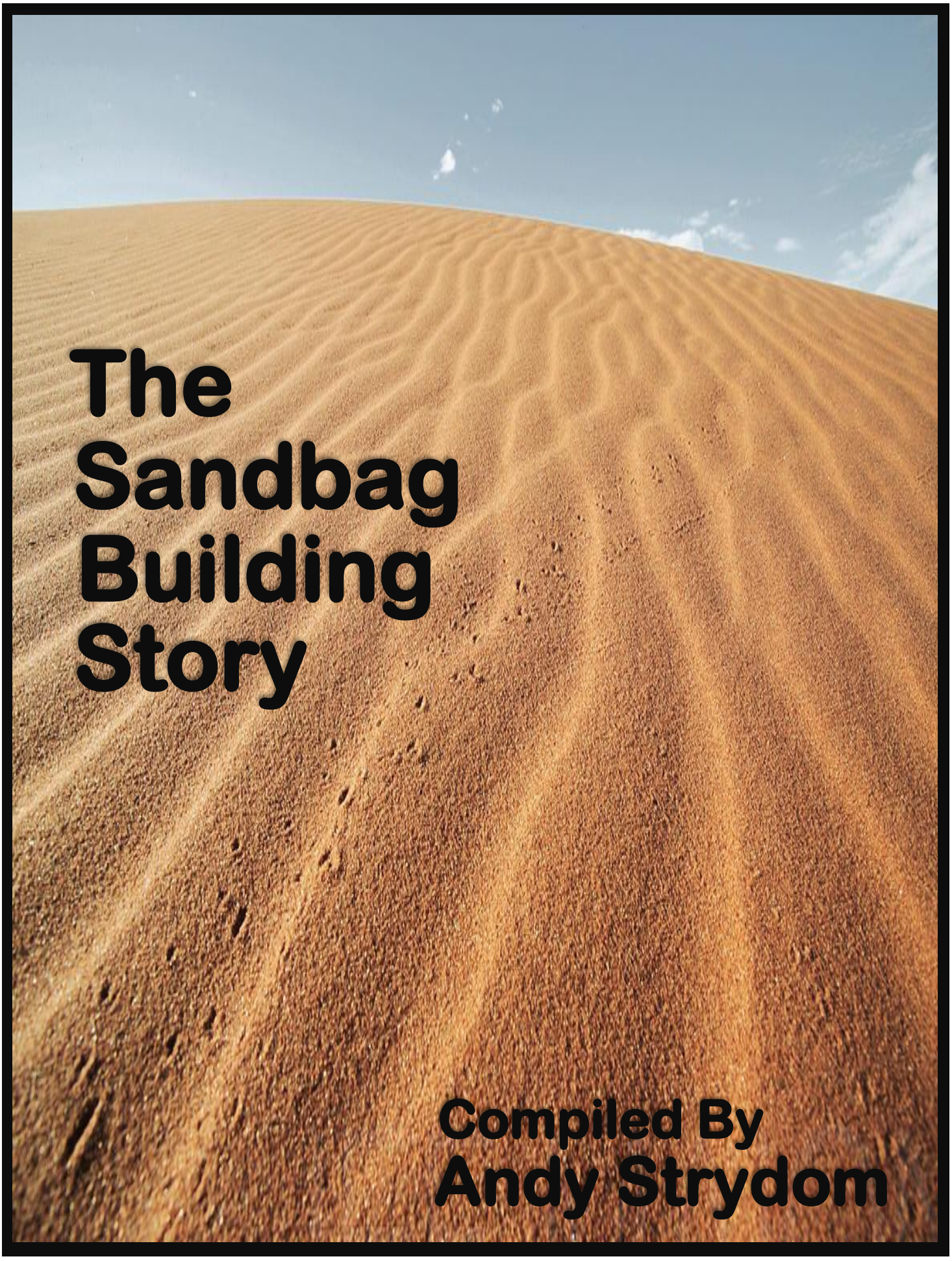
The
Sandbag
Building
Story
Compiled By
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" Nothing is built on stone ;

all is built on sand,

but we must build as if the sand were stone "

Jorge Luis Borges (1899 - 1986)

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HISTORY

1 000 year old earth-built skyscrapers - Shibam, Yemen

Sand has been the most widely used construction material for at least 10 000 years and even today at least a third of the world's population live in houses built of sand.

Earth construction techniques have been known for over 10 000 years. Mud brick (adobe) houses dating from 8 000 to 6 000 BC have been discovered in Russian Turkestan (Pumpelly, 1908) and rammed earth foundations dating from ca. 5000 BC in Assyria. The 4 000 year old Great Wall of China was originally built solely of rammed earth; only a later covering of stones and bricks gave it the appearance of a stone wall.

