masonry protection

4. Mud copping

P2 NEW PARAPET CONSTRUCTION
ROOF AND GARGOYLE

GARGOYLE INSTALLATION

P3

STONE PARAPET

(1, 1, 1) SAND-SOIL-LIME

40, 40, 5 CM PAVEMENT

5 CM MORTAR (CEMENT-SAND)

WATER-PROOF MEMBRANE

MUD-STRAW BRICK (SLOPE 1:100 TO 2:100)

SAND LIME MORTAR

15 CM COMPACTED EARTH LAYER

GEOTEXTILE

PLAIDED PALM-LEAF MATTING

STIPPED PALM-LEAF SPINES

ATHL JOIST

APPUIS SOILIVAGE

ET CHAINAGE BOIS

NEW WALL

EXISTENT WALL

WATER-PROOF MEMBRANE

WATER-PROOF BITUMINOUS FILM

FIRED BRICK FRAME MASONRY AROUND THE GARGYLE

TAMARISK WOOD WATER-SPOUT

10X7X40 CM WOODEN SECTION FOR FIWING WATER-SPOUT

STONE MASONRY AROUND THE GARGYLE
ROOF AND GARGOYLE

GARGOYLE INSTALLATION

1. Stone masonry protection
FLOOR TREATMENT

ST1  FLOOR TREATMENT FOR ROOM

Room

- Stabilized plaster
- Fired brick
- Plinth
- Compacted stabilized mud layer
- 40x40x5 Fired brick Pavement
- Geotextil
- Gravel bed
- Drainage

Detail for addressing the finishing of floor layer.

ST2  FLOOR TREATMENT FOR COURTYARD

Courtyard

- Stabilized plaster
- Plinth
- Pavement
- Cement-sand mortar
- Compacted soil
- Geotextil
- Drainage

Slope 2:103

Detail for addressing the slope of opening area and drainage problems.
SITE ANALYSIS
ATTURAIF DESIGN OVERVIEW
15 SEPTEMBER 2006
NODE 6

ADDIRIYAH MUSEUM AT SALWA PALACE - WALKWAY
ATTURAIF DESIGN OVERVIEW
15 SEPTEMBER 2008
VIEW TO MUSEUM ENTRY FROM NODE 7

ADDIRIYAH MUSEUM AT SALWA PALACE - WALKWAY
ATTURAIIF DESIGN OVERVIEW
15 SEPTEMBER 2008
TO ZONE A SOUK

ELECTRICAL SUBSTATION

GROUND FLOOR PLAN - B25.1, B25.2

DISPLAY

ENTRANCE

MAIN STREET

INFORMATION

DISPLAY

MAIN ENTRANCE

TO SALWA
OPTION 1 - DIRECT LIGHTING

DAY TIME

NIGHT TIME

OPTION 2 - DIRECT/INDIRECT LIGHTING

DAY TIME

NIGHT TIME

PRECEDENT LANTERNs

SCHEMATIC LANTERN

PRELIMINARY LIGHTING CONCEPTS
CONCEPTUAL DESIGN
27 JULY 2008
ZONES C & D:
The concept design for Zones C and D builds on the same ideas of honoring history and improving functionality and visitor experience that guided the design for Zones A and B. New connections have been made to link existing units, new lighting, canopies, and wider openings have been added to improve visibility at both street and shop entities, and new stairs and ramps have been added to improve internal circulation. In addition to these universal elements, the conceptual design takes advantage of both the topography and areas of complete or near-complete degradation to create a series of dynamic spaces and programmatic nodes that we impossible in the more intact homes of Zones A and B. Programs and vendors are grouped by shared use and relate to adjacent use (Treasury, Moudi’s Sabala, and the Arabian Horse and War Museums.)
TRADITIONAL CULTURE DEMONSTRATION AREA

ZONES C & D - PROGRAM
CONCEPTUAL DESIGN
27 JULY 2008

INTERACTIVE (AUCTION)
EXCHANGE SHOPS (GOLD, SILVER, TRADITIONAL CONS, WEIGHT AND MEASURES)
CRAFT DEMONSTRATION AREA
INDUSTRY (STONE, METAL, PALM, TENT)
TRADITIONAL CRAFTS
TRADITIONAL CULTURE DEMONSTRATION AREA

ZONES C & D - UTILIZATION CONCEPTUAL DESIGN
27 JULY 2008

VENDOR SPACES (72 SHOPS - 1600 SQ M)
MAJLIS (INTERPRETIVE SPACE)
SERVICE SPACES

INTERPRETATION
DEMONSTRATION
DISPLAY
SHOP
SHOP
DEMONSTRATION

SCALE 1:200