



## **Geo-Building Technologies, LLC**



### **The Art of Innovation**

# **THE GREENMACHINE®**

**A Cost and Quality Analysis of GeoBricks**

**A New Technology**  
**A New Construction Material**  
**A Positive Environmental Contribution**

## The GreenMachine®

The GreenMachine® is a mobile one ton machine used to manufacture precision tongue and groove compressed soil bricks. Because of its size, maneuverability and self contained nature, the GreenMachine® can be moved to any project site and using the soil extracted from digging the foundation, can manufacture GeoBricks. The GreenMachine® is capable of manufacturing up to 6 bricks per minute, which translates to 360 GeoBricks per hour and 2,800 GeoBricks in an 8-hour shift.

The GreenMachine is relatively simple to operate. Being fully automated, once set up, it will manufacture GeoBricks without interference from the operator. To manufacture GeoBricks, a team consisting of one trained operator and 6 unskilled local laborers are required.

The GreenMachine® has the potential to revolutionize the construction industry in Afghanistan.

## GeoBricks:

GeoBricks are tongue and groove bricks that consist of compressed soil (compression at 3,000 psi) with the option of adding cement or lime for further stabilization. Cement or lime serves as a re-enforcer that will enhance the weather proofing of the GeoBricks.

GeoBricks can support the construction of beautiful houses with high quality and integrity of the construction. In addition GeoBrick structures are cheaper by a factor of approximately 30% compared to other comparable construction materials and technologies. Following is an analysis of the cost and quality advantages of GeoBricks in Afghanistan:

## Cost benefits of GeoBricks:

- **One GeoBrick is equivalent in size to 3 kiln fired bricks** – The GeoBricks are 25x20x 10cm (L x W x H). Just by looking at the tongue and groove shape of the GeoBricks, you can see that they are the size of 3 kiln fired bricks. A daily production of 2,800 GeoBricks thus translates to more than 8,000 kiln fired bricks per day.
- **GeoBricks are cheaper to buy than equivalent sized first grade kiln fired bricks** – We compare one GeoBrick with 3 first grade kiln fired bricks. Other types of bricks (2<sup>nd</sup> and 3<sup>rd</sup> grade kiln fired bricks and sun dried mud bricks do not have a compressive strength to enable a proper comparison. Most types of GeoBricks cost less than first grade kiln fired bricks. A price list can be made available upon request.
- **GeoBricks do not require mortar to hold them together** - Mortar comprises approximately 30% of brick masonry costs. Application of mortar requires highly skilled masons and needs more time. Furthermore, mortar needs to be watered for days to enable a slow and orderly curing. All of this increases the cost and time of construction. GeoBricks will save the builder these costs.
- **GeoBricks do not require highly skilled masons to build** - Unskilled labor with basic training can erect a wall. The most critical part of the construction with GeoBricks is to lay the first layer of bricks. Attention must be paid to ensure that the surface is even and that the bricks line-up straight. After that corners must be laid (very little training needed to achieve this) and the bricks are stacked on top of each other. The tongue and groove construction of the bricks will prevent inaccuracies in erecting the wall. Since unskilled labor is significantly cheaper than skilled labor the cost of construction is thus minimized with GeoBricks.

- **Geo-Brick Walls are faster to erect** - With a team of 2, the walls of a 100m<sup>2</sup> hall can be built approximately in 2 days. Thus construction using GeoBricks is significantly cheaper and speeds up the process of the overall structure construction. Where frame structure construction is used, the time to erect the walls is even shorter, as there is no need for building corners and maneuvering around interlocking of bricks in corners. This further contributes towards reducing the construction costs.
- **GeoBrick walls do not need to be plastered** - The consistent shape of the bricks ensures good presentation of the wall. GeoBricks are manufactured with high level of precision (0.4 mm tolerance on 6 sides). Hence the GeoBrick walls look presentable. As a result it is not necessary to plaster the wall for protection or presentation. Plastering requires painting and painting requires regular maintenance. By avoiding plastering, GeoBricks save significant amount of work, money and construction time.
- **Maintenance cost of GeoBrick wall is low** – Because plastering is not required, maintenance effort and costs are significantly reduced, thus saving money not only during construction but also on an ongoing basis.
- **GeoBricks do not need to be transported** - Using the mobile GreenMachine® GeoBricks can be manufactured onsite, which eliminates brick transportation costs. Transportation cost has made kiln fired bricks in most parts of the country very expensive. In addition to this, because of inadequate roads often the transportation of bricks is not possible at all. Thus many people, especially in rural areas, are forced to rely on locally available sun-dried mud bricks and traditional Pakhsa (clay-mass) construction technology. While sun dried mud bricks have very low compressive strength, pakhsa construction is not flexible forcing people to limit their imagination in terms of design of their structures and buildings. In addition to this, Pakhsa walls require significant cost and effort to prepare the mud for long term resistance, which makes them often unaffordable. The result is an unfortunate reliance on low quality pakhsa, which compromises the integrity of the structure. Since GeoBricks can be manufactured onsite, it enables people to avoid the very high cost of transportation by towing the GreenMachine (weighs one ton and is on wheels) instead of hauling kiln fired bricks. Thus rural population can have access to a strong and beautiful brick at affordable price.
- **Because of onsite production, wastage due to transportation and handling is also eliminated** – During transportation of kiln fired bricks, more than 15% (in many cases up to 25%) of kiln fired bricks are damaged/broken. Thus one out of four bricks has lost its characteristic and has been reduced to at least half the size. This requires more time and effort during erection of the wall and compromises the quality of the construction. Because GeoBricks can be manufactured onsite, wastage is non-existent, which in turn reduces the cost and time of construction and saves the builder money, while ensuring high quality of construction.
- **Lower energy costs due to higher insulation rating of GeoBricks** – GeoBricks are rated R14 for insulation. GeoBrick houses are cooler in the summer and warmer in the winter. During thermal testing, GeoBrick rooms measured 33°C at outside temperatures of 42°C, while comparable structures measured 46°C. The energy costs required to warm GeoBrick houses in the winter and cool it in the summer are significantly lower than that of other materials. Thus a long term benefit for GeoBrick home owners/users is also provided. In the short term, construction costs is reduced significantly by using less number of bricks (less thick walls) and by avoiding the use of glass fiber and other types of insulation material.

