Proposed disaster resistant prototype low cost

"House of the Future"

for

Gingoog City, Mindanao, the Philippines.

Entrant: Peter Hickson,
Australian Business Volunteer (ABV) Advisor for
Gingoog Earth Building Company.

Category: Green Builder

Philosophy: Socio/economic, spiritual/cultural and ecological sustainability.
Appropriate, renewable, sustainable technologies.

Location: Gingoog (Hing-orrg) City, Mindanao, Philippines.

Site Location: Barangay 25, National Hwy, Gingoog City,
Misamis Oriental, Mindanao.

Climate Zone: Tropical. 7 degrees north of Equator

Climate: Warm humid coastal climate.

Construction: Bamboo reinforced Cob earth, coco lumber and nipa thatch.

Design: Tropical

Style: Attic style using a blend of traditional indigenous ideas and materials with earth and minimal use of high embodied processed materials.

Features: Bamboo reinforced Cob earth construction system
Promotes better use of indigenous materials
Adds earth to the palette of sustainable options
Appropriate Climate Responsive Tropical design
Clever use of space using attic bedrooms
Builds out hazards and builds in longevity
Dry Compost toilet to reduce disease and illness
Greywater onsite treatment and reuse

Introduction

This prototype house was built in late 2006 as a low cost sustainable solution to housing needs of Gingoog City, Mindanao the Philippines. It could be considered the "House of the Future" for Gingoog City and other similar places.

It is locally inspired and uses a tropical designed, attic style that combines bamboo reinforced cob earth building technique with as much locally available indigenous materials as possible.

The house was designed and built by Peter Hickson, Australian Business Volunteer Advisor with the help of 10 local trainees. Peter is a Green Builder, from South Coast NSW, specialising in earth building, training and consulting.

The home would stand out in Australia for its tiny size, tiny budget and tiny footprint both physical and ecological.

Its impact in Gingoog could be great but its importance here at GREX is for its use of appropriate, sustainable and renewable technology and its relevance as a reminder of how little we really need to be happy. This is a dream home for the 10 Filipino trainees who built it.

Affordability and aesthetics against existing local housing options.

In Gingoog City the majority of people live in rural villages (Barangays) in extremely humble self-built bamboo and timber homes with nipa palm thatched roofs. Some are very clever in design and use of space and sustainable local indigenous materials. Most are very temporary and are simply replaced after a short number of years through natural decay or when necessary after a storm event. These existing low cost homes have no toilet, no running water or electricity. They use a "dirty kitchen" or small bench top open wood fire with no chimney.

In urban areas the homes are commonly constructed using 100mm thick hollow concrete blocks with low-pitched iron roofs. Low cost houses are 5m by 5m total built on 72 to 100 sqm average building site.

The concrete blocks use so little cement for economy that they can often be crumbled by hand. It is almost impossible for me to lift them without crushing them. The wall relies entirely on the concrete core filling and steel reinforcement together with cement render for any structural integrity though they are often rendered inside only. The standard of construction is very poor. The designs are western bungalow styles with low-pitched roofs covered with steel corrugated sheeting so thin it cannot be stood on during installation. It

lasts only 5-8 years for the standard steel sheets and 12 to 15 years for Galvanised sheets.

More expensive western inspired housing is available to wealthier people. These homes are professionally built using the 100 or 150 thick hollow block rendered inside and out. They are a scaled down western style mansion. Steel roof trusses are often utilised because the construction system using hollow core blocks buried in the ground and concrete infill slabs invites termite attack. Decorative pre-painted steel tile panels are used on the expensive homes. Iron roofs are hot and noisy in rainstorms. Reflective or bulk insulation materials are not available. Watermarks from condensation are evident on ceilings.

Commercial buildings use reinforced concrete post and beam rigid frames with hollow block infill.

Earth Building is definitely a viable and affordable alternative.

Climate

Tropical coastal climate latitude 7 degrees North - warm and humid. Cooler when overcast as it often is. There are two seasons wet and dry. Local people complain about the cold conditions and sickness in the wet season.

Building Site

Barangay 25, National Highway, Gingoog City, Misamis Oriental, Mindanao, Philippines.

The building site is located on 12 Hectares of the coastal plain just 300m from Gingoog Bay to the North and the foothills and then taller mountains starting 2 kilometres to the South. The coastal plain and the site in particular is well vegetated with coconut palms and an understory of fruit trees such as banana and mango, to name familiar species. The vegetation is open and provides shade and cooling breezes most of the day. Breezes usually flow from the bay towards the mountains and vice versa and are also generated from the cool side to the hot side of the house as the sun moves.

