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Recycling Of Waste Material: Opportunities for Development

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Abstract: In 2011, the American Research Center in Egypt (ARCE), financed by the United States Agency for International Development (USAID), in cooperation with the Egyptian Ministry of Tourism and Antiquities (MTA) (formally the Ministry of Antiquities) implemented a project entitled "Job Creation through Cultural Resource Management in Luxor" followed by a project entitled "Cultural Heritage Tourism". Within the projects, many examples of the recycling of waste material, sustainable construction and social development was prevalent. Examples include the recycling of mud brick, stone debris, limestone aggregate, scrap stone, stone powder use of solar and natural lighting. The recycling of material met all three themes of sustainable development in social, economic and environmental aspects.

Keywords: United States Agency for International Development, USAID, Egyptian Ministry of Tourism and Antiquities, recycling, Luxor, job creation, site improvements, mud brick, waste material, sustainability

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I. INTRODUCTION

With the decline in tourism after the 2011 Egyptian Revolution, The United States Agency for International Development (USAID) solicited proposals for meeting specific criteria to reduce the severe economic impact to local individuals affected by the downturn. These include: (1) creating temporary jobs for locals previously involved in tourist related employment who lost income due to the decline in tourism, (2) improving tourist related sites to attract tourists to visit Egypt, (3) provide income to the Ministry of Antiquities (now the Ministry of Tourism and Antiquities- MTA) through ticket fees with the opening of new historic sites, (4) training of MTA conservation, archaeology and photography employees, (5) promote recycling and other environmental aspects. All of the sites are under the directive of the MTA. This paper will be concentrating on criteria number 5.

The American Research Center in Egypt (ARCE) was awarded a project entitled "Job Creation through Cultural Resource Management in Luxor" (Job Creation) from 2011 to 2015 (Cooperative Agreement No. AID-263-A-11-00020). Following this project, ARCE was awarded another project entitled "Cultural Heritage Tourism" (CHT) that started in 2015 and was completed in June of 2018 (Cooperative Agreement No. 263-A-15-00007). The authors, in their previous capacities of Associate Director - Luxor, and Conservation Manager, developed, budgeted, implemented and managed the projects. Within these two projects, there were many examples of recycling waste materials that were re-used on the project and elsewhere.

The main Scope of Work involved clearing and cleaning up sites on the West Bank of Luxor using no heavy equipment. The idea of the project was to hire local individuals that represented one family, and provide full time employment for approximately two years to clean up the debris. The debris was cleared by hand utilizing simple tools. The sites include the village of Qurnet Murai, Sheikh Abdel Qurna and Dra Abu el Naga. Within these sites are ancient tombs of noblemen. The Egyptian government believed that to save the tombs from further damage, the villagers must be relocated and the remaining structures must be demolished. From 2006 to 2008 the relocation of the villagers commenced and the houses and other structures were demolished. Much of the debris from the structure demolition were left in place. The debris consisted mainly of mud brick, wood, limestone chippings and some cement. Qurna was the first project and Qurnet Mauri and Dra Abu el Naga was the second. So many locals were unemployed that the 1,000 workers in Qurna (the first project) did not work in the second project that consisted of approximately 500 workers.

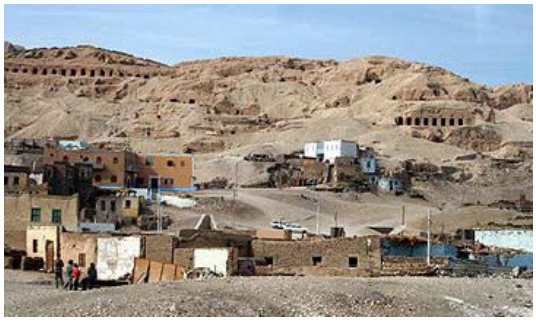

Photo 1: Qurna Village prior to resident relocation

Photo 2: Google Earth image of the village of Dra Abu el Naga in 2002 showing intact village structures

Photo 3: Google Earth image of Dra Abu el Naga after the demolition of the housing and other structures in 2012

Photo 4: Google Earth image of Dra Abu el Naga after debris cleanup in 2019 showing the debris removed and stairway to tombs in upper necropolis shown as a white streak. Stairway was made from recycled stone.

