low-cost sustainable housing, materials + building technology in **developing countries**

shelter initiative for climate change mitigation (SICCM)

UN-HABITAT 2008

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00 INTRODUCTION

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The World Bank identified 152 developing countries as of the year 2007, of which it is reported one in three people are without adequate shelter. [1] UN-Habitat is working to lower the statistic through the provision of low-cost, sustainable building materials and technologies while recognizing the 'Adequate Shelter for All' agenda, committing to, "Access to safe and healthy shelter and basic services recognized as essential to a person's physical, psychological, social and economic well-being and should be a fundamental part of our urgent actions for the millions of people in the world without decent living conditions." [2]

SUSTAINABILITY

Lack of housing worldwide is not restricted to certain parts; both rural and urban areas with unsafe or inadequate shelter produce negative impacts – resulting in the proliferation of informal settlements and are a major cause of environmental pollution with little or no resource to sewage, garbage disposal and sanitation.

The increasing demand of housing required, coupled with informal settlements constantly expanding, is underlined by the crucial necessity to research new methods of design and material technologies – as the manufacturing and transport poses threat to substantial environmental damage with additional energy consumption and waste production once occupied. It is possible, and necessary, for the design of low-cost housing to confront environmental issues and propose opportunities to reduce carbon emissions and greenhouse gases through a choice of materials, construction technologies and the influence design dictates on how energy is sourced and consumed.

The pragmatic term 'sustainability' has many definitions, adaptations and applications. The most common and widely accepted meaning was created by the Brundtland Commission, formally the World Commission on Environment Development (WCED), "Sustainable development is meeting the needs of the present without compromising the ability of future generations to meet their own needs." [3] Building on this definition, the Declaration of Rio on Environment and Development identified that sustainable development was the balance of three things: environmental protection, economic growth and social development. Environmental protection can be narrowed to produce specific ways of reducing green house gas (GHG) emissions through the built environment. It is the disadvantaged communities that tend to contribute least to global climate change and yet are effected most – becoming involved in, and influencing, housing and environmental policies both locally and nationally. The most efficient measures to reduce GHG emissions fall into three categories, of which it is important to focus on just one for the most effective results. Categories include: reducing energy consumption and embodied energy in buildings, utilizing low-carbon fuels for a higher share of renewable energy or controlling the emissions of non-CO2 green house gases. When considering new-build, the most viable choice is the controlling of non-CO2 green house gas emissions - through material selection, construction technique and essential transportation of goods required - while an integrated design approach is required to ensure an effective combination of architectural and engineering systems. The environment is where we live and development is what we all do in attempting to improve our life within that abode, and as a result the two are inseparable. The built and natural environment has a huge impact on the quality of life. [4]

1 www.unicef.org
2 www.unescap.org
3 www.unngocsd.org
4 Akintoye, A. (2006) A Public Partnership for Sustainable Development of Infrastructure in Developing Countries Covenant University, Nigeria Pg. 433

02 SUSTAINABLE LOW-COST HOUSING

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OVERVIEW

The link between sustainability and urban housing has been an ongoing global debate for more than two decades, failing to gain the depth of attention necessary until the late 1990s. Sustainable housing remains a relatively new concept to developing countries. While there have been different approaches and conceptions of sustainable models for development internationally, specific to climatic circumstances, addressing the major shift in the distribution between rural and urban migration and exploring stages of implementation, there remains definitive barriers. In most developing countries, the mindset regarding sustainable development is limited to an understanding of economic growth, while to the north the focus emphasizes ecological issues. The Habitat Agenda underlines the importance of developing new approaches in managing and planning rapid urban growth and human settlements.

Problems associated with urbanization differs relative to location, making it impossible to develop an overall approach to sustainable housing. The overall concept should be a compilation of energy and environmental energy issues in the built environment. It is also necessary to define the judging criteria associated with 'sustainable housing'.

The definition of low-cost, in a housing sense, depends greatly on the economic capacity of the target group. One concept of affordability may prove to expensive in other instances of country implementation. Economic models should be interwoven to include financial schemes, reducing the problem of affordability. Creating jobs through labor models, workshops and capacity building is critical to the long-term objectives and direct community benefit, particularly focusing on women.

Sustainable materials are key to limiting the impact on the ecological system. Local techniques and technology, resources and materials are a good starting point when researching or implementing projects. Housing models should determine the sustainability of the building materials through life-cycle analysis, and occupational use of building including renewable energy, water, land and use of resources.

Appropriate technology goes hand in hand with the design and building materials. It should correspond to local conditions, reflect and respect climatic conditions and demand a minimum of maintenance.

Local sensitivity with regards to status can greatly impact the success of projects. When introducing new low-cost housing developments and design it is important not to be labeled as homes only for the low-income families and individuals.

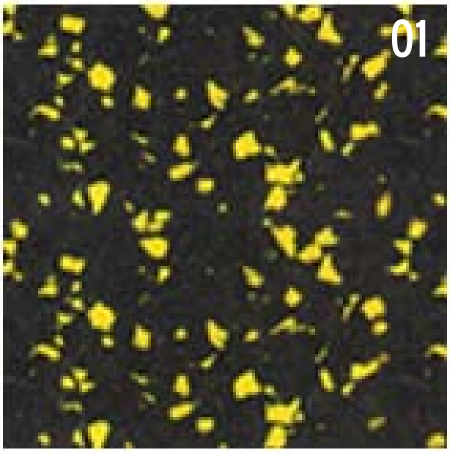
Organization and elements of implementation must become the responsibility of the Local Government, with environmental and energy issues incorporated into all levels of planning and decision making.

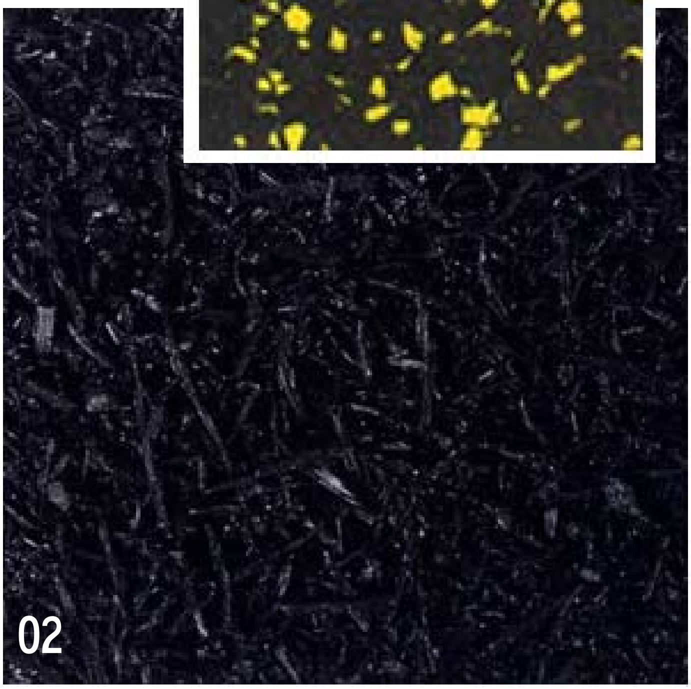
BARRIERS

Sustainable housing is a relatively new concept in developing countries - producing and leading to an assortment of barriers when researching past projects and planning for future developments. Common obstacles were discovered throughout the research stages of sustainable low cost housing in development projects: most models concentrate on one or two elements of sustainability, rather than incorporating it as a whole; there is a lack of, or difficulty in gaining, access to sufficient information about project and programs in developing countries; low-cost housing projects in an urban context are few.