Many centuries ago, in dry climatic zones where wood is scarce, construction techniques were developed in which buildings were covered with mud brick vaults or domes without framework or support during construction. Bronze age discoveries have established that in Germany, earth was used as an infill in timber framed houses or to seal walls made of tree trunks. Wattle and daub was also used.

The oldest example of mud brick walls in Northern Europe, found in Heuneburg Fort near Lake Constance, Germany dates back to the 6th Century BC. In Mexico, Central America, adobe buildings are known in nearly all pre-Columbian cultures. The rammed earth technique was also known for many years, while the Spanish conquerors brought it to others.

In Germany, the oldest inhabited house with rammed earth walls dates from 1795. Its owner, the director of the fire department, claimed that fire resistant houses could be built more economically using this technique, as opposed to the usual timber frame houses with earth infill. (Minke G - 'Building with earth' - 2006)

In Africa, nearly all early mosques were built from earth. In the medieval period, earth was

used throughout Central Europe as infill in timber framed buildings, as well as to cover straw roofs to make them fire resistant. In France, the rammed earth technique called

Mosque of Djenne, Mali

terre pise, was widespread from the 15th to the 19th centuries. Near the city of Lyon, there are several such buildings that are more than 300 years old and still inhabited.

The full value of using sandbags during times of warfare for shelter from bullets and mortar as well as for curbing water from rivers that have burst their banks has been well documented over the years.

Today, with the high and increasing cost of modern construction materials, most people in developing countries cannot afford to use them. Hence the use of earth, the most ancient and unbiquitous of building materials with a do-it-yourself approach.

Since the industrial revolution, fossil fuels have made possible most of the construction in developed countries, meaning that they have been able to overcome the limitations of human labour. This has been at enormous cost in terms of pollution and carbon emissions, massive overconsumption of resources and an increase in unemployment.

People in industrialised countries are rapidly realising that the days of cheap energy and

gross wastefulness are numbered. The quest for low cost, healthy, non-polluting, low energy building materials and techniques is gaining momentum, and earth is being re-discovered as being superior in many instances to modern materials such as concrete, steel and glass.


Al Midhar Mosque, Yemen - 38m tall

The idea of making walls by stacking bags of sand or earth has been around for at least a century. Originally sandbags were used for flood control and military bunkers because they are easy to transport to where they need to be used, fast to assemble, inexpensive and effective at their risk of warding off both water and bullets.

Because of this history of military and flood control, the use of sandbags has generally been associated with the construction of temporary structures or barriers. Using sandbags to actually build houses or permanent structures has been a relatively recent innovation.

The same reasons that make them useful for these applications carry over to creating housing. Since the walls are so substantial, they resist all kinds of severe weather (or even bullets) and also stand up to natural calamities such as earthquakes and floods. They can be erected simply and quickly with readily available components. And most importantly, it is affordable.

SandBag Building fills a unique niche in the quest for sustainable architecture. The bags can be filled with local, natural materials, which lowers the embodied energy commonly associated with the manufacture and transportation of building materials.

The fill material is generally of mineral composition and is not subject to decomposition (even when damp), attractive to vermin, or burnable …. In other words it is extremely durable. The fill material is generally completely non-toxic and will not offset noxious fumes into the building.

SandBags have the tremendous advantage of providing either thermal mass or insulation, depending on what the bags are being filled with. When filled with soil they provide thermal mass, but when filled with lighter weight materials, such as crushed volcanic stone, perlite, vermiculite, or rice hulls, they provide insulation. The bags can even act as natural non-wicking, somewhat insulated foundations when they

are filled with gravel.

Because the sandbags can be stacked in a wide variety of shapes, they have the potential to reduce the need for common tensile materials within the structure. This not only saves more energy (and pollution), but also helps save our forests, which are increasingly necessary for sequestering carbon.

Another aspect of sustainability is found in the economy of this method. The fill material is inexpensive, especially if on-site soil is used. The sandbags themselves are affordable.

The ease and simplicity of building with sandbags should also be mentioned, since there is much unskilled labour available around the world that can be used for this building methodology. One person familiar with the basics of sand bag building could easily train others to assist in the erection of a structure. This not only makes the process more affordable, but also more feasible in remote areas where many common building skills are not to be found.