The building envelope chosen was within 10 m of established rainforest trees to the east and shoehorned between shade trees with open lawn and more established trees 30m to the west. This position maximizes shading and privacy but allows an open breezeway between neighbouring buildings to the bay.
The southern breezeway to the mountains is also available with a view to the mountains through trees available from the living room (sala) and the verandah outdoor sitting area.

Prototype Low Cost Cob house and "House of the future" for Gingoog City.

The aim of this home is to provide safe, durable, affordable and desirable buildings by introducing new appropriate and sustainable, systems and technologies to Gingoog City whilst maximizing and improving the use of local appropriate, sustainable, renewable indigenous materials.

My philosophy as a Green Builder is to consider and satisfy all aspects of sustainability socio/economic, spiritual/cultural and ecological sustainability.

In this part of Mindanao buildings are subject to mild earth tremors to medium earthquakes, termite (iny) attack, pinhole borers (bok bok), and are occasionally affected by typhoons. The coastal plains would be at risk from tsunamis and storm surges. There is little impact from drought or wild fire. The climate is hot and humid tropical with wet and dry seasons. Even in the dry season Gingoog can experience afternoon downpours.

I believe the best suited Earth Building Technology for Gingoog City is cob.
I have developed a new reinforced cob building system designed to overcome local conditions and potential hazards. The basics of the system are outlined below.

I have added Earth to the palette of indigenous building options available in Gingoog and have introduced 9 new technologies, techniques and construction systems in this building.

An Australian style reinforced concrete slab on ground with edge beams is used as a monolithic physical barrier to termites, for ground separation and safe and efficient construction platform. Correct mixing and placement of concrete and use of a plastic membrane and fill sand plus continuous pour have been introduced to improve strength, durability and performance of the slab. Coloured oxide is used to create a low cost finished floor.

Hold down bolts for the frame are embedded in the slab prior to setting.

A lightweight minimal timber post and beam coco lumber frame is erected complete with first floor frame and attic wall frames, roof purlins, counter battens and nipa palm thatch roofing. The posts are positioned to the centre of the earth wall.

100mm thick concrete hollow blocks with reinforcement and core filling are used to construct a basement chamber for the dry compost toilet and storage area. A suspended reinforced coloured concrete slab is used for the mid level toilet and bathroom floor.

The timber frame is encased in cob walling. The 250 thick cob walling is earth walling built in situ from prepared lumps of earth or cobs. The cobs are produced from clay soil with the addition of enough locally sourced river sand, rice straw ash and rice straw and water to produce cob that is strong and resistant to erosion.

The walls are reinforced vertically with the corner posts and mid posts of coco lumber and with additional bamboo poles attached at slab and to the floor frame each side of the window openings. A split bamboo ladder frame is used as horizontal reinforcing every rise of 400.

The nipa palm thatch is both the roofing material and an attractive exposed ceiling combined. The coco lumber walls are clad with coco lumber board and batten externally. Coco lumber 150 by 25 boards were dressed and used for flooring.

Amakan woven split bamboo sheets are used as internal linings wall stud walls, downstairs ceiling and as infill panels for handcrafted doors on plantation grown Gimelina timber frames. Split bamboo is used for cover strips.

The door and window frames are locally crafted gimelina frames and wooden louvre blades. Gimelina is also used for the stairs.

The flooring system is designed to be a structural floor diaphragm. The frame is attached to the cob by encasement and ties. The cob walling is the permanent wall bracing and additional hold down. The internal vertical reinforcing is fixed to the floor frame. The tops of walls are therefore well restrained from lateral out of plane forces whether from wave, floodwater, earthquake or wind load.

The kitchen is constructed of locally produced plywood using plantation timber.

Sustainability of Materials

The **coco lumber** use for all structural framing, flooring and external cladding is harvested from 100-year old palms that have grown too tall to be climbed and are no longer viable for harvesting. They are gradually being replaced with new higher yield dwarf varieties. The timber is locally cut and milled where felled with chainsaws cutting by eye along marks made with flick lines.

Bamboo for vertical and horizontal reinforcement, ridge and barges, cover strips on amaken linings and verandah fixed seating is locally grown and harvested. Split bamboo was treated against Bok Bok attack by soaking in the salt water as per local practice.

Gimelina used for window and door joinery and the staircase is a local hardwood. It is locally grown in plantations.
Nipa palms grow locally along watercourses. Nipa palm thatch is hand made in 1500 long panels by folding cut leaves over a split bamboo spine and stitching it in place with natural fibre. It is made locally under the palms. It will last 12 to 15 years if close thatched with six layers and if used at a steep pitch (minimum 25 degrees is best). Nippa could be improved in fire and insect resistance if soaked in Borax solution. It is one-third the cost of steel G.I. sheets, renewable, lasts as long and helps the economy in the local bio-region.

