Building Back Better Communities in Haiti

Proposal for Lot 1: Housing Expo

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Introduction

Ecological Building Network (EBNet) is an informal association of engineers, builders, NGO's and architects that has spent decades studying ways to build healthy, seismically safe buildings using the simplest of materials such as earth, straw, bamboo and stone. That effort will prove hugely germaine to the reconstruction effort in Haiti, where so much of the problem boils down to delivering the most utility with the least cost or imported material. Our contention, articulated in this proposal, is that the main benefits of "modern" housing—thermal comfort, power, water, sanitation, and seismic/hurricane safety—can be achieved with substantially less cost or fuss than is commonly thought.

In the spring of 2010 EBNet was asked to join a growing collaboration of NGO's and builders to address the pressing need for housing in Haiti. Affiliates and partners include: Architecture for Humanity, Builders Without Borders, Kleiwerks, Habitat for Humanity, and the International Federation of the Red Cross. This collaboration culminated in a charette (group design session) held on July 1, 2010 in San Francisco. Over 20 professional engineers, architects, planners, and NGO representatives (including two from Haiti) attended the meeting in person, while another 100 people in North America and 10 in Haiti participated via live video web feed. This proposal constitutes a summary of the best ideas to emerge from that charette, and meets all objectives of safety, affordability and maximum use of local and available materials.

Background

EBNet was founded in 1999 by Bruce King, a practicing structural engineer in California with 35 years of experience designing buildings of every type all over the world. The focus of EBNet has been the development and promotion of local and natural building materials through research, standards development and dissemination of technical information to those throughout the world who can put it to practice. Much of this work is of particular relevance to developing countries, where affordable, safe and comfortable housing is needed, and importing building materials is both prohibitively expensive and sometimes toxic. EBNet works on a project basis, recruiting international experts when needed, while keeping ongoing operational costs at a minimum. Past projects include:

- The First International Conference on Ecological Building Structure. Held in 2001 in San Rafael, California, experts from 15 countries came together to explore, exchange and develop ideas for best practices and materials for sustainable design. The international community that emerged from that conference continues to interact, and the proceedings are still in demand.

- Research on the performance of plastered straw bale wall assemblies. In 2001, EBNet received $300,000 in funding from the State of California to conduct a series of structural, thermal, moisture and fire tests on plastered straw bale and earth plastered wall assemblies. This research was pivotal in removing obstacles in building officials' acceptance of straw bale, and helped promote an international movement towards building with straw.
- Build Well 2010, an international conference held in January, 2010 in Sausalito California, which brought together leaders in design, development, production and investment in sustainable building materials.
- Development and passage of ASTM International E2392-10, *Standard Guide for Design of Earthen Wall Building Systems*. This four-year project has the greatest potential to affect the everyday lives and living conditions of billions of people in developing countries, where building materials such as wood, concrete and steel are expensive and scarce.

the Haiti Native Reconstruction Project

Following the earthquake, a number of our collaborators traveled to Haiti from the San Francisco Bay Area. Like EBNet, each is familiar with designing and engineering to the strictest seismic standards in the world, and also experienced with so-called "natural" building materials and techniques. Upon their return, they set about recruiting a number of San Francisco area architects, engineers and builders to discuss how we as a group can assist the rebuilding effort. EBNet was asked to join in the discussions, and after two informal meetings it was decided that the next step would be to bring experts from throughout California and Haiti for an all-day design charette to come up with prototype designs for simple shelter. The meeting, held on July 1, 2010 and was sponsored by EBNet and hosted by Gensler; participants included:

Andy Thompson & Nick Sherrow-Groves, Engineers	Arup
Nadège Lespinasse, Architect and Kirsten Ritchie, Engineer	Gensler
Frederika Zipp, Engineer	Architecture for Humanity
Regine Laroche, Architect	(special guest from Haiti)
Darcey Donovan, Engineer	Pakistan Straw Bale reconstruction
Martin Hammer, Architect	Builders Without Borders
Chris Andrews, Architect	Christopher Andrews Architects
Valerie Carey	Kleiwerks
Darrel DeBoer, Architect	
Anthony Dente, Engineer	K. Donahue Structural Engineers
Bruce King, Engineer	Ecological Building Network
Tim Owen-Kennedy, Builder	Vital Systems / Green Microfinance
Dan Smith, Architect	Dan Smith Architects
Bob Theis, Architect	
Larry Strain, Architect	Siegel and Strain Architects
by audio/video feed	
Nathaniel Corum, Architect	Architecture for Humanity
Kiko Thebaud, Architect and Urban Designer	Haitian, from Boston
Kevin Rowell, Builder	Kleiwerks, from Port au Prince