In recent years a process has been put together whereby the bags are placed within a framework. The framework is easy to erect but offers the benefit of helping with the stability of the entire structure. The framework offers no structural integrity - it is simply a guide for the placement and stacking of the bags. The framework is very useful in ensuring the bags maintain a straight edge during their packing.

The combination of these two components have emphasized the fact that a sandbag wall is superior to a conventional brick wall of the same thickness.

The sandbags in combination with a light timber frame can be seen as a modified timber frame house. But, once the roof is in place and the building plastered, the whole house structure performs monolithic and appears exactly like a conventional brick house.

The system is not dependant on any kind of industrial grid measurements. That means any specific measurements that are required for wall thickness, size and height of the building or wall openings, can easily be achieved.

ECOLOGICAL

The impact on environmental influence is huge; the carbon dioxide emission of one square meter sandbag wall drops by more than 95% compared to a conventional brick wall.

Sand can be found locally nearly everywhere around the world, in some regions even directly on the construction site. As there is no need to process the sand, there is very little transportation of materials. The sand makes up 98% of the weight of the walls materials.

Since clay cement sticks perfectly to the open porous structure of the sandbags an earthen plaster would be the final ingredient that makes the sandbag building methodology completely green.

ECONOMICS

It would be impossible to generally quote the percentage savings when compared to conventional building.

There are many factors that would influence the final cost, such as foundation issues and the various specifications with regard to windows, doors, roof design and finishings.

The average **delivered** price of clay bricks is R 2.30 per brick. For an exterior wall a total of 110 bricks are required per m². The cost of bricks per sq/m therefore is R 253.

Similarly, the cost of M190 building blocks would work out to R 138 per sq/m.

The delivered cost of sandbags per sq/m is R 96. The cost of sand varies from region to region - but, on average it is possible to purchase 6 cubes of sand for R 1200. Depending on the density of sand 840 bags will contain 6 cubes of sand. Therefore, the combined cost of both the bags and the sand works out at R 127 per sq/m. Bear in mind that this method of construction does not require mortar in between the bags, nor does it require the installation of brick force between the bags.

Naturally, if sand was freely available at the source of the building site, then the cost of the sandbag building material drops to the cost of the bag only per square metre - which would in that case work out to be 53% less than conventional building.

Cost of materials for conventional brick building works out at R 600 per sq/m (on average). This amount includes the labour cost.

Conventional bricklayers will lay 600 bricks on average per day. This means that an area of less than 5sq/m can be built per day (assuming that a double skinned external wall is being built). By contrast, sandbags can be laid correctly at the rate of 180 bags per hour. In a working day the area that can be covered using the sandbag building method works out at 30 sq/m - which is five times faster than conventional brick construction.

However, a better quality and a more ecologically friendly house would have been secured for a lessor price than a conventional one. If time is money, then sandbag construction has the advantage of a very rapid construction rate. It also provides a monolithic high high weight construction without bringing moisture into the building structure. If cladding is to be used instead of plasterwork, then the structure could be completed in even less time.

Sand can be found in places all over the world and is considered an unlimited resource.

Sand is an interesting material as it contains fluid as well as solid characteristics, but has unique features due to the grain and texture of sand. It has the unique ability to absorb and resolve all kinds of impacts. Within seconds, forces are distributed to countless sand grains and in this way just disappear. This may be the explanation for the superb earth-quake resistance of sandbag houses and also for their excellent sound absorbing qualities.

Another interesting characteristic is the comparative low density of sand. Clean sand usually has 40-50% voids. Those countless small air spaces are responsible for the relatively good thermal insulation of sand. The insulation of a 23cm thick sandbag wall is at least twice as good as the insulation of the standard 28cm external cavity wall.

The life cycle carbon footprint will therefore be a fraction of a conventionally built structure.

ECOBAG

The most important qualities for a sandbag building bag needs to be - durability, UV stability and good adhesion. A thin non woven geo-textile made from a polypropylene blend is the most suitable material for this type of building. Its structure is like felt and guarantees good adhesion to the plaster - which is of extreme importance. The bags do not slip off each other and they stick safely together within the wall. The plaster penetrates the bag and never loses its bond. Another good feature of the geo-textile fabric is that it is vapour permeable due to the millions of airpockets between the fibres.

When using green type building methodologies, natural materials are usually desired. Materials such as jute, hemp and cotton all have the same positive characteristics as mentioned above, except their durability. Jute and cotton will start to rot as soon as the wet sand is filled into the bags. While hemp is much more moisture resistant than the other materials, it is still comparitively expensive.