II. PROBLEM DEFINITION

The problem of the above referenced projects was how to develop a project that provides the unskilled local worker with employment for two years and, at the same time, to provide the workers with training in local vocational aspects, environmental awareness and sustainability that could be applied elsewhere upon project completion and where the skills could be used for income generation.

III. OBJECTIVES

The objectives are to recycle as much of the debris, and other waste materials, as possible and to train the workers to be aware of recycling and environmental factors while working them in a field situation. The process must be sustainable and involve technology locally available and be economically viable. It was also the objective to reduce the debris placed in the local landfill.

IV. SCOPE AND LIMITATIONS

The scope is to provide employment to local individuals affected by the downturn of tourism to clear demolition debris and improve the site for tourist visitors to the noblemen's tombs. The scope also included factors to limit the environmental impact by recycling as much of the debris as possible rather than placing it in the local landfill. This also reduces trucking (transportation) costs. Included in the scope is to provide a quality product. One limitation is that not all of the workers are to be trained in the recycling program. It is a volunteer program meant for interested individuals to actively partake in the recycling and skill training program. No additional funds above the rate for labor site cleanup were provided to the participant. It was meant as an opportunity for self-improvement and not a method to obtain an additional wage. With this criteria, approximately 25% of the workers participated. Economic viability of the improvement system was not part of the project. Although it makes sense to improve a tourist area to attract more visitors and thus obtain additional funds, the focus was on temporary employment, site improvement, vocational training and promoting sustainable ideas. Without studying the economic viability, it is logical to assume that recycling in this case, and on a small scale, makes economic sense to utilize viable material that would otherwise be placed in a landfill. Limitations also included excluding testing of the mud brick properties. It was assumed that the experienced local brick makers had the knowledge of the ratios of the mixture ingredients. It would be hard to imagine that we would instruct local professionals on what proportions should be mixed after their years of local brick making experience.

A large mud brick recycling and training operation was established in the Dra Abu el Naga area. Since this program is funded by USAID, no resale of recycled mud brick or other waste material was possible. To stay within this accord, the manufactured mud bricks were given to local foreign and domestic archaeological missions per their request. Orders were taken on the size and quantity of mud brick and they were produced accordingly. Recycled mud brick was also used for several ARCE project features.

V. METHODOLOGY AND METHODS

The study of human traits and habits is difficult and can introduce ethical questions. Therefore, in planning the recycling program, *observations* and *documentary analysis* was used to structure the curriculum. The Job Creation project started in 2011 and was completed in 2015. This project involved a total of approximately 800 local village workers. It was during this project that observations could be made on worker attitude, production and processes. Documentary analysis was used to verify the production, how issues and problems were solved, cost, and other factors in the cleanup of the site. This included work progress photos and depositing all the documentation in a data base.

The definition of methods is "a particular procedure for accomplishing or approaching something, especially a systematic or established one". For the part of the project involving mud brick recycling, certain criteria had to be met. The criteria is the basis for the development of a program and plan that defines the specific methods. The program outlined the overall supervision necessary to carry out the specific goals in a systematic way. A structure was planned and developed and the program was implemented. Observation and documentary analysis were among the tools used to formulate the planning, strategies and techniques of the mud brick recycling program.

In regards to observation, as stated by Rosenbaum (2005), experiments with human subjects are often ethical and feasible when (a) all of the competing treatments under study are either harmless or intended and expected to benefit the recipients, (b) the best treatment is not known, and in light of this, subjects consent to be randomized, and (c) the investigator can control the assignment and delivery of treatments. Observing and recording the production rate was a method used to determine future applications. Documentary analysis, was also performed in the early stage of the policy innovation. Documents also present none of the problems (practical, ethical, interactive) of human subjects of research, and can provide a useful supplement to data collected from human subjects by other means as stated by Shaw, et. al. (2004). The production rates, progress, problem solving, cost and other issues in the early stages was documented and reviewed and included in the development of the program.

