Submission Category: Unbuilt Works

Project Type: Research & Development (R & D) of SOLtek a solar-heated kiln to cure concrete masonry units (CMU’s)

Project Address: Our Lady of Perpetual Help Village, Plaine de Nord, Haiti (Applicable to all developing nations using CMU construction)

Date of Substantial Completion: In-the-field casting & curing (December 2016) / Lab testing (February 2017)

Photos: See PDF

Architect’s Statement: The research and development of the SOLtek Kiln began with a university-based, research project carried out by a team of architecture students in 2012. The class was funded by a major foundation that represents the masonry industry in the U.S.A. and Canada. Their project, SUN TRAP, established the conceptual bases for the subsequent phases (2013 – 2017) which were undertaken by the office of the Architect who is submitting this project and who was the instructor for the research course. Both the Architect and students will be recognized on the Award, should the project be fortunate to be deemed worthy of an award.

The jury is directed to the required PDF of this submission which contains an integrated presentation of both written descriptions, photo documentation and graphic documentation. All drawings for SOLtek were executed in situ and in freehand to reinforce that there is very little available electricity where the casting and testing of the kiln was carried out, thus precluding the use of computers.

The following are the critical aspects covered in the PDF of design considerations, limitations, requirements and solutions required.

IMPETUS / CATALYST TO ENGAGE THIS R & D PROJECT: The impetus or catalyst that “jump-started” this dual focused project was an event that took place on January 12, 2010. This was a catastrophic magnitude 7.0 M earthquake, with an epicenter near the town of Léogâne, approximately 25 kilometers west of Port-au-Prince, Haiti’s capital. Estimates are that 75% (+/-) of the existing concrete and concrete masonry structures were damaged or destroyed. Haiti’s government has estimated the death toll at 230,000 and says more bodies for which a final determination of death in future years may never be known.
• **DEFICIENCIES IN CMU CONSTRUCTION BECOME READILY APPARENT:** The educator/practitioner’s earliest experiences (2001-2003) involved him and students in mission work in Haiti working alongside local masons in constructing (mixing “concrete,” casting CMU’s and laying them for) prototype latrine projects and a K-6 school. This was followed by his experiences as project designer and manager with his architectural practice that took on five projects in Haiti pro bono. Four of the five buildings that were / are being constructed between 2011 and the present used the traditional reinforced concrete frame and CMU in-fil construction system. These experiences made him painfully aware of the incredible deficiency in the quality of the materials used in CMU manufacturing and construction: (dirty water (*)); non-graded-for-size, unwashed “river sand;” a cement /sand ratio of up 15 to 1 +/-; and **NO CURING OF THE CAST BLOCK UNITS** except for having them dry in the sun. Added to the deficiencies of mixing and casting process ...either using a single, hand-packed block mold on the ground or two block, manually operated, block-making machine is the almost total lack of skills of a majority of masons in rural communities. quality control in the majority of concrete masonry construction due to the lack of knowledge and skills of the majority of Haitian masons active at present in construction.

• **INITIAL PHASE UNDERTAKEN BY ACADEMIC, RESEARCH CLASS:** The Architect (architectural educator / practitioner) for the SOLtek kiln was the studio/class instructor for the team of architecture students who undertook the initial R & D of a solar kiln that they named **SUN TRAP.** Since then his firm has taken on this project with his time being donated through their pro bono service initiative. During this last trip in December 2016, he conducted the latest round of casting, curing and testing of the initial small scale prototype of SOLtek. His firm plans to continue to develop the project with a half-scale model that will accommodate twenty (20) half-scale blocks that is planned to be built and tested in Haiti during 2017.

• **LIMITATIONS:** The limitations that the R & D team faced were those encountered in any research project ... both pure and applied ... dealing with materials and methods of construction in developing countries.

•  **``TIME COMMITMENT GIVEN PRO BONO FORMAT:** To get to the sites in Haiti where the R & D was carried out takes one, full day each way of travel plus needing to spend the required 48 hrs. (2 days) in order to ascertain the desired research findings. Thus, four (4) days is the minimum time commitment for each visit and research trial.