06 MATERIALS

06 RUBBER





01 // TIRE VENEER

Summary:
Tires are essential globally, at all levels of development. Millions are discarded annually as they wear out relatively fast – this product makes use of recycling the material into a usable material for various types of applications.
How it is used:
The most common application is as an environmentally responsive flooring material – resilient both indoors and out. Areas of use extend to areas such as sports and recreation, animal housing and high traffic areas outdoors – and a variety of consumer products, vibration dampeners and furniture surfaces internally.
How it is made:
In the retreading process, the old tread is removed by grinding and the resulting dust is termed buffings. These buffings are non-laminated polymerically bound black SBR rubber. To give more aesthetic appeal to the material, colorful virgin EPDM rubber granules are added along with a urethane binder. The homogenized mixture is approximately 80% black rubber and 20% colored rubber although this percentage can be varied. The percentage of black rubber indicates the post-consumer content.

02 // ACOUSTICEL

summary:

Understandably, tin shacks and typical materials used to construct informal settlements are extremely inefficient thermally. Inhabitants can end up spending as much as 20% of their disposable income on space heating throughout the winter months, using bio-fuels such as wood, coal and paraffin. The gasses released lead to heavy indoor pollution levels that are up to 10 times higher than prescribed by the World Health Organization. An easy and effective solution is to make a house more energy efficient is to address different, low-cost types of insulation.

01 // STRAW AND RESIN PANELS

Summary:

Informal settlements in northern Pakistan have become the pilot site of a new technology created at MIT to provide much needed insulation and sound absorption for existing housing. Using agricultural waste, such as straw, a binder is applied that is made up of local resins to form insulating panels that can be easily installed under and between existing corrugated metal sheeting – and lightweight corrugated iron currently being used as roofing by over one million people in Pakistan alone. The technology and construction method also mitigates added deaths when the region experiences earthquakes, as heavy earthen roofs often collapse and bury those inside. With the manufacturing is able to be carried out locally with already available materials to meet the growing needs, there is an opportunity for business creation and income generation.

Pilot manufacturer: Ghonsla (Pakistan)

02 // FLAX INSULATION

Summary:

Flax is a plant native to the region extending from the eastern Mediterranean to India and China, and was once extensively cultivated in Egypt – today flax fibers are amongst the oldest fiber crops in the world. The fiber has is soft, flexible, stronger than cotton but not as elastic. Natural insulation can be made from 100% flax fibers by matting them together into a non-woven process and then utilizing their properties for insulation in lofts or wall cavities. The material has very low embodied energy and the thermal conductivity of flax insulation is 0.037 W/mK, making it ideal for breathable constructions.

03 // WOOD FIBER INSULATION

Summary:

Wood fiber insulation panels are made from 100% pulped wood fiber with no added harmful chemicals or materials, using the dry manufacturing process there is no water treatment necessary and energy costs are low. There are various types of wood fiber insulation for different uses and purposes – floor and roof insulation and internal/external wall insulation. The thermal conductivity values range from 0.04 – 0.05 W/mK. They protect against cold in the winter and heat in the summer.

04 // WARMCEL

Summary:

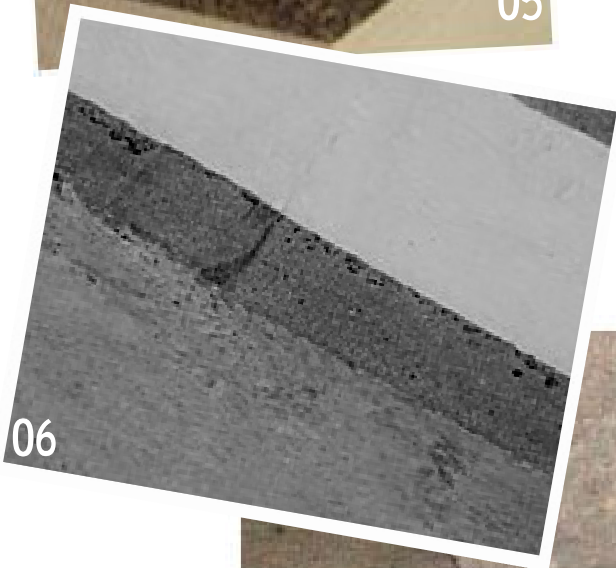
Warmcel is an insulation are cellulose fibers extracted from 100% recycled newspaper with natural mineral additives that make it insect, rodent and fire resistant. The lifecycle proves more than acceptable as it consumes minimal energy to manufacture, is non-toxic and can be disposed up without any biodegradability problems. Thermal insulation performance is excellent, with a k value of 0.035 and a U value dependant on thickness: 100mm, U=0.35; 200mm, U=0.175; 250mm, U=0.14; 300mm, U=0.12.

05 // CORKOCO

Summary:
The material is a panel made of combination cork and bioecologic coconut fiber, mainly used for acoustic insulation.
How it is used:
The performance is specialized in providing acoustic insulation and insulation – for installation in attics, gaps, between rooms or apartments.
How it is made:
There are two levels of performance panels available. One is simply a coconut fiber panel; the other is a sandwich of a corkpan panel between two sheets of coconut fiber.