The method of planning and programming was established in a step by step procedure. The first step was to generate a list of criteria in association with the waste material:

- Determine what waste material could be recycled.
- Determine means and methods of recycling (sustainable and low tech).
- Determine if the recycled material could serve a purpose locally.
- Determine if the material could be recycled within budgets.
- Determine if there is any special training associated with the recycling.

The second step was to set up a field program structure that would focus on the objectives of the project.

- Provide adequate supervision
- Provide professional local mud brick making individuals to oversee the manufacturing of the mud brick and to act as an instructor and mentor to the trainees.
- Provide adequate tools
- Provide adequate training
- Provide a quality product (quality control)
- Designate adequate recycling space
- Provide or arrange for adequate delivery of recycled material

The third step involved implementation, corrective actions and improvements that focuses on the objectives and tracks the economic cost of the program.

VI. LITERATURE REVIEW

Mud brick has been a tremendously significant material in Egypt since ancient times. Thousands of years of mud brick structure remnants are still present in many parts of Egypt today. Mud brick is currently still being used in local structures. Some of the main reasons for its use as confirmed by Al-Ajmi, et. al. (2016) that the use of earth construction is well established in energy efficient housing and that the advantages of mud brick include its low cost and great thermal behavior. Mud brick is generally inexpensive, environmental friendly, and until recently in Egypt, abundantly available. According to Correas-Amador (2011), mud brick architecture has been disappearing for the past decades, as red brick and concrete have become the principle building materials

following a ban in 1984 on using Nile silt to make bricks. One of the impacts due to this ban according to Galal Ahmed (2004), is that traditional sustainable building materials are being abandoned for quasi-urban unsustainable housing patterns and building materials.

According to Minke (2006) in nearly all hot-arid and temperate climates, earth has always been the most prevalent building material. Even today, one third of the human population resides in earthen houses; in developing countries this figure is more than one half. It has proven impossible to fulfil the immense requirements for shelter in the developing countries with industrial building materials, i.e. brick, concrete and steel, nor with industrialized construction techniques. Worldwide, no region is endowed with the productive capacity or financial resources needed to satisfy this demand. In the developing countries, requirements for shelter can be met only by using local building materials and relying on do-it-yourself construction techniques. Earth is the most important natural building material, and it is available in most regions of the world. It is frequently obtained directly from the building site when excavating foundations or basements.

Many organizations have embraced the concept of sustainable development. Leadership in Energy and Environmental Design (LEED) standards incorporate reuse of existing buildings and the preservation of the surrounding environment. It is also most desirable to use materials that are recycled or renewable and those that require the least energy to manufacture. They ideally are locally sourced and free from harmful chemicals. They are made of nonpolluting raw ingredients and are durable and recyclable as stated by Wines, (2008).

There is very little information associated with small village recycling, especially in conjunction with materials related to demolition waste. Kemp (2000), states that a common occasion for building in towns would have been replacement of houses and other construction. A portion of the whole bricks could have been recused for re-use from the demolition of old structures, but the principal demolition product is likely to have been rubble which would have been available for breaking down into the raw material for new bricks and mortar. The likelihood of recycling is an important factor in any study in the composition of bricks on other than virgin sites. According to Wilson (2007), the ability to make a living by recovering salable material from waste is still a key driver for the urban poor. Included in this is that most International Finance Institutions include a strong element of institutional capacity building. It is one of USAID's goal to include capacity building as one of their criteria objectives and although not associated with an institution as such, the training in the recycling of mud brick aligns closely with individual capacity building.

As stated by Soliman (2012), the Egyptian experience showed that the involvement of local people in the housing process became a major theme for providing a reasonable shelter, formally or informally, for low-income groups. However, self-build housing appears the most appropriate methods for the urban poor to house themselves. An important area for innovation and program design in Egypt is the various forms of self-build housing solutions. Low-cost land and self-build housing solutions consist of a wide range of options that compose the steps of the progressive housing process.

It is clear that recycling would be a main factor in some housing solutions especially when combined with self-build factors.