## Quality Benefits of the GeoBricks:

- **With 8% cement content, GeoBricks have triple the compressive strength of kiln fired bricks** – Compressive strength of GeoBricks with 8% cement is 158 kg/cm<sup>2</sup> (2,240 psi). Typically, kiln fired bricks in Afghanistan have a compressive strength of 50 to 70 kg/cm<sup>2</sup>. Thus with 8% cement, GeoBricks are three times as strong as kiln fired bricks. During construction of a wall, a kiln fired brick exposes the structure to significant hazards as it may, under circumstances not be able to bear the weight of the roof and other associated loads such as snow, etc. The designer's solution is typically to increase the width of the wall or to use a concrete frame as load bearing columns while kiln fired bricks are reduced to partition walls only.
- **With no cement content, GeoBricks have twice the compressive strength of kiln fired bricks** – Even with soil only, GeoBricks have a compressive strength of 110 kg/cm<sup>2</sup>, which is more than twice the compressive strength of kiln fired bricks (50-70 kg/cm<sup>2</sup>). Thus GeoBricks maintain the integrity of construction.
- **A GeoBrick wall is able to swings up to 11 cm in horizontal direction** - thus minimizing risks due to earthquakes, hurricane winds of up to 193 km/hr and other such natural hazards. Because of its tongue and groove construction, GeoBricks can swing around their center of gravitation and return to their original location. Up to 4½" of horizontal swing allows the brick to withstand hurricane winds and earthquakes of more than 5 on the Richter scale. Also GeoBrick walls do not crack as easily and do not damage the wall as readily as kiln fired bricks do.
- **GeoBricks have an insulation rating of R14** - This is by far more superior than comparable construction material. As a result, inside GeoBrick structures are cooler in the summer and warmer in the winter. In addition to saving energy costs and lowering construction costs, GeoBrick rooms are more pleasant to live in. This provides a higher quality of life for dwellers and users.
- **GeoBricks have less wastage** - due to the ability of the GreenMachine® to manufacture them onsite. Broken kiln fired bricks used in the construction of walls compromise the compressive and shear strength of the construction thus exposing it to disasters. GeoBricks are manufactured onsite and have significantly lower breakage. Thus the integrity of construction continues to be maintained.
- **GeoBricks with 8% cement content do not allow small arms fire to penetrate** – GeoBrick walls have been fired at from 25 yards (22 meters) using AK47 (Kalashnikov). The bullets were not able to penetrate the wall. Thus GeoBricks play a strong security role for people who are exposed to the possibility of small arms fire from terrorists, guerrillas and other armed groups. Given the present situation of Afghanistan, where schools, clinics, residential homes and other types of structures are targeted by opposing groups, GeoBricks with 8% cement content provide ideal protective wall structures.
- **GeoBricks are suitable for single and double storey structures** – Single storey GeoBrick structures are known to have withstood earthquakes of level 5 on the Richter scale without any type of damage. Multi-storey structures have not been tested for earthquake resistance. A testing program is being worked on to evaluate the earthquake resistance of the GeoBrick structures for multistory constructions. At this time, we suggest the use of frame structure for multistory buildings and the use of GeoBricks as non-load bearing walls for such structures.
- **GeoBrick rooms are quieter than comparable structures** – Because of the type of material used (soil) and the compactness of the soil, GeoBricks demonstrate significant sound proofing characteristics. GeoBrick structures are known to be much quieter than other structures and hence ensure higher quality of life for the residents and users.