(100 others from North America, and 10 from Haiti, watched and listened by web feed)

The charettes guiding principles were:

1. Use local materials readily available in Haiti, with the least possible importation of materials from abroad. This means use of materials not only local to Haiti, but local to the particular building site, reducing the need for transport.
2. Design shelter that not only performs to seismic standards, but is also designed for energy and water efficiency, as well as other sustainable and non-toxic standards.
3. Design shelter that is culturally derived and desirable.

This proposal constitutes a summary of the best ideas to emerge from that charette.

Consortium / Team details

EBNet is an all-volunteer organization of modest size. We swell and shrink our ranks and funding as fits the project at hand, though as the preceding list shows, are able to accomplish much. As with other EBNet projects, the Haiti Native Reconstruction Project is being staffed, designed and funded on an ad hoc basis. Primary collaborators, with whom EBNet has worked for many years, are:

Regine Laroche, Architect, Port au Prince
Ms. Laroche has 22 years of experience in Haiti and the USA, mainly within the private sector but also the public sector. Her focus is largely on residential design, with some commercial and institutional work, as well as urban and community development and revitalization projects.

Bruce King, Structural Engineer, *Ecological Building Network*
Mr. King has been working with native and local construction materials for 20 years, and is world-reknowned for his publiations and talks on more ecological and community-friendly ways to build.

Martin Hammer, Architect, *Builders Without Borders*
Mr. Hammer helped introduce straw bale construction to earthquake-affected Pakistan for the organization Pakistan Straw Bale and Appropriate Building. Martin traveled to Haiti in March as part of a reconnaissance team from the Earthquake Engineering Research Institute, and is currently representing Builders Without Borders in Haiti.

Kevin Rowell, based in Haiti, and **Valerie Carey**, based in SF Builders, *Kleiwerks*
Mr. Rowell and Ms. Carey are Program Directors for Kleiwerks International, which has helped train thousands of people in the construction with local materials in Laos, Thailand, Cambodia, USA, India, Mexico, Peru, Argentina and Costa Rica. Kleiwerks has been in Haiti since mid-February.

Tim Owen-Kennedy, Builder, and **Bob Theis**, Architect
Mr. Owen-Kennedy is the owner of Vital Systems Construction; Mr. Theis is practicing in Berkeley, California. Both have decades of experience with local materials in construction, and are now working on housing and schools with the Peasants Association of Fondwa, Haiti.

Anthony Dente, Engineer *Kevin Donahue Structural Engineers*
Mr. Dente has been part of the EBNet efforts from the beginning, and would be our on-site administrator in Haiti during construction.

Nathaniel Corum, Architect and **Frederika Zipp**, Engineer *Architecture for Humanity*
Mr. Corum has many years of experience with Architecture for Humanity designing and building around the world on site specific projects. Frederika Zipp is a mechanical engineer who has been to Haiti since the earthquake, and is involved in rebuilding efforts there.

Dan Smith, Architect *Dan Smith and Associates*
Mr. Smith has been in practice for many decades in Berkeley, California specializing in using and adapting local materials. He has been instrumental in developing low-cost building blocks using minimal energy inputs.

Building Material Palette

There are two broad "families" of materials to work with:

1) Exotic / Industrial *(imported and/or energy-intensive and/or expensive)*

Reinforced concrete is a reliable building system – if done right. It has historically *not* been done right in Haiti, by every measure, which is why so many died in the January earthquake. To rebuild well with concrete in Haiti would require widespread training and the introduction of quality control all along the supply chain, especially at the jobsite, and would then be effectively beyond the financial means of most Haitians. Conventional reinforced concrete (that is, concrete bound by portland cement) should only be used sparingly, where it is really necessary.