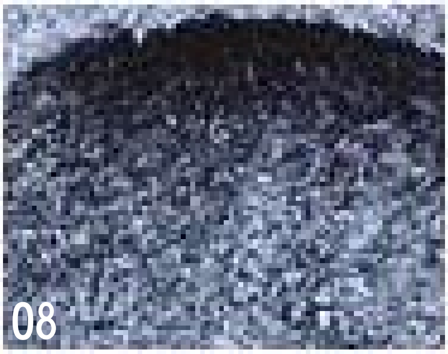
06 // GRANCRETE

Summary:
Greensulate is a low-cost, biodegradable rigid insulating composite. At the end of its life-cycle, the material biodegrades, rapidly breaking down and enriching the surrounding soil – even accelerating the rate of breakdown for surrounding and nearby waste.
How it is used:
It can be used as an insulating composite for packaging or industrial use in housing, to retain heat easily and cost-effectively as it is cheaper than foam products (between 0.50-3.00 USD per cubic foot). Greensulate acts as a biodegradable replacement for polystyrene and Styrofoam.
How it is made:
There are no energy inputs, including heat and light since the material is grown from renewable agricultural waste resources using both agricultural and industrial waste streams.



07 // THERMAFLEECE

Summary:
Thermafleece is an alternative type of home insulation, for applications in roofs, walls and floor construction. Only 14% of embodied energy is used in comparison to common fiberglass insulation.
How it is used:
The material is intended for use as an insulator in home construction.
How it is made:
The material is made from wool, offering a naturally higher fire resistance than cellulose and plastic insulates. Instead of burning, it rather melts away from the source of ignition



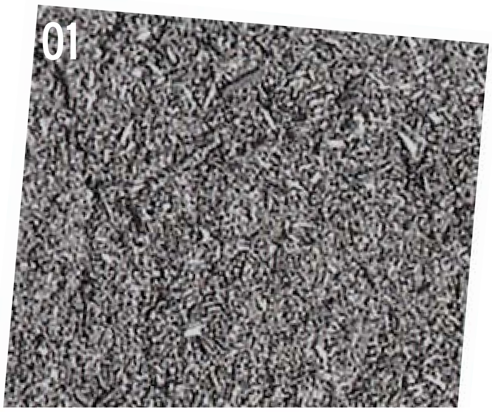
and extinguishes itself.

08 // NATURAL TOUCH COTTON FIBER INSULATION

Summary:
The insulation is a different type of composite, offering excellent performance qualities with regards to heating and sound absorption for residential applications.
How is it used:
The material comes in rolls, and is applied directly to walls, roofs and floors in homes.
How is it made:
The insulation contains 85% post-industrial recycled natural fibers, most of which are sourced from denim manufacturers giving the blue color.

06 CONCRETE/ CEMENT

Cement based building materials consume vast quantities of natural resources and contribute to a large proportion of construction, demolition and similar waste. **The production of cement, the primary component of concrete, accounts for 5-10 percent of the world's total carbon dioxide emissions. If the manufacturing of cement could be altered to reduce the carbon emissions by just 10%, it would accomplish one-fith of the Kyoto Protocol goal of a 5.2 percent reduction in total carbon dioxide emissions.** There are currently available multiple alternatives or additives that can help reduce waste and CO2 emissions when applied correctly and suitably to location specifications.



01 // RICE HUSK ASH/ POZZOLANAS

Summary:
Pozzolanas are materials containing reactive silica and/or alumina, which in their own right have little binding ability. Yet, when mixed with lime and water it will set and harden like cement. They are important ingredients in alternative cement compounds, making a significant contribution towards low-cost materials.

Rice husks are a large by-product – one ton is produces per five ton of rice paddies, and it is estimated that 120 million tons of husk could be available annually on a global basis. Rice is a major crop in many third world countries – including China and the Indian sub-continent, South-east Asia and in some regions of Africa and South America.

While once considered as a waste by-product, it has now been successfully implemented as a Pozzolanas in the commercial production of cement in several countries including Colombia, Thailand and India including several pilot projects underway in most of the major rice-growing countries worldwide – leaving considerable opportunity for expansion into small and large scale production. Environmental aspects are deeply incorporated into the manufacturing process, as low-heat is necessary for the burning of the husk and carbon quantities of the ash over 10% will adversely affect the strength. Simple incinerators can be made of fired clay bricks capable of controlling lower carbon quantities, used in banks of 3-4 they may produce one tone of ash per day.

Weight for weight, rice husk contains an energy value about half that of coal, and is therefore an important energy source, though it must be consumed close to natural production as transportation is a very unviable option. Only 20% of its weight may be utilized as a pozzolana.

The success of using rice husks depends on the self construction of individual ovens. With the ovens, this method would be sufficient and successful, making rice husk ash an affordable and sustainable alternative to cement.

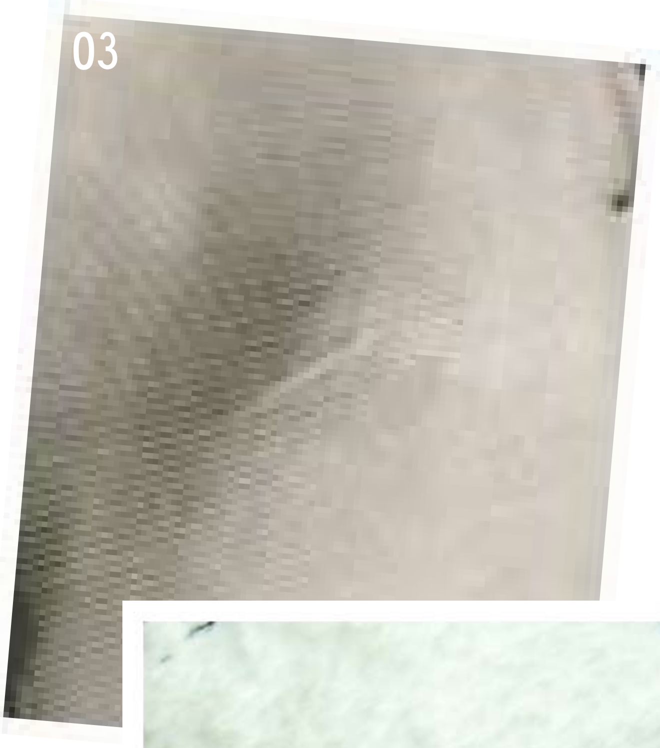
02 // RECYCLED MATERIALS IN CONCRETE

Summary:
Despite obvious environmental and cost advantages, there is limited development and research regarding the inclusion of waste or industrial by-products in the makeup of concrete building materials. One risk of incorporating recycled materials into the compound is a lack of homogeneity and the chance of contamination that in general lower the quality of the product. There is evident opportunity for further engineering and research testing of new cement products containing waste, focusing on durability and the binding capability crucial for their viability.

03 // CONCRETE CANVAS

Summary:
Concrete canvas is exactly what its name says – canvas impregnated with concrete power. With a wide range of applications, it is an extremely valuable solution to both short term emergency response and long term installations.