VII. CASE STUDY

The project was unique in that entire villages that were situated in an important archaeological site were demolished and the majority of debris was left in place. It provided an occasion to not only practice the idea of recycling but also to make the local workers aware of the possibilities and opportunities with the aspect of recycling with mud brick and other materials as well. It also provided an avenue to clean and improve a site and utilize it to train in conservation, vocational skills, and other capacity building techniques. Tourist attraction was also a focus factor that will provide future income generation.

Inquiries were broadcast to local missions that were in need of mud brick for their projects. Several foreign and local archaeological missions requested mud brick based on their needs. Each mission requested a different size and several missions requested two different sizes. Molds were made to specification and stamps were fabricated to stamp the mission's logo on the mud brick. Most of the mud brick was used in capping ancient mud brick to not only protect the ancient material but to also give the visitor an idea as to what the original space and structure may have looked like (see Photo 5, Photo 6 and Photo 7). The stamped mud bricks would allow future archaeologist to understand that the mud brick encountered was not of ancient origin.

Photo 5: Example of an area of exposed ancient mud brick

Photo 6: Area in Photo 5 after protecting and capping ancient mud bricks with recycled mud brick

Photo 7: Example of capping ancient enclosure wall to protect the original mud brick from the elements and to gain an idea of what the original enclosure boundary may have looked in ancient times.

Photo 8: Mud brick debris after sorting. Designated for recycling

With the plans developed, customer orders received, supervisors organized and the tracking and corrective action elements in place, the implementation of the mud brick recycling program began at Dra Abu el Naga. With an abundance of debris and all of it removed by hand, the reusable material was easily sorted for recycling (see Photo 8). With a large open area, supervised groups were chosen to perform a particular task for optimal production. Experienced mud brick masons were mixed with the various groups of workers wanting to learn how to make mud brick. Like a production line, the recyclable material was placed in a designated area. It was then collected and placed in a mixing area where the old mud brick remnants were broken down with water and mixed with additional straw as needed (see Photo 9 and Photo 10). It was also evident that dung had been previously use as a stabilizer due to the odor of the material. The mixture was then transferred to the casting group where the mud brick was cast according to a specified size (see Photo 11). Quality control supervisors were at hand to make sure the castings were of good quality. The bricks were dried in the sun and then collected and stacked ready to transfer to the designated customer (see Photo 12).

Photo 9: Mud brick debris broken down to start the mixing process

Photo 10: Mixing the mud brick debris with water and straw as needed

Photo 11: Placing the recycled mud brick debris in the mold. Forming and stamping with mission's logo

Photo 12: New mud brick drying in the sun with stacked dried specimens

With the implementation came several obstacles and problems that required corrective action. The first problem involved the fact that the area missions requested large orders and there was a limited amount of time remaining in the project. It was not a question of required material but a question of the quantity of workers to produce the orders. A decision had to be made to either 1) reduce the quantity of recycled mud brick and inform the mission(s) 2) increase the production rate to fill the orders, 3) increase the amount of workers to fill the orders as requested. Filling the orders would require more workers to produce the recycled bricks. At issue was the fact that all of the debris from the demolished houses had to be removed by a certain date. Redirecting workers to focus on the production of mud brick reduced the production of the cleanup and site improvement operations. Hiring more workers was not possible due to budget constraints. Therefore, Decision 3 (increase the amount of workers to fill the orders as requested) was not possible.

After discussions and calculations between the management and field supervisors, it was decided that Decision 2 (increase the production rate) would be implemented.

Through the efforts of management and field supervisors, the production of the mud brick increased and larger quantities were being produced. This solved the quantity issue but soon after this corrective action, another problem arose that required another corrective action. Coupled with the increase in production there was a decrease in the quality of the fabricated brick. It was absolutely necessary to train in the quality of a mud brick for delivery to the missions. A large amount of time was spent on this factor.

To increase the quality of the brick, it was necessary to focus on the fabrication which caused a decrease in the production rate. After calculations factoring in the time remaining in the project and the production rate expected for a quality recycled mud brick, Decision 1, (reduce the quantity of recycled mud brick and inform the mission(s)) was adopted. In this case, only one mission out of six was affected.