The **Amakan** paneling is woven locally into 2400 by 1200 sheets from split bamboo and is attractive and low cost. It is one-third the cost of 4 mm plywood.

Cob walling is made from subsoil often won from the building site. It requires the addition of local river sand and rice straw ash and rice straw from the local rice paddies. The rice straw and ash are considered waste by-products and are freely available.

Sand and gravel for the concrete is excavated from a number of extensive wide dry riverbeds in the summer.

Cement is produced an hour or so from Gingoog. It is extremely expensive in local terms costing a day's wages for a labourer or Ph Peso 175 about AUS$4.50 (2006).

Steel for reinforcing is produced in Mindanao but is also very expensive though used sparingly.

Recycled 20 l plastic drums were used for the chute of the compost toilet.

A **recycled 200 l drum** was used for the vertical sand and gravel greywater filtration system.

Hydrated Lime was used for the render, slip coat and limewash for the earth walls. They were produced by mixing various proportions of clay and or fine sand found onsite. It is also expensive however a bag and a half of locally produced hydrated lime was all that was required. A small amount of red oxide was also added to colour external walls.

The **100 thick hollow concrete blocks** for the compost chamber were made locally. We could have used cob.

Earth walls reduce the amount of cement and steel used in the building by providing an alternative to hollow concrete block work that is core filled with concrete, reinforced and cement rendered.

The design with the attic bedrooms reduces the footprint of the building and therefore minimizes the financial and environmental cost of building in durability using a concrete slab. It also maximizes the useful space for material input, suits the small allotments.

The entire building comprises 22.75 sqm downstairs living/kitchen
5 sqm mid level bathroom/toilet
38.71 sqm attic loft bedrooms
5 sqm loft space above the bathroom

Total floor area 71.46 sqm. (Most is useful or utilized)

The verandah adds a further 8 sqm and is an essential outdoor living space. Verandahs are often left off the low cost and expensive modern western styled homes here. Most people then build outside living using native materials.

The home has 3 separate bedrooms and 2 other loft sleeping spaces and can easily accommodate a large Filipino family in relative comfort.

Climate Appropriate

My assumption is that this building will never be air conditioned, that the local population is adapted to their climate and that the building is to be a third skin not a climate controlled environment.

Air conditioning, which I consider "a technological fix to bad building design", is simply not an option for the Philippines in low cost housing.

The design is an Appropriate Climate Responsive Design for a warm – humid tropical climate.

I was asked to introduce Earth Building to Gingoog City. I researched to see if heavy weight construction was recommended or suitable for the climate before accepting the assignment. The basis of my design is drawn from research into appropriate climate responsive design for tropical climates plus through observations and investigations of substantial older Spanish colonial buildings called 'Ventilatas' and smaller local indigenous designs that utilize natural ventilation and very clever use of indigenous materials and space.

The building is a holistic blend of ideas, features and principles both borrowed locally and introduced from around the world.

My philosophy is to learn from other cultures and places and as an advisor try not to impose western values and to avoid transporting our great failings especially in our over consumption of energy and resources and acceptance of waste. I am trying to share the best, well proven green building technologies

from around the world. This philosophy is an economic sustainable reality here in the Philippines because, unlike in Australia, energy, transport, manufactured materials are truly expensive compared with average incomes.

The situation here dictates that designs must suit the climate and utilise daily fluctuation of temperature and cooling breezes and shade to the best advantage. The design must avoid heat gain through both design and choice of materials particularly in the external fabric exposed to the sun especially the roofing materials. The building still needs thermal mass for storage of warmth and coolth to even out diurnal and day-to-day fluctuations that can be very rapid and great.

Other locations nearby for instance the highlands have different climates and require a totally modified design for an upland tropical climate.

Buildings must be small and use materials in a clever way to create space.

Anything produced from natural materials locally is affordable and high-embodied materials transported from afar or made locally are not options.

Passive and Active Solar Design

Similar principles used for passive solar design in temperate climates are also important in the tropics but direct solar gain is not the aim. Quite the opposite is true.

Orientation, Shading, Zoning, Breezeways, Thermal mass and Insulation are important but for different reasons in the tropics.