• **OPTIMIZE TIME IN-SITU IN HAITI:** These included making the most of the time actually spent by the Project Director / Chief Researcher on construction sites in Haiti during or immediately after actual construction took place. This afforded photo-documented proof of the poor construction materials and methods of construction that cannot be easily ascertained once the structures are covered in stucco ... thus giving the appearance of buildings of sound construction.

• **REPLICATE THE ACTUAL ENVIRONMENTAL, CLIMATE, MATERIALS CASTING AND SITE CONDITIONS FOUND IN HAITI.** The only feasible way to accomplish this was to undertake in-situ testing in Haiti whenever possible (see limitation No.1., above) ...with the most current testing results of the SOLtek kiln taking place in December of 2016.
SOLUTION: All of the following are dependent on a BASIC VOCATIONAL EDUCATION PROGRAM THAT WOULD BE CONDUCTED IN-THE-FIELD BY HAITIAN EDUCATORS accompanied by the architect/educator who is principal investigator on this project and an interpreter.

1.0. The IMPROVEMENT IN THE QUALITY OF THE MIX THROUGH ... teaching simple methods to ensure:

   1.A. THE STRICT MONITORING OF CEMENT/SAND/AGGREGATE RATIOS
   1.B. “GRADING SAND AND AGGREGATE W/ SIMPLE SIEVES
   1.C. OBTAINING “POTABLE” WATER BY CATCHING & STORING RAIN water

2.0. The DEVELOPMENT OF SOLtek ... a simple, low tech, solar-heated kiln ...so as to include a curing step that would add substantially to the compressive strength of the manufactured (cast) block units.

RESULTS TO DATE: The latest testing of the SOLtek Kiln proved that, in concept, this piece of equipment used in a prescribed manner to ensure optimum results SIGNIFICANTLY INCREASED THE COMPRESSIVE STRENGTH OF THE CMU’s.

NEXT PHASE OF TESTING will involve a half-scale mock-up of a 20 UNIT SOLtek kiln. Half-scale blocks will be cast in Haiti, cured in the SOLtek kiln and several will be tested for their compressive strength. The remainder will be used in a mock-up of a portion of a wall and tested for resistance to lateral loads.

SHORT-TERM ASSESSMENT: It is apparent that a sustained program that combines vocational education with in-the-field apprenticeships for masons must be established on a national scale but focused at the local level as CMU production will remain a “cottage industry” in Haiti and other developing countries for the foreseeable future.

LONG-TERM ASSESSMENT: In addition, it is also apparent that modern-day, masonry material supply industry, block and cement manufacturing plants, concrete batching facilities and transport capabilities must be developed according to a national plan that will guarantee availability to all regions but with regulations to guarantee affordable prices to local mason contractors.
**IMPETUS**

The impetus or catalyst that “jump-started” this dual focused project was an event that took place on January 12, 2010. This was a catastrophic magnitude 7.0 M earthquake, with an epicenter near the town of Léogâne, approximately 25 kilometers west of Port-au-Prince, Haiti’s capital. Estimates are that 75% (+/-) of the existing concrete and concrete masonry structures were damaged or destroyed. Haiti’s government has estimated the death toll at 230,000 and says more bodies for which a final determination of death in future years may never be known.
The devastating failure rate as a result of the lateral seismic forces on the structural integrity of the majority of structures in Port-au-Prince and its environs confirmed what anyone involved in the design, engineering and construction of cast-in-place concrete and concrete masonry systems already knew. That is ... the lack of any building code coupled with the total lacking of any quality control as it applies to both the materials used and methods of construction of these two systems led to the inevitable total collapse or severe compromise of their structural integrity.
PRIOR / CURRENT INVOLVEMENTS:

The architectural educator / practitioner who is the studio instructor for the team of students who undertook the initial R & D of the SUN TRAP has made 25 trips to Haiti since 2001 with the latest being in early September 2017. During his trip in December 2016, he conducted the latest round of casting samples and curing them in the small scale prototype of SOLtek, the solar heated kiln his firm is developing. During these trips he also continued to develop masonry skills (right) and communication skills through sketches & language with the help of an interpreter (below/ left). Two of the buildings he is the architect for are in use while construction is completed on the Our Lady of Perpetual Help Orphanage (below / center)
All of the aforementioned experiences led the project director to conclude that THE SINGLE MOST OBVIOUS LIABILITY IN THE CURRENT MANUFACTURING PROCESS OF CMU’S IN HAITI IS THE LACK OF ANY CURING OF THE CAST BLOCK UNITS except for having them dry in the sun (right). The blocks that result have little strength as witnessed by them being able to be easily broken by hand (below).
Initial investigation of R & D of a solar-heated kiln carried out by a team of architecture students who develop SUN TRAP in the fall semester of 2010. Students assemble prototype (left/above) & present their project (right/above).
Initial investigation of R & D of a solar-heated kiln carried out by a team of architecture students who develop SUN TRAP in the fall semester of 2010. Final presentation boards (above).
1.0. The IMPROVEMENT IN THE QUALITY OF THE MIX THROUGH ...

teaching simple methods to ensure:

1.A. THE STRICT MONITORING OF CEMENT/SAND/AGGREGATE RATIOs (Right)
1.B. GRADING SAND AND AGGREGATE w/ SIMPLE SIEVES (Below/right)
1.C. OBTAINING “POTABLE” WATER BY CATCHING & STORING RAIN WATER (Below)
Research & Development of SOLtek

A solar-heated kiln to cure concrete masonry units (CMU”s) and increase their strength
Research & Development of SOLtek
A solar-heated kiln to cure concrete masonry units (CMU”s) and increase their strength
SECTION - IMPROVEMENTS in IMPROVING STRENGTH & QUALITY in CMU's MADE in HAITI (or any Third World country)
CUT AWAY ISOMETRIC VIEW OF
BASIC MODEL OF SOL-TEK KILN

*READILY AVAILABLE COMPONENTS
1. LOCAL, LOW COST

1. 8X16 CMU
2. BAMBOO FRAME
3. 8X8 CMU TO BE CURVED
4. VISQUEEN (BLACK) DRAPED OVER
5. VISQUEEN ON GROUND
6. GROUND - RACKED/LEVEL
7. 1X8 BOARDS UNDER VISQUEEN
TYPICAL SECTION - THERMODYNAMIC ENERGY FLOW

1. Condensed Moisture
2. Concrete Block
3. Black Visqueen (Membrane)
4. Earth (Leveled Soil)
5. Frame
6. Moisture Vapor

KEY:
1. 8x8x16 Block (Section)
2. 8x8x16 Block (Elevation)
3. 1x8 Wood Boards
4. 1x8 Wood Boards
5. Visqueen (On Ground)
6. Visqueen Draped Bamboo Frame
7. Ground

SOLtek Kiln - R&D Stacked Units to Increase Production
Small scale test kiln – Kit of parts using PVC & plastic bags

Small scale test kiln – Assembled w/ test containers under
(L to R) Haitian research assistant working sieve; mixing measured amounts of cement and sand; compacting samples; cast units with core forms still in inserted; cast forms within and outside test kiln; and, cast units with time (hours) of curing in kiln indicated.
TESTING: After returning to the USA w/ the samples cast in December 2016, the architect / prime researcher allowed the samples to dry in the air for 28 days before he and his student assistant tested them on a standard compression machine. Continued on next sheet.

Testing samples after 28 days of additional curing in the air w/ no additional watering.
TESTING – Continued:

Samples tested to initial fracture (top/right) and total failure (bottom/right).
LONG TERM SOLUTION:

Long term solutions must be approached with the realistic understanding that the “culture of the accepted low quality of construction in Haiti will be slow to change. It is apparent that a sustained program that combines vocational education with in-the-field apprenticeships for masons must be established. As important is the need for an in-the-field training for those engaged in the “cottage industry” that will remain the main form of production in most cases. This would focus on control of both the quality and quantity of the materials used as well as the use of the SOLTeK kiln. International funding needs to be secured to guarantee the implementation of the above at a large enough scale to be truly be effective.