Steel is, likewise, a hugely utilitarian, durable, and well-proven material that comes only at great financial and carbon emission cost. Like portland cement concrete, its use should be limited to applications for which it has no effective equal, such as currogated galvanized metal roofing.

Structural lumber is now nearly all exotic, in that most of Haiti's forests are gone. Wood buildings perform well in earthquakes, and badly in fires. In Haiti, as the rest of the world, large urban fires over the past century prompted a wholesale cultural shift to preferring steel and concrete construction for their apparently superior durability. That predjudice is reinforced by the simple fact that large fires occur much more frequently than large earthquakes, and hurt more people in the dense urban settings most of us inhabit. Fire is a visceral threat to us, while earthquakes, but for the few years following a large one, are not.

Polymers (plastics) appear in hundreds of forms in modern buildings, but come with an array of hidden costs as are only now coming to light. Like concrete, they can be marvelous when used wisely, and by contrast be disastrous if not.

Reinforced concrete, steel, plastic and lumber are all "exotic", or non-native, in that they can only be acquired by import and/or at very high financial and carbon/fuel cost.

2) Native *(locally sourced and/or labor intensive and/or free/cheap; a partial list)*

Concrete rubble is present in overwhelming abundance following the earthquake. However, the re-use of rubble as aggregate for new concrete is hugely problematic, and is not encouraged here. Where so soft as to be friable in the hand, it should be crushed for use as soil amendment. Where stronger, it can and should be used to make bedding for roads, raised building pads (above flood levels), courtyard walls for privacy and security, and in some cases in building walls as part of an "earthen building" system (see next page).

Clay, sand and rock are free and present everywhere, and can be used as per the guidelines on the next page.

Bamboo *Guadua* and other lumber-grade species are currently rare in Haiti, but their use as imports can and should spawn plantings and local jobs "growing building material". Because bamboo delivers more useable fiber, faster, than conventional softwoods such as Southern Pine, and is a better fit to Haiti's climate, bamboo cultivation appears to be the best target for a "construction agronomy" strategy.

Reclaimed lumber is available, but supplies and qualities vary widely; it cannot be central to a reconstruction strategy, but should be used whenever practicable.

Rope made from sisal, hemp or other local plants is available, and can be used in building systems with a special eye on moisture durability.

Straw bales are available for wall construction.

Some materials will be very useful, but only available in limited quantity in particular areas, as is the case with localized supplies of quality lumber, or used shipping containers.

See next page for building guides and strategy with native materials.

Building Guides & Systems

Guides include: *Sphere* standards for settlement, *Global Task Force on Building Codes*, and the *International Building Code* (IBC 2009) provisions for wind and earthquake load resistance.

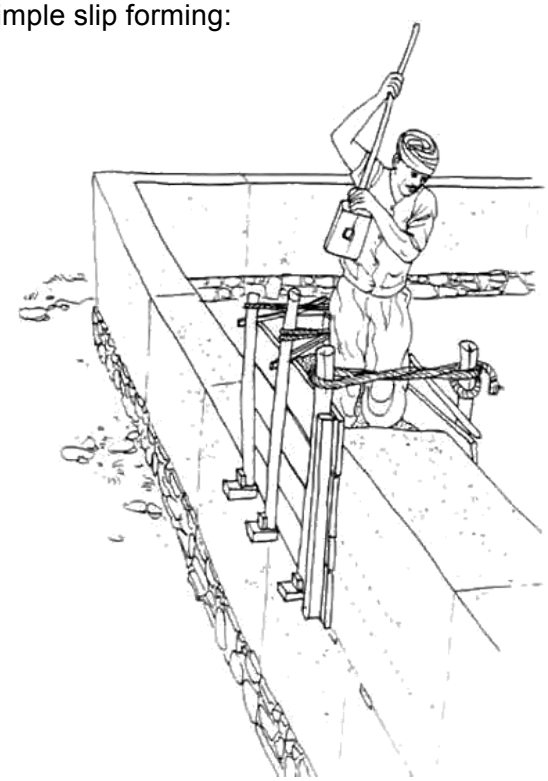
This proposal, however, keys primarily around ASTM International E2392-10 *Standard Guide for Design of Earthen Wall Building Systems.* The ASTM Standard (hereafter the "Earthen Standard") was recently published with the intent of providing guidelines for seismic safety applicable to the many forms of earthen construction to be found around the world. Though there is not a strong tradition in Haiti of earthen building, the reinforcing guides presented in the standard apply equally well to reconstruction where both steel and cement are hard to acquire. Its central tenets are two:

1. **Use clay as a binder** wherever the high strength of cement is not needed, e.g., most parts of most one-story dwellings. Soil-cement hybrids are also effective, as demonstrated by the many cement-stabilized rammed earth and adobe houses in California, but harder to build properly.
2. **Provide tensile reinforcing and/or containment** at key locations in the wall, bridging or containing the seismic cracks that appear in heavy, brittle structures. Suitable reinforcing materials include rope, galvanized wire, heavy fishing line or netting, and bamboo/cane.

There are a great number of ways to build with earth. Some, such as solid earth brick (adobe), "tire" houses, and earth bag or earth tube houses are less appealing because they are harder to reinforce, or, worse, present the appearance of reinforcement when they are in fact quite vulnerable. Some are not viable simply because they depart too much from cultural norms and sesnsibilities.

Three basic systems are here proposed that adapt well-known technologies to the materials available in Haiti:

1. Rammed earth involves packing a damp mixture of gravel, sand and binder into formwork; reinforcing can be laid horizontally into the wall between ramming "lifts". The ancient Moroccan system may be especially appropriate, as it requires very little wood; the wall is built in sections using simple slip forming:



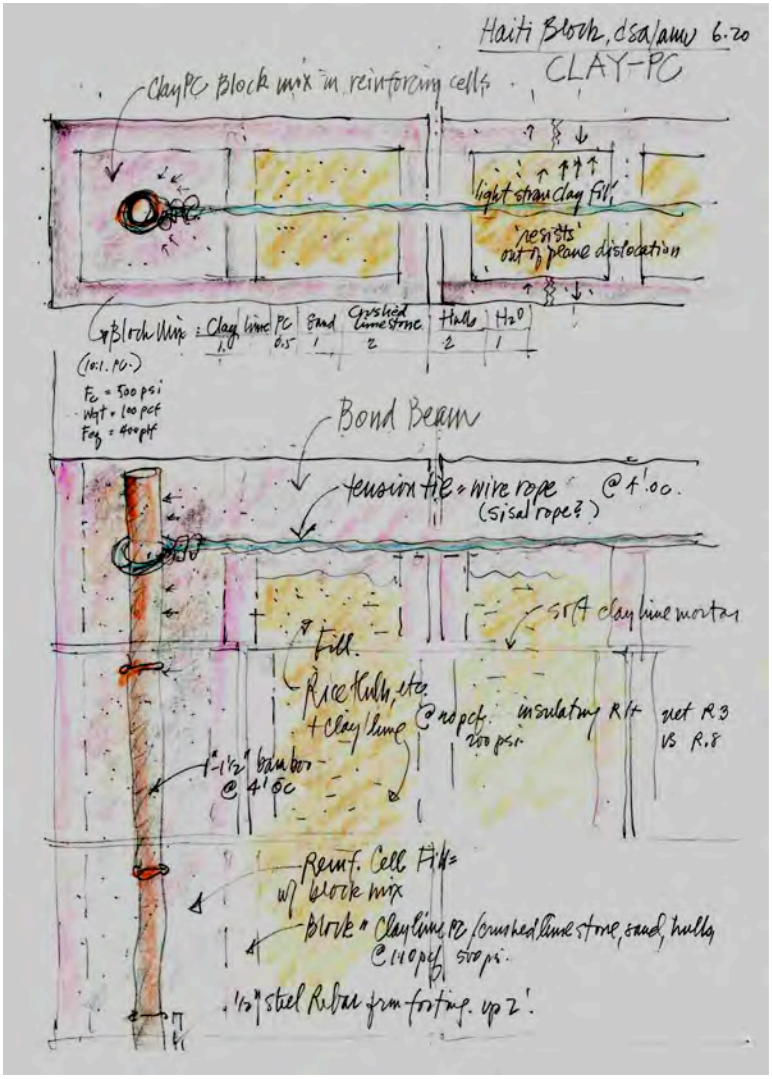
formwork in place around rammed earth wall