The material is a 3-dimensional fiber matrix containing a specially formulated dry concrete mix. A PVC backing on one side of the surface ensures the material is completely waterproof, while hydrophilic fibers on the opposite surface help aid the hydration by drawing water into the cement. The material can be pulled, slightly stretched, draped and so forth – fixing in place is done by nails, staples or coated with an adhesive for easy attachment to other surfaces. Once fixed, the material may be hydrated either by spraying or being fully immersed in water. The water activated the concrete powder and the canvas concrete hardens to become strong, durable, waterproof and fireproof. Fresh water and sea water may be used to hydrate. Once wet, the material remains flexible and workable for 4 hours. Once set, the fibers help to reinforce the concrete and prevent cracking.



04 // MAGNESIUM OXIDE CEMENT

Summary:
Magnesium oxide cement is often referred to as 'eco-cement' as it has been engineered to incorporate a large proportion of waste materials while retaining highly durable qualities for construction. Magnesium deposits are found worldwide and cover roughly 8% of the earth's surface and phosphates are available from rock, animal wastes and fermented plants.

Depending on where they are mined, magnesium oxide and magnesium choloride cements require only 20-40% of the energy required to produce Portland cement. MgO uses 'reactive' magnesia that is able to be manufactured at a lower temperature than Portland cement, and utilizing a large portion of Pozzolanas by-product and producing environmentally friendly, non-toxic cement. This makes it more recyclable than Portland cement and is expected to improve the durability while being capable of high propensity for binding waste materials. Studies are ongoing, currently producing positive results.

Magnesium-based cements are proven exceptional in promoting the health for occupants of homes in which they are used as the prime building material. The natural compound binds exceptionally well to other cellulose materials, such as plant fibers, wood chips, Styrofoam, and stone, unlike Portland cement that repels cellulose. The compressive strengths are many times stronger than conventional concrete. When combined with clay and cellulose results

in a cement that can breathe water vapors electro-magnetically as the clay enhances the movement of moisture and will never rot because it always expels moisture.
Natural Source: India and China

05 // FLY ASH TECHNOLOGY - FLASH BRICKS

Summary:
Fly ash is a fine, toxic powder produced as a byproduct from coal-burning power plants.

In India alone, approximately 100 million tones are generated per year, while 200 million tones are produced in China. The Indian Government took action in 2005, requiring 25 percent of the fly ash to be used in the manufacturing of clay bricks for construction within a 50 km radius of the original coal plant source.

Coal fired power plants are not as common world wide – such as in the Middle East where acute shortages of durable and natural building materials mean importation at considerable financial and environmental cost.

Bricks can be manufactured entirely from waste fly ash, formally referred to as Flash Bricks. The manufacturing process traps any harmful chemicals to reduce generated greenhouse gases. The materials properties include being 28 percent lighter and 24 percent stronger than comparable clay bricks. A separate aggregate called Flashag, a concrete can be made that is 22 percent lighter and 20 percent stronger than standard products.

The construction technique and process is improved as the material allows for lighter structures, shallower foundations, less expensive transport costs with environmental benefits as fewer emissions are produced and the speed of setting is quicker for comparative standard bricks, and less usage of cement and steel reinforcement.
Natural Source: India and China

06 // CANNABRICK

Summary:
Cannabrick is derived from the cannabis plant – using the woody inner core as a material element for construction. This part of the plant is free of THC and used primarily for construction in the housing sector. Performance is excellent against fire and water, as silica leached from the soil through the plant, combined with unabsorbed lime makes a chemical bond similar to cement – and cannabis cement requires lime. The material is 100% natural, 100% fireproof and conforms 100% to the Kyoto carbon credit compliance.

06 CONCRETE/ CEMENT

07 // SYNDECRETE

Summary:
Syndecrete is a version of concrete that uses natural minerals and recycled materials as aggregate. Fly ash is also part of the compound, an environmental material that conserves natural resources and prevents the production of typical concrete contents by resourcing waste from coal production.
How is it used:
There are a variety of domestic applications – tiles, sinks, countertops and slabs.
How is it made:
The manufacturing process utilizes fly ash, which is a by-product of coal when it is consumed in a power plant, and then combines lime to form the cementitious compound. This method requires less water and gives better durability and workability when compared to typical concrete.

08 // TX ACTIVE

Summary:
TX Active has been described as'pollutant-eating' cement. It is a photocatalytic cement that works to reduce organic and inorganic pollutants present in the air. A case study illustrates the Milan example, where if by 15% of the visible urban surfaces was a material containing TX Active, it would cause an approximate reduction in pollution by 50%. Scientific laboratory results have shown that three minutes of sun exposure is sufficient to obtain a reduction of polluting agents up to 75%.

09 // BENDABLE CONCRETE

Summary:
A new type of concrete has been developed by the University of Michigan. The fiber-reinforced bendable concrete is 500 times more resistant to cracking, and weighs 40 percent less. The compound is made up of 2 percent fiber, designed for maximum flexibility. The costs and overall emissions are estimated to be lower as a result of its long lifespan.

10 // GRANCRETE

Summary:
Grancrete is a spray applied to Styrofoam walls, of which it adheres to and cures within 15 minutes. With properties proven to perform better than concrete, such as it being stronger, fire resistant, able to withstand both tropical and sub-freezing temperatures and ideal for a range of geographic locations, this is ideal for the construction of low-cost housing. The Styrofoam remains in place after the spray is applied, acting as an insulator – although woven fiber mats may be substituted and reduce the raw materials required. It is important to source materials and labor

that is as indigenous as possible – Grancrete makes use of the natural resources such as soil and ash found in nearly every village, it is made of 50 percent sand or sandy soil, 25 percent ash and 25 percent binding material – the binding material consisting of magnesium oxide and potassium phosphate, with the latter being a biodegradable element in fertilizer. After two days of training on how to control and calibrate the machinery, the house may be fully assembled in another two day period. The cost of an approximately 400 square feet home would cost roughly $6,000 US for labor and materials – considerably less than the same dwelling constructed with conventional materials.
(developed in USA/ can be manufactured and applied worldwide)

06 TEXTILES

01 // ZEROFLY

Summary:

Zerofly, manufactured through Vestergaard Frandsen, is a plastic sheeting deployed in complex disasters to provide immediate shelter with an added insecticide proven to protect against disease vectors such as malaria mosquitoes. The strategy driving the development of such materials incorporates the Millennium Development Goals of combating diseases, improving maternal health, reducing infant mortality rate and establishing global partnerships for development. Environmental importance is also critical – Zerofly works to assure the protection and minimization possible adverse effects on the environment through reducing waste and emissions into the air, ground and water, recycling and reusing materials and products where ever possible and implementing environmentally friendly technologies.