Orientation to make use of the sun's angle within equatorial zones is not important. The sun is overhead and changes angle only slightly throughout the year. So orientation to north or south is less important. Orientation and position to maximise breezes and avoid wind shadows from neighbouring buildings is more important. Also important is controlling overheating at low sun angles during sunrise and sunset. The building is positioned to be in shade in the morning, and during the day. In the afternoon sun is controlled through the verandah and wooden louvres then more distant trees. It was also positioned and designed to capture breezes from any direction.

Shading through landscape and building design is critical in the tropics. Building under established trees dramatically reduces solar radiation and generates air movement. If vegetation isn't available fly roofs are an option. Wooden louvres or shutters are good at maximising, controlling and directing airflow and controlling shade. Evergreen trees rather than deciduous are required. Large eaves are important for maximum shading and to protect the earth walls from tropical downpours. In a tall building like this it is achieved with the 700

overhanging cantilever attic floor and roof gable eaves that protrude more as they rise in the traditional Asian style.
Zoning of spaces and materials is important for keeping bedrooms cool at night and living rooms cool by day in the summer and providing more protection and warmth in the wet season when the local population complain of the cold. Heavyweight construction is used in the downstairs daytime zone and lightweight construction with naturally insulated materials is used upstairs in the night time zone.

Breezeways to make the most of natural and generated breezes are the best form of passive cooling. Single room designs allow breezes from any direction to cool those rooms whereas the conventional multi roomed floor plan inhibits airflow. Tall, steep and well-ventilated roofs encourage air movement. Louvres offer maximum ventilation with easy permanent insect screening and excellent control over the flow and the best protection in rain whilst maintaining ventilation in storms. Ventilation flaps are located in the cantilevered eave overhang where the attic roof meets the floor.

Thermal mass in the concrete slab and earth walls is used in the daytime living room (sala) and kitchen areas that are well shaded from the suns daily path especially at sunrise and sunset with large established trees to the east and more distant trees to the west. The verandah on western side helps with shading.

Wooden louvre windows maximise ventilation but also can block the sun when required. The thermal mass is used as usual for its storage and thermal inertia. Cool air at night is stored in the walls for daytime use. The mass evens out diurnal fluctuations and rapid changes in temperature in storms and from movement of clouds and during downpours. It stores the cooler night time temperatures for daytime comfort.

The thermal mass is a heat store for moderate warming downstairs and slow release by convection into the loft area in the wet season. It is controlled by shutting down airflow with the louvres and floor flaps and allowing the warmth to rise through the building.

Lightweight construction is used for night time sleeping areas and for daytime siesta. The cladding for the roof and lightweight walls are Nipa thatch and Amakan woven bamboo paneling that don't absorb, transfer or store heat.

Earth has great "Y" value or capacitance or storage and the thermal lag of 300 thick earth walls is 8 hours. The shaded walls will always be within the average diurnal mean air temperature range with an 8-hour lag. The average of the diurnal and day to day temperature range is always reasonably comfortable in the context of local climate and offers far more comfort than the peaks and

troughs and rapid changes that can occur in storms.
Insulation is less important in a naturally conditioned building in tropical climates because buildings are open and well ventilated. External fabrics that don't conduct or radiate heat inside are essential especially roofing but also walls and windows exposed to the sun at sunrise and sunset. The roof and upper wall materials are effective insulators so insulation is unnecessary. Nipa thatch and amakan are good insulators but also breathe so they are ideal for warm humid conditions. Earth walls have average "R" values in terms of insulation though they have good capacitance and thermal inertia to balance temperature.

Energy Efficiency

The building is designed to have no heating or cooling requirements apart from a electric stand fan for the short period of time in the day when the air is still.

Solar Hot water systems are not available here but cold showers and washing is normal and desirable. Simple direct instantaneous in line electric heaters can be used to raise water temperatures if required.

All 9 lights use fluorescent light globes.

Cooking is with a two-burner bench top mounted gas stove. Normally this would be done in a dirty outside kitchen or open wood fire using locally grown bio-fuels.

Clothes washing is done by hand in a bucket in the shower recess.

Clothes drying is on an external clothesline with another 2 lines with one in the loft and another under the verandah for drying in wet periods.

A small 12volt 3.2 W computer fan powers the compost toilet exhaust vent.

A small refrigerator, electric jug, rice cooker, stand fan, and TV are the only appliances and are for the convenience of Australian Volunteers. Very few appliances are used in low cost houses here.

Photo Voltaic panels are viable for remote housing but in reality this house is in town with mains power available. A small remote power system would easily cope with the energy demands of this home.

I have spoken with the Manager of Moresco Power Company and the local power supply is mainly Hydro with Diesel generator backup. Power cost is based and charged according to actual cost to the supplier so the rate is variable with Hydro supply and demand and the mix of expensive diesel power required. Temporary "Brown outs" are commonplace.