VIII. RESULTS

Overall, the results of the program were successful. For sustainability, the three factors of Economic, Social and Environmental aspects were met. Several points were realized upon completion of the project:

- Reduction of debris in the local landfill
- Awareness of the workers on recycling waste material as a commodity
- Training of workers in the production and fabrication of recycled mud bricks
- Training local supervisors in the facets of planning, estimating, time management, problem solving and corrective action
- Importance of fabrication of a quality product
- Serving the community and local missions
- Utilization of the experience in possible future income generation

IX. ANALYSIS AND DISCUSSION

This paper has mainly focused on the recycling of the debris from a demolished village into recycled mud brick. However, one of the points described in the results reflect the general overall message to the workers and staff of one of the most important points of the project: Recycling waste material as a commodity. Several other small operations were ongoing throughout the life of the projects. Examples include:

- Application of stone fragment debris readily available throughout the landscape coupled with waste stone from a local mission to be used in construction of walls and pathways (see Photo 13 and Photo 14)
- Recycling scrap sandstone from a local mission to construct an outdoor floor (see Photo 15)

- Recycling limestone chipping debris that would have been placed in a landfill to be screened and used for base surfaces for parking and walkways (see Photo 16)
- Recycling sandstone & limestone scrap to produce powder for use as an ingredient in lime mortar. This was extensively used throughout the projects in the training of MTA conservation employees in the use of sustainable, readily available resources (see Photo 17)
- Use of solar powered lighting in temples and tombs after site improvements and conservation efforts were completed (see Photo 18 and Photo 19) including the use of LED bulbs.
- Use of Solatube® natural lighting system. (see Photo 20)
- Use of solar powered ventilation system (see Photo 21).

Photo 13: Waste stone from a local mission in the foreground

Photo 14: Craftsman utilizing readily available natural and waste stone material for use in a site improvement pathway

Photo 15: Scrap sandstone from a local mission recycled for exterior flooring


Photo 16: Use of locally fabricated screen to capture required aggregate sizes for use in parking and walkways

Photo 17: Crushing scrap stone to power to be used as an ingredient in lime mortar

Photo 18: Backup solar power for temple lighting

Photo 19: Solar powered site lighting

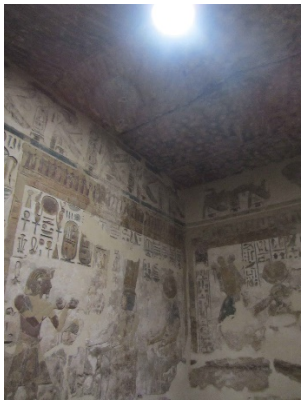

Photo 20: Solatube ® natural lighting

Photo 21: Solatube ® domes with solar powered ventilation

It is clear that the recycling of the material encountered in the projects was more environmentally friendly and added important lessons in recycling, but added to this is the cost saving aspects of the activities. Minimal costs associated with transportation, purchase of added ingredients (i.e., straw for mud brick) and fabrication of a screen for aggregate sizing was much more cost effective than trucking debris to the local landfill and purchasing mined aggregate for base surfaces for parking and walkways. The recycling extended cost savings for use of stone fragment debris to be used to construct walls and pathways and reduced the purchase of sandstone and limestone power used in lime mortar. Costs in labor is higher in the preparation of such materials but is offset if new material had to be purchased and transported.

X. CONCLUSION AND RECOMMENDATIONS

Dependent on the circumstances, recycling material in many settings can be a major environmental improvement as well as having social and economic benefits. The ARCE Job Creation and CHT projects financed by USAID have demonstrated the possibilities and opportunities utilizing recycled waste material including cost reduction and sustainability factors. Although the literature on the subject relating to recycling of material from demolition activities in small villages is lacking, theories can be developed in comparing small villages to cities. For example, based on the ARCE projects, many areas in larger cities could recycle demolished structures on site to produce new structures or relocate the material to another site and reduce the landfill deposits. Although mud brick is not often used in larger cities in multi floor structures without the addition of concrete or masonry, it is possible to study and design composites of waste material, especially plastics to produce a material with the structural integrity and properties to become a viable building product or a product to meet other basic demands.

DECLARATION OF INTEREST: NONE

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