02 // ENKARETAIN + DRAIN

Summary:

The product provides an all-in-one drainage and water retention matting. The material has several important qualities; among them is high strength, a durable composite – inert to biological degradation and naturally encountered chemicals, extreme resistance to punctures and tears. Where LEED sustainability recognition is given, the product can contribute up to 2 points when used in conjunction with other recycled content products.

How it is used:

The material can be used in a variety of ways; some of the most popular are green roofs and roof gardens, reducing storm water runoff, heat islands and energy consumption. The water retention factor allows plants to root and keep a continuous source of moisture, while filtering and draining any excess.

How it is made:

Made of 50% post-industrial recycled polypropylene, the composite comprises a fused drainage core, entangled filaments and specially formulated water retention fabric bonded to one side. Other elements include post consumer recycled non-woven polyester fabric mechanically bonded to a layer of synthetic hydrophilic (water) absorbent mat – designed to hold between 10 and 12 times its unit weight of water.

03 // GREEN CELL FOAM (GCF)

Summary:

Green cell foam, developed at Michigan State University, is an environmentally friendly, bio-based and bio-degradable foam – designed to perform best in short-term use as it holds a short-term, typically single use, lifespan. It acts a solution to waste generated in packaging when transporting materials, components and articles. The material

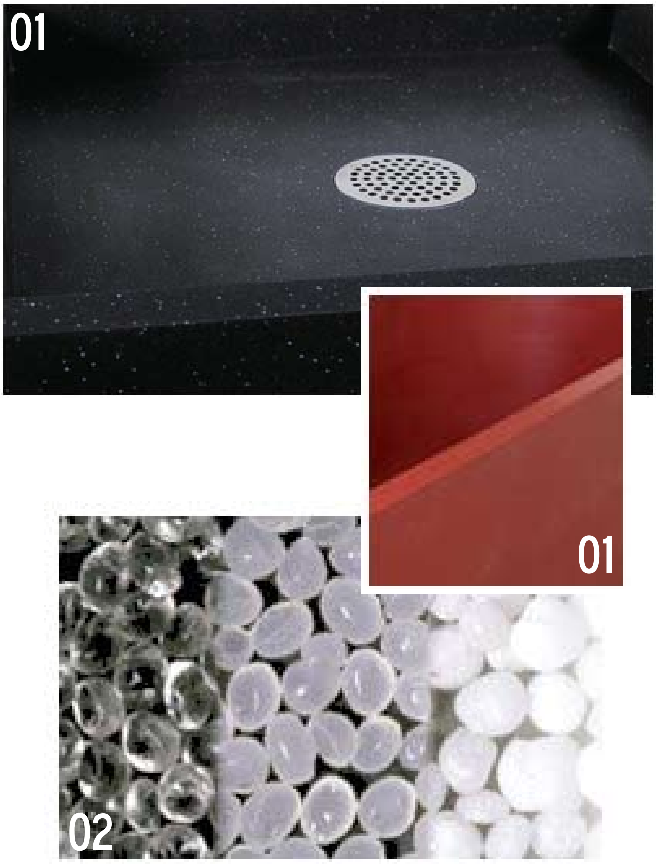
provides protection during the shipping, and then can be easily discarded, composted, recycled, dissolved or even burned.

How it is used:

The main purpose of this material is for protective, water resistant packaging of industrial and consumer items, also having the ability to act as an insulator for shipping coolers.

How it is made:

There is a one-step green extrusion process that uses non-GM, high-amylose cornstarch to produce the resilient and flexible foam.



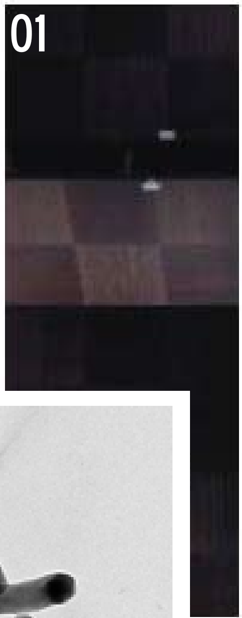
01 // DURAT

Summary:
Durat is a solid polyester based material used for custom made interior surfaces and molds. The content includes recycled plastics and is itself 100% recyclable. The product is very durable, resistant to wear, humidity, chemicals and can be renewed by slight sanding.
How is it used:
The material is manufactured in sheets typically, but can create sink models and custom made sanitary units. Often sheets are used for counter surfaces with seamless joints.
How is it made:
The manufacturer collects raw plastic waste in Scandinavia and transforms it into high quality products, using modern technology and flexible molding systems.

02 // NATUREWORKS

Summary:
Cargill Dow has invented a new technology to produce performance polymers entirely from annually renewable resources. Using a patented technology, they start with natural sugars derived from plants such as corn, wheat, beets and rice and use fermentation to create lactic acid (a food additive) and some simple refining steps to create polylactide polymers (PLA). The result is the only commercially viable polymer to combine performance and cost competitiveness with outstanding environmental benefits.

NatureWorks clear plastic polylactide PLA can be shaped into a variety of bottles, containers, trays, film and other packaging. NatureWorks LLC operates a global-scale facility in Blair, Nebraska, USA, capable of producing more than 140,000 metric tons (300 million pounds) of NatureWorks PLA per year. From cradle to resin, the production of NatureWorks PLA uses 68 percent less fossil fuel resources than traditional plastics (PET) and it is the world's first greenhouse-gas-neutral polymer.



01 // FLEXFORM HIGH DENSITY HARDBOARD

Summary:
FlexForm is a blend of natural fibers and fiberized thermal plastic polymers – either polypropylene or polyester. The fiber compositions can be custom blended to meet a variety of needs. The finished product is available in rolls or sheets, in any length for specific applications.
How it is used:
FlexForm can take the replacement of many materials and applications, as its properties are so flexible and adaptable.
How it is made:
The material is 100% recyclable after use, created with natural fibers. FlexForm produces no toxic VOC emissions, and can reduce a manufacturer's total emissions of volatile chemical while helping improve the environment through bettering interior air quality, lessening trim waste through the process of recycling and reducing land fill.