FINISH

The finish of both the interior and exterior walls is a matter of choice. The most common way is to plaster the walls. It represents the monolith and solid character that the building is made of. Sandbag walls can be plastered perfectly straight for a clean finish - or even bagwashed. Most houses are finished with a classic smooth cement plaster finish.

To make the home more ecological, an earthen plaster, or a clay/lime combination plaster are a perfect choice. Earthern plaster requires no processing energy, is vapour permeable and responsible for a very comfortable room climate. This is most likely the least expensive method of finishing a wall. Care should be taken to protect the clay from rain erosion. This can be achieved by large roof overhangs, breathable paints like lime wash or by applying a thin finish layer of lime plaster.

Another useful product to use for the outside would be Everite's Fibre Cement Nu-Tec Board, which is manufactured from a combination of Portland cement, silica and organic fibres. They do not contain any asbestos fibres. These materials have considerable strength in their own right and will not deteriorate with age. They are unaffected by moisture and will withstand the harshest Southern African weather conditions.

New plastic/wood composites are also available for consideration to be used as a cladding material. They offer an advantage in that the material never requires any maintenance, however, care must be taken in using this material since they tend to expand and contract considerably.

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FOUNDATION

Usually very deep and strong concrete foundations with steel reinforcements are done for new houses. This is due to the fact that brick houses can get dangerous structural cracks as a result of the smallest ground movements. These ground movements will not affect the stability of sandbag houses though.

Cost savings and an ecological benefit can be achieved with a simple sandbag foundation, obviously suited for sandbag houses to be built on. Any sand could be used except shale and clay - or sand with a clay content of less than 10%.

All organic top soil should be removed and the soil underneath would have to be checked to verify its stability. If the soil is stable, then double layers of sandbags filled with a sand/ cement mix 10:1. These bags with a wet slurry on top would form a very simple foundation.

If the topsoil goes deeper down, then a rock bed of gravel could be a better alternative to concrete. The sandbags with the sand/cement mix would then be laid directly onto the gravel and lightly tamped. Leaving out the concrete and steel makes a large impact on reducing CO^2 emissions and of course, would also be cheaper.

The same principle as for the foundation would apply for the floor. Only one layer of sand stabilized with cement is the flexible basis for a 80mm concrete screed. This would have a wire steel mesh embedded within the concrete screed.

To avoid the cement option completely, earthen floors or wooden floors would be a good alternative.

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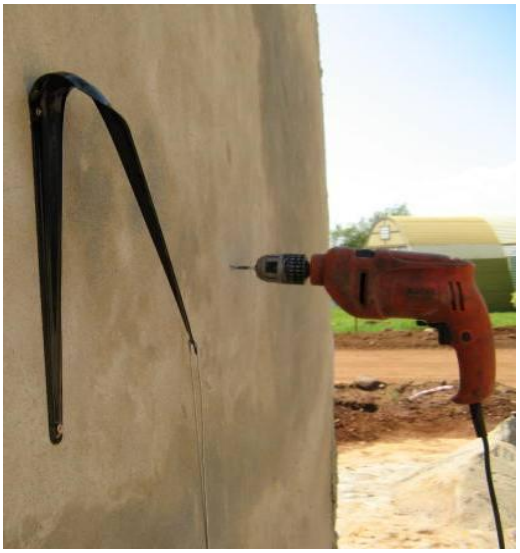
STRENGTH



Sandbag building is extremely strong. It is quite possible to drill into the walls to hang kitchen cupboards, curtain rails and picture frames. No preparation to hang these items would be necessary - they are hung and secured as though it were secured on a standard brick wall.

A standard Corobrick external wall would require 110 clay bricks per square meter. At an average weight of 2,3Kg per brick = 253 Kg per sq/m.

A total of 12.5 x M190 cement blocks would be required per sq/m for an external wall. At an average weight of 16 kg per block = 200 kg per sq/m.

In sandbag construction a total of 42 bags are required per sq/m for all walls. At an average weight of 9,28Kg per bag = 389 Kgs.

SandBags have been used to make defensive barriers in various situations. In combat, sandbags protect equipment and personnel from bullets and shrapnel. In civilian use, people frequently use sandbags to protect buildings, even whole towns, from floodwater.

The fact that sandbags are strong is undisputed. This simple known fact has simply been adapted to be used in home construction in order that the very same benefits can be experienced by the home owner.

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TESTING

In the Summer of 2009 a thermal insulation lab test was conducted at the official German testing institute MPA in Hannover. During a two week testing period the thermal conductivity of a 30cm thick sandbag wall was determined.

The results of the test concluded that a standard 30cm sandbag wall would insulate at least 5 times better than the typical 15cm post and beam brick wall commonly found all over India, China and most developing countries.