Private power generation partnerships are possible and the Moresco Board would consider the case for individual grid-connected co-generation. A large Japanese Photo Voltaic plant is being built in neighboring Cagayan DeOro.

Water Management

Most low cost homes draw water from a neighborhood well with a hand pump by the bucket load. This building is connected to town water with very little pressure and flow (about 1 litre/minute). Because the flow is so limited water consumption is minimal. However using a dry compost toilet to save flushing also minimizes waste. This technology benefits the water management further because the greywater from the elevated bathroom is easily treated and filtered by passing it directly through a vertical sand and gravel filter. A hose allows it to be moved around for automatic reuse in the garden. Greywater is not stored it is allowed to soak away.

Water shortage is not an issue here so roofwater is not collected or stored. Storage or ponding can breed mosquitoes.

Waste Management

Human and vegetable scraps are composted in the toilet with sawdust added with each deposit liquid or solid. After complete composting it can be then used in the garden as a safe and rich fertilizer.

The introduction of this technology is most important in urbanizing barangays where homes are built on tiny blocks and water is drawn from the ground wells. Septic tanks, pit toilets and sewers discharged to waterways are all prone to failure with stormwater flows exacerbating the problem especially in the wet season. Dry composting toilets should minimize illness and disease from ground water pollution.

All glass bottles are returned on a deposit basis. Most food is fresh and locally grown rather than processed and packaged so rubbish accumulation isn't the problem it is in Australia.

Food scraps are often feed to animals.

Plastic bags are the biggest problem. Only clean ones can be reused but those contaminated by food need to be disposed of at the local rubbish tip.

Aesthetics and Affordability

This home is based on local tropical design and materials and is therefore more suitable than western styled bungalows. The size is that of a medium cost home

but the cost is substantially lower and the earth building technology suits self-builders so the cost could be significantly reduced by sweat equity and using materials from the site.

The colours chosen for the timber windows and the limewashed walls are commonly used here on expensive buildings. Most concrete masonry walls are not rendered, but left unfinished rough and grey.

The home includes a front verandah with built in bamboo seating for relaxing and socializing outside. This is a feature of all local vernacular designs but is now absent from modern western influenced bungalows and is being replaced in wealthier homes by a carport. The home is designed to be well suited to the very small, < 100 sqm, homesites available for housing.

The budget was Ph Pesos 250,000 or Aus $6,250. To get an idea of the local market affordability an incomplete 25 sq m low cost home built basically to lockup with no services costs Ph Peso 70,000. These homes are supervised and self-built. Medium cost bungalow style project homes of rendered and painted 100 HCB with G.I. roofing and finished to the same standard as this house cost around Ph Peso 10,000 per sqm. So a 3-bedroom project home would cost around Ph Peso 500 - 700,000.

It is paramount here to use efficient and clever use of materials to create useful space at minimum cost.

The cob home offers a safe, comfortable, affordable, durable and desirable housing solution using appropriate, sustainable, renewable technologies.

Compliance

Homes using indigenous materials don't need to be submitted to Local Government for approval. This home does however comply with local codes but would not satisfy the Building Code of Australia (BCA) in some minor areas. Staircases and landings here can be just 750 wide and steeper than in Australia. Less surface temperature reinforcing steel is used in the slabs but cracking has not occurred probably because the building is so small and humidity may allow slower curing. Thatched roofing is not available or used in Australia and would present a bush fire hazard in most places but is appropriate, practical and acceptable in Gingoog.

In am certain the home would more than satisfy the intentions of BASIX though it doesn't comply with water storage or hot water requirements.

The Local Government here is aware of the dry composting toilet, grey water treatment and earth construction and is supportive and interested.

Permaculture design landscaping.

Permaculture design principles have been applied and implemented throughout the building process from choice of location on the much larger site and in the design and construction phases through to landscaping. No trees were removed.

Two of the established shade trees are coconut palms or "the tree of life" as it is locally known. There is enough space on this tiny lot to grow an under storey of fruit trees such as banana, or calamansi (a small lime) plus a small vegetable and herb plot and some ever-useful bamboo.

Compost from the toilet would be utilized in the garden. Treated greywater could be used in swales to add sunlight treatment as the plants are watered. Space is limited for animals but in reality if this home were used for permanent occupation there would be chickens and maybe even a pig. A deep litter no smell pen would be the best option using Korean technology.

The fencing is of split bamboo, paths are natural gravel, natural stone forms the garden borders and the garden and a tiny little lawn is able to survive with the local rainfall.