02 // HYPERBRANCHED AMINO SILICA [HAS]

Summary:
Hyperbranced amnino silica [HAS] product is unique, in that it address the problems of existing CO2 capture techniques – involving a solid material that is unable to be used repeatedly, or liquid adsorbents that are expensive and require significant amounts of energy. HAS is capable of absorbing 5 times as much carbon dioxide as the best existing materials currently available. Studies and tests are ongoing, at the Georgia Institute of Technology, by Jeffrey Drese.
How it is used:
HAS is a new low-cost material for capturing carbon dioxide directly from the smoke stacks of coal-fired power plants and similar generators of the GHG.
How it is made:
The material has a high capacity for absorbing carbon dioxide, produced with a simple one-step chemical process, and may be reused several times. By adding CO2-adsorbing amine polymer groups to a solid silica substrate using covalent bonding the material was formed and works to perform. The amine polymer is initiated on the silica surface which creates solid material that can be filtered out and dried. This chemical bond makes it possible to be used and reused many times.
(HAS http://www.gatech.edu/newsroom/release.html?id=1746

03 // ECO PAINT

Summary:
Ecopaint is a new paint has been developed, to act as a sponge for some of the most noxious gases (NOx) released in vehicle exhaust that can lead to respiratory problems and triggers smog. Only available in Europe, it is currently

undergoing further testing.

How it is used:

It is envisioned this can be used by architects and designers in a more urban context and at large scale.

How it is made:

The paint's base is polysiloxane, a silicon-based polymer. Embedded are 30 nanometre wide spherical nanoparticles of titanium dioxide and calcium carbonate – being so small makes it possible for the paint to appear clear, with the possibility to add pigment for desired effects.

04 // ABACA

Summary:

This Material uses the residues produced from banana harvesting and recycles them into a high-pressure decorative laminate. Available in ten neutral hues, and is suitable for horizontal and vertical applications. The recycled banana fiber in the product comprises of approximately 40% post-industrial recovered content.

05 // REAPOR

Summary:

The material Reapor is developed by the Fraunhofer Institute for Building Physics. It is fiber-free, waterproof, fireproof and resistant to acid attack. While being light in weight, it is stable and performs well, insulating against heat and cold and absorbs sound. The environmentally friendly aspect is evident in the 90% recycled glass content, and it can be recycled entirely. Construction and manufacturing is made easy through simple machinery, and ease to saw or drill. The basic compound is an expanded glass called Liaver, a spherical and lightweight building material made from recycled glass. The material can be used as an additive to mortar or plaster to reduce the density and weight. As glass only melts at the point of contact, no additional binders are required. The size and distribution of the pores are entirely customer/project controlled – giving a determinable degree of thermal and acoustic insulation as well as weight requirement.

01 // CLAYTEC REED BOARDS

Summary:

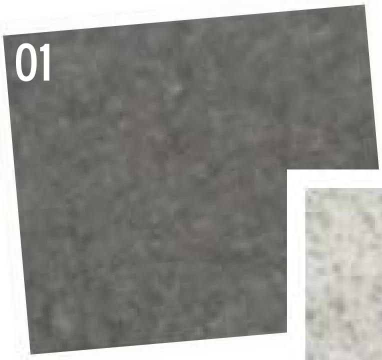
Claytec reed boards are manufactured from renewable sources mainly derived from plants, bound using zinc coated wire and held in position with dabs of plaster before an outer surface coat application. There has been a proven performance which rates above standard under European regulations in areas of global warming and mineral extraction.

How is it used:

They are primarily used for the base construction in walls, ceilings and roofs. Alternatively, they may be incorporated into internal timber framed construction before being coated in plaster.

How is it made:

A level surface may be accomplished by laying them crossways. Fixings include reed board pegs, screws or pressed into freshly applied plaster. The construction may be carried out easily, requiring minimal tools. All cutting work is done through a metal blade jigsaw, or side-cutter for portions with metal binding wires.



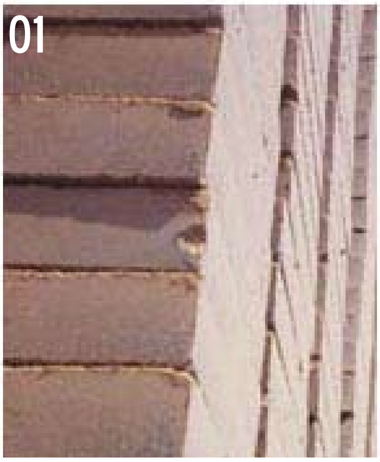
01 // SHETKA STONE

Summary:
ShetkaStone is an innovative product produced from recycling all types of paper (including glossy, waxed and magazines) and combining it with plants and cloth fibers. The result can be made into anything from countertops, benches and molding. The company is based in the USA, where paper currently accounts for 40% of the total solid waste produced.
How is it used:
The patented process is created by making slurry of pre and post consumer waste, which is formed and hardened. This is ideal for interior fittings, such as counters, cabinets and so forth.
How is it made:
The material offers a 100% sustainable life cycle due to the recycled content as the waste created in the manufacturing process, as well as products that have become damaged or reached the end of their use, can go back into the manufacturing procedure.

02// CARDBOARD

06 EARTH/ ADOBE/ CLAY

Clay is commonly presumed to be a sustainable material. Yet, the environmental impact is most devastating throughout the production process as the energy consumption for firing bricks and the quarrying of raw materials is great. The overall impact must also include the transport and production of the raw materials, while limiting the use of primary raw materials results in a smaller environmental footprint for the production process. The lifecycle of a brick generates very minimal waste, equating to approximately 1.2g per kg of the product. Other benefits include high thermal mass with balanced and responsive conditions for cold and hot periods, good sound insulation properties, and ability to absorb and diffuse water vapor and absorb odors.



01 // EARTH BLOCKS

Summary:
Material production requires approximately 75% of the energy used in construction. The brick industry in India produces 22% of the CO_2 emissions by the construction sector and requires about 27% of the energy used in building material production. Combinations of factors lead to the continuing of inappropriate, poor environmentally sound materials and building standards.

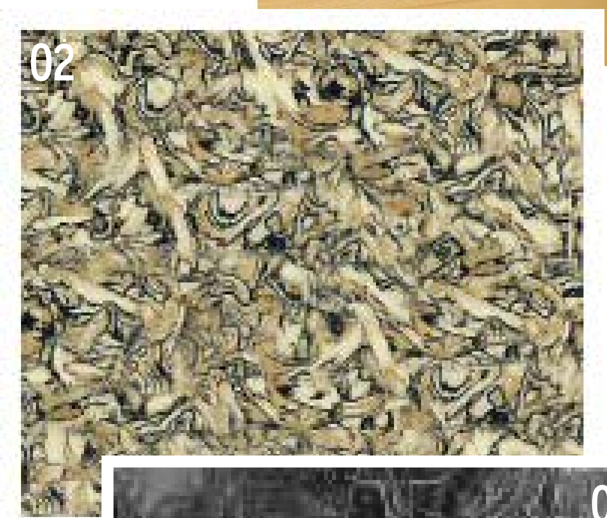
The production of simple earth blocks only requires around one thousand of the energy needed to fire bricks, and even in cases where earth is stabilized with cement it is no more than a sixth per kg of material.