In 1996 tests were done at the SABS with regard to structural stability and rain penetration. In both cases, the results far exceeded the requirements of the Agrement Board.

The Agrement Board of South Africa have successfully completed a full series of tests on this building methodology, which resulted in a certificate being issued in November 2011.

BENEFITS

The advantages of this construction system is that it is environmentally, economically and socially sustainable. It is a low impact system on the environment, affordable and job creating.

What makes this building system so environmentally friendly and sustainable ?

Transport - the walls for 250 x 40m² houses can be built from a single 12m container load of EcoBags. 1500 bags fit inside the boot of a small car and weigh only a few kilograms. This is equivalent to 3000 bricks over the same area in a cavity wall.

construction can take place at locations where road access is not provided. This reduces the damage and congestion by heavy trucks which carry bricks and cement.

sand can be found almost everywhere in the world, in some regions even directly on the construction site. As there is no need for centralised processing you have very little transportation of materials. The sand makes up for 98% of the weight of the walls materials.

Embedded Energy - the carbon footprint of this building system is much lower than when conventional materials (cement, clay bricks and steel) are used, which have enormous embedded energy and hence carbon footprint. The carbon dioxide emission of a one square meter sandbag wall drops by 96% compared to a conventional brick wall

Fill Material - local site sourced fill material is used to fill the EcoBags. This dramatically reduces fossil fuel use and transport costs to site. It also means environmental damage from quarrying is eliminated.

Water Requirements - are minimal, as the main construction process uses no mortar.

Timber - the sandbag building system uses 2/3 less timber than conventional building. Though theoretically a sustainable resource, wood is becoming increasingly scarce and expensive, and carbon is locked in *growing* trees only.

Waste Production - on-site waste generation is almost eliminated - such as timber offcuts and other precious resources. Landfills are not part of the sandbag building systems requirements.

no bricks lie around the site before, during or after completion, eliminating "site-clearing", which is a major cost factor on any building site. Unused bags can be removed from the site overnight reducing the incidence of theft.

Insulation - the excellent thermal insulation of a sandbag wall results in drastically reduced heating and cooling costs over the life of the building, especially when combined with appropriate passive thermal design. Even in hot climates, airconditioning can often be eliminated. The life cycle carbon footprint will therefore be a fraction of that of a standard house.

Longevity - appropriately designed sandbag structures will stand for decades if not centuries. This makes them highly sustainable, as the longer any usable item lasts, the less often it has to be replaced, thus saving resources and reducing waste.

Reduce, Reuse, Recycle - the sandbag building system epitomises a low cost environmental impact system. Not only is the use of resources reduced, but the material from which the bags are made are easily recyclable. The raw material from which the sandbag is made is a by-product of the refining of crude oil into petroleum.

Strength - sandbag construction is heavier than brick construction and is therefore wind resistant.

sandbag walls are bullet proof.

the wet bags behind the plaster enable the plasterwork to cure instead of merely drying. The end result is a very hard and reinforced cement finish.

Waterproof - the sandbag building system resists water penetration due to the fact that the sand in the bags is a filter medium - any water penetrating the plaster will simply "filter" down to the dampcourse and exit the wall to the outside.

Electricity - no electricity is required on a sandbag building site.

Employment - the only skilled labour required is the plasterer.

the construction technique can easily be learnt in a few days by people without experience in the building trade. A regular builder would pick up the sandbag building process immediately.

all electrical conduit, water, waste and sewerage pipes can be recessed into the sandbag walls by unskilled labour prior to plastering.

all members of the community can get involved, thereby creating a sense of ownership, belonging and contribution among the participants

Cost - since the construction rate of the sandbag building system is rapid, the cost of finance is dramatically reduced. In many cases, building cost can be reduced by as much as 30%.

"The EcoBuilders SandBag Building method is relatively new, but it's future is extremely bright. It has the potential to reform the green construction market throughout Africa.

There is a priceless opportunity to take advantage of this age old technology available to make it available to the communties around you.

There is nothing magic or theoretical about it, just a simple proven use of affordable materials on a budget that pays for itself out of reduced energy and thermal costs.

More importantly, this method of construction offers significant opportunities with regard to job creation and skills upliftment. From the manufacturing of the sandbags right through to the construction process, sandbag construction offers *employment opportunities to both men and women.*

The EcoBuilders SandBag Building System will save you energy, save you money and healthier for you to live in.

Contribute significantly towards your communities future by investing in the sandbag method of construction."

Andy Strydom