02 // ECOBRIQUE

Summary:
The Ecobrique is a French revolution in brick making by vBc 3000. It is a ceramic product made from partially dried sewage sludge by incorporating waste treatment plant residue in the clay matrix. The lightweight material is just as durable as the traditional counterpart – being fired in traditional kilns or rotary furnaces. Throughout this process, the organic matter creates porosity and expansion in the material, this is where it lightens and gives good properties of heat insulation and soundproofing.

03 // CLAYTEC

Summary:
Claytec bricks are comprised of clay, sand and straw. As they are hand pressed and unfired, they are unsuitable for load bearing walls. Benefits do include good acoustic properties, thermal qualities that help regulate temperature and humidity, the clay absorbs and diffuses water vapor, absorbs odors and have a low embodied energy.



01 // ACCOYA WOOD

Summary:
Accoya is a new type of wood species, well researched with repeatedly demonstrated high performance qualities. The properties exceed some of the best tropical hardwoods, while the manufacturing process utilizes a non-toxic process after sourcing wood from certified and sustainable sources.
How it is used:
The material is suitable for several housing purposes, such as cladding, siding and facades – requiring infrequent maintenance and offering durability and insulation. More detailed applications include doors, window frames, decking and furniture.
How it is made:
The technical properties of the wood have been improved based on a process of acetylation, studied by scientists for more than 75 years. The process alters the actual cell structure of the wood by transforming free hydroxyl groups into acetyl groups – hydrogen, oxygen and carbon already present in all wood types. The compounds can be derived independently from acetic acid. Therefore, the process does not introduce anything to the wood that does not naturally occur in it.

02 // DAKOTA BURL

Summary:
Dakota Burl composite is a unique bio-based material, which exhibits the same aesthetic qualities of traditional burled woods.
How is it used:
The material is primarily for interior use, such as tables and counters, cabinetry, furniture and similar architectural applications.
How is it made:
The material is created from an agricultural fiber and sunflower hulls and can be worked using standard woodworking tools.

03 // PALM FIBERBOARD

Summary:
Palm trees are dense throughout most tropical and subtropical regions. Stripped palm stalks, palm leaves and the tree trunk are made waste in vast quantities after harvesting oil takes place.
How is it used:
The Wilhelm Klauditz Institute [WKI] has developed ways of manufacturing fiberboard with the fibers for use in the construction and furniture industry.
How is it made:
By optimizing various stages of the process for pulping the fibers they may be made into materials. Other residues are crushed and pulped in a thermomechanical process.

Steam heats the fibers and the soft raw material is ground into a refiner. Finally, an adhesive is added to the material, and hot-pressed to create the desired density of the fiberboard.

04 // ARBOFORM

Summary:
The Fraunhofer Institute for Chemical Technology is developing a thermoplastic wood material, based on natural resources that have properties allowing it to deform under heat. Although the material holds similar properties to wood, it can be easily and cheaply injection-molded like a plastic. The rigidity is a result of the raw material lignin, the second most frequently occurring polymer in nature. Because of the properties, the material may be used as a base material. With regards to furniture, the lignin replaces traditional synthetics such as polyamide.

05 // ECO-SHAKE

Summary:
Eco-shake is an innovative roofing material replacing common wood shake shingles. It is manufactured with 100% recycled material, reinforced vinyl and cellulose fiber. Performance excels in extreme weather conditions, suitable for all climates. The UV protected, lightweight shingles require no maintenance, are wind, fire and impact resistance – installed easily.
How it is used:
The shingles are designed for suitability in both commercial and residential roofing applications, suitable for all climates.
How it is made:
The product is made from two recycled materials – reinforced vinyl and cellulose fiber. Through the process of manufacturing, it dramatically reduces the amount of materials that would otherwise end up in landfills, and benefits the environment through preserving natural forests by using only waste wood products.

01 // CORETOUGH

Summary:

CoreTough is a honeycombed composite wall, sandwiched between a rivet free, one seamless piece of thick outer facing and thin inner facing. Pound for pound, the material is lighter than aluminium and stronger than steel. The performance addresses and solves four common problem areas with metallic materials and construction: leakage, rust and corrosion, dents and dings, and weight management. The manufacturing process starts with a plastic sheet material, the core material is formed through a process of heat and convection, the core sheet is expanded to the desired honeycomb thickness and geometry. The outer layer is then mated, giving a high degree of rigidity.

05 DESIGN

PASSIVE SOLAR DESIGN

Passive solar building design was developed on the basis of combining climatology, thermodynamics primarily focusing on heat transfer and human thermal comfort, achieving heating and cooling methods independent of, or infrequently requiring, active systems. The aim performance is to capture and steadily release heat through convection, conduction and radiation during cooler periods, while blocking sun and cooling in warmer months. Specifics tailored to individual applications with careful integrations of the following principles are crucial for controlled implementation: considered site and location of the shelter, prevailing climate, design and construction, solar orientation, the size, placement and orientation of glazing and shading elements and defined thermal mass. Computer modeling can be used in conjunction, making refinements and testing applications of various other technologies - deriving significant energy savings without compromising the functionality or aesthetics. While passive solar design is one part of improving the green performance of buildings, a step towards cost-effective zero energy building and does not impact the life cycle analysis.

SUN PATH

Seasonal variations and climate zones depend greatly on daily sun paths specific to the hemisphere and latitude. Generally the sun rises in the east and sets in the west. Though, in equatorial regions located at less than 23.5 degrees, the position of the sun at solar noon oscillates from north to south and back again, throughout the year. During six of the summer months, in regions closer than 23.5 degrees from either the North or South Pole, the sun traces a complete circle in the sky without setting – while it remains below the horizon for the six months constituting winter. In the non-tropical latitudes of the Northern Hemisphere, farther than 23.5 degrees from the equator the sun reaches its highest point toward the south, and operates more rigidly through the seasons. Daylight hours are shortened as the sun rises and sets progressively further south as winter solstice approaches. Summer generates reversed patterns, with the sun rising and setting further north, creating longer daylight hours. The contrary is observed in the Southern Hemisphere, while both regions see the sun follow east to west configurations.

PLANTING

By positioning rooted deciduous trees or bushes to the south of buildings can help achieve partial effects of passive solar design. The summer months are shaded by full foliage, preventing excessive and unnecessary heat gain. While winter months cause a loss of leaves, allowing an increase of solar heat gain on the colder days.

DESIGN

It is important to create adaptable design options for changing seasonal patterns and temperature irregularity caused by 'thermal lag' - where the sun remains at the same altitude for the 6-week period before and after solstice, although the heating and cooling requirements are significantly different. Thermal lag incorporates the period of time a material requires to absorb and then re-release the heat, or for heat to be conducted through the material. Influential factors include: the temperature difference between each face, exposure to air movement and air speed, texture and coatings of surfaces, thickness of material and the conductivity of the material. There are several mechanisms that help control temperature severity during different hours of the day, such as interior insulated drapes, shutters, exterior roll-down shade screens or retractable awnings.

WINDOW PLACEMENT

NATURAL VENTILATION

DIRECT GAIN AND THERMAL MASS

Direct gain is the simplest form of natural heating by exposing thermal mass to direct sun exposure, capturing and storing the passive heat gain for slow and gradual release. Some of the most effective thermal mass materials are dense, heavy and dark in color - include concrete, stone and masonry – retaining heat even in the absence of direct sunlight. Thermal mass controls its properties on the cycle of climate temperatures. In warmer months the mass is prevented from receiving direct sunlight through design mechanisms such as roof overhangs, and so absorbs excess indoor heat, lowering the internal temperature.

INDIRECT GAIN

Indirect gain uses the same materials and methods as direct gain systems, with an adaption to design principles. Thermal mass is positioned between direct sun exposure and the space to be heated with the methodology of inducing a separation of warm and cool air flows using natural pressure systems. Examples of performance systems include trombe walls, water walls, roof ponds and deep-cover earthed roofs.

The sun's heat is collected and trapped in a narrow space between the window and the thick masonry wall after it passes through the windows. This heats the air, which rises and spills into the room through vents at the top of the wall. Cooled air then moves to take its place from vents at bottom of the wall. The heated air circulates throughout the room by convection. The thermal mass continues to absorb and store heat to radiate back into the room after the sun has gone. Louvers can be placed in the vents to prevent warm air from escaping through them at night.

PASSIVE COOLING

Passive cooling uses design features or technologies to stimulate air flow and cool the environment without reliance on energy sources or power consumption. The stack effect can be utilized in tall buildings – incorporating a 'solar chimney' to draw out the hot air that rises.

ISOLATED SOLAR GAIN

Isolated solar gain segregates the direct area of heat absorption to later redistribute elsewhere using air or liquid, such as water, either directly or through a thermal store. The design and passive concept becomes more flexible – with the establishment of a convective loop. Alternative options to capture an isolated heat gain in air are through sun-spaces, greenhouses or conservatories.

DAY LIGHTING

Energy consumption is costly in several ways, therefore it is important to provide alternatives where possible. Day lighting is a better, natural quality of light source as opposed to artificial lights which increase energy demand. To maximize the gain there are standardized design techniques: detailing large south-facing windows – the size at least 15% of the room's floor area in all cases, keep the main orientation of the building within 30 degrees of the south and situate the most frequently used rooms to the south side of the shelter, while rooms with minimal use should have smaller window sizes and be positioned to the north.

ANGLE OF INCIDENT RADIATION

Incident radiation in more technical terms is the amount of solar radiation hitting a surface per unit of time and area. The amount of solar gain transmitted through glass is dependant and effected by the angle of penetration. The majority of sunlight hitting glass within 20 degrees of perpendicular is transmitted, while light is mainly reflected at more than 35 degrees from perpendicular.

CONSTRUCTION
AIR TIGHTNESS

THERMAL-BRIDGE-FREE

07 TECHNOLOGY + CONSTRUCTION

01 // MOLADI FORMWORK SYSTEMS

Summary:
The system allows a whole house to be cased and built in one day, using plastic formwork or cimbras. With the labor of unskilled employment, time is reduced along with waste and cost. The final product is a wall stronger than brick using a technology that far outweighs poorly designed concrete-block and masonry structures that are far more costly.
How it is used:
The system is a developed construction technology. Moladi creates a steel-reinforced concrete structure that is able to withstand natural disasters such as hurricanes and earthquakes, while providing thermal insulation and moisture resistance.
How it is made:
Using on-site plastic molds, concrete is poured to create flatting raft foundations, high strength walls and leaves the option for any roof material to be applied.
(developed/manufactured in South Africa - successfully used in South Africa, Kenya and Botswana)

02// CARBON CAST

Summary:
Carbon Cast is a pre-cast technology uses a carbon-fiber grid as a secondary, corrosion free, reinforcement or shear transfer depending on the scenario. The technology works to require less concrete, adding to the durability and producing a lighter structure. Insulation may be easily integrated into a more compact wall make-up and improving the thermal performance given its low thermal conductivity. Cladding panels also benefit, weighing less than conventional precast panels.

03 // INSULATING CONCRETE FORMWORK (ICF)

Summary:
Insulating concrete forms are hollow ‘blocks’ or a ‘panel’ that is made of expanded polystyrene insulation, or other types of insulating foam, that builders can use to stack and form walls (Similar to Lego bricks). They can create a cavity wall, or become a mould for the structural walls of a building when concrete can then be pumped in to form the structural element of the walls. The structure is basically a sandwich consisting of a heavy, high-strength material between two layers of light and highly insulated material to create air tightness, strength, and insulation, mass and sound attenuation.

Advantages of this system include:
- Minimal air leaks, if any – which provide a consistent comfortable balance and less heat loss
- Extraordinary energy performance
- Fast and simple construction


03

- Competitive costs
- High sound absorption for locations prone to high traffic, circulation or is densely surrounded
- Little waste and the opportunity to utilize local materials
- Time-tested structural integrity
- Resistance to forces of nature and climate change – providing a superior lifespan and low embodied energy values
- Low maintenance and high durability
- Lower whole life cost and higher resale value
- Flame-retardant EPS will only burn while the flame is directly applied to the foam, the smoke that results is less toxic than wood smoke from ordinary timber
- During construction, the walls and floors form one continuous surface that keep insects and vermin out
- A healthy indoor environment – actual ICF homes have shown an almost complete absence of any emissions

03 // CORDWOOD

Summary:
This type of constructions demands additional space as the walls typically range between 12 – 24 inches thick, with pieces of wood slightly proud of the mortar and are best for round floor plans. Thermal mass helps to average the interior temperature throughout different seasonal periods. The make-up is dominated by wood, accounting for approximately 40-60% of the wall system; the remaining consists of mortar, and only three to four inches deep on each side with insulating fill. Different combinations and mixtures of mortars and insulation fill impact on the overall R-value or resistance to heat flow. The wood is derived from the ends of fallen trees or left over log ends, even split firewood, utility poles, split rail or fence poles. It is best to use rot-free wood. The costs are significantly less than standard timber frame housing, it requires less long-term maintenance and is less expensive to construct. Due to the thermal mass, this type of construction is more ideal for colder climates.