Two other basic systems are here proposed that adapt well-known technologies to the materials available in Haiti:

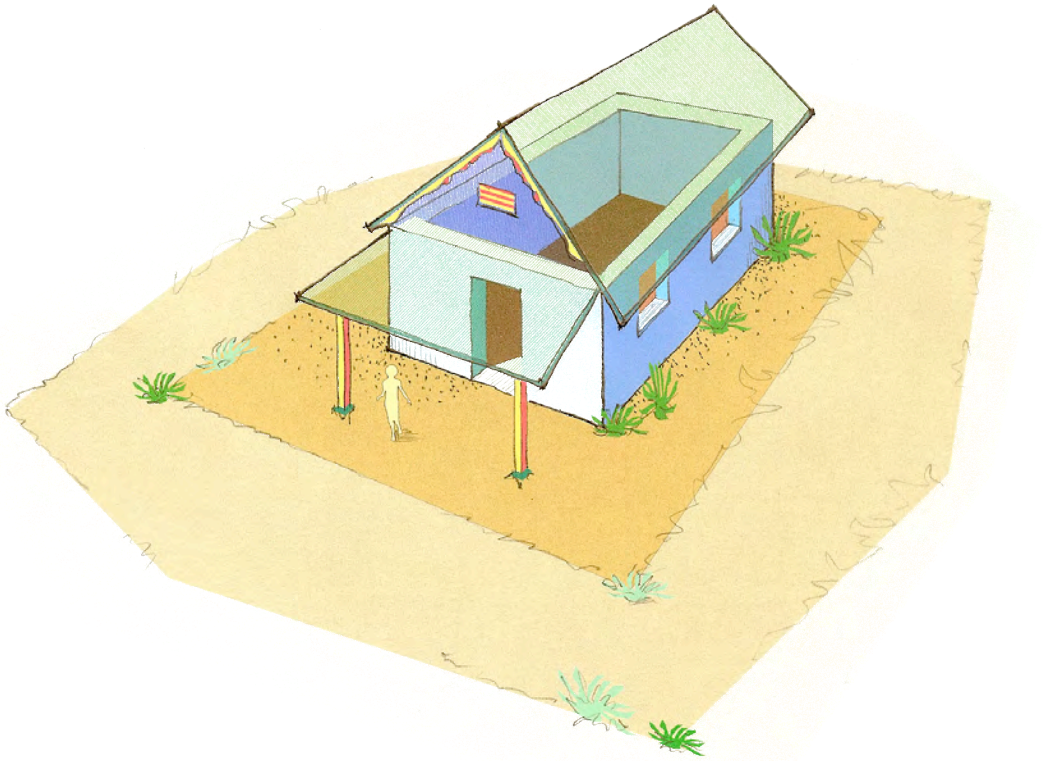
2. Cob involves packing a moist earthen mixture by hand into walls; no formwork is required. This system is the most laborious and time-consuming, but very easy and well proven. There are thousand year old cob cities in the Middle East, and entire cob villages in Devon and many other places in the UK.

As with rammed earth, reinforcing can be woven or placed into the wall as it goes up. Most modern cob buildings have curvilinear walls, which give inherent strength to the structure and diminish the strength requirements on the material itself.

3. Hollow block masonry is very much like the well-known hollow concrete block construction now common everywhere. The difference lies in the material: Dan Smith Architects and Architecture for Humanity have been developing the AMU (Alternative Masonry Unit) with a form easily adapted to field construction, and to the use of many combinations of aggregate, binder, and fiber reinforcing. In Haiti, blocks could be made onsite using clay binder, but reinforced and grouted with concrete at the wall corners to get a confined masonry effect.



Building Design Features



~ thatched roof (for sun protection and thermal comfort) over metal decking (for durability and seismic performance), with solar PV collectors as allowed by budget

~ structural bamboo trusses, roof framing and wall reinforcing; spawns local industry growing native stock of Guadua (large diameter) bamboo.

~ rain collection to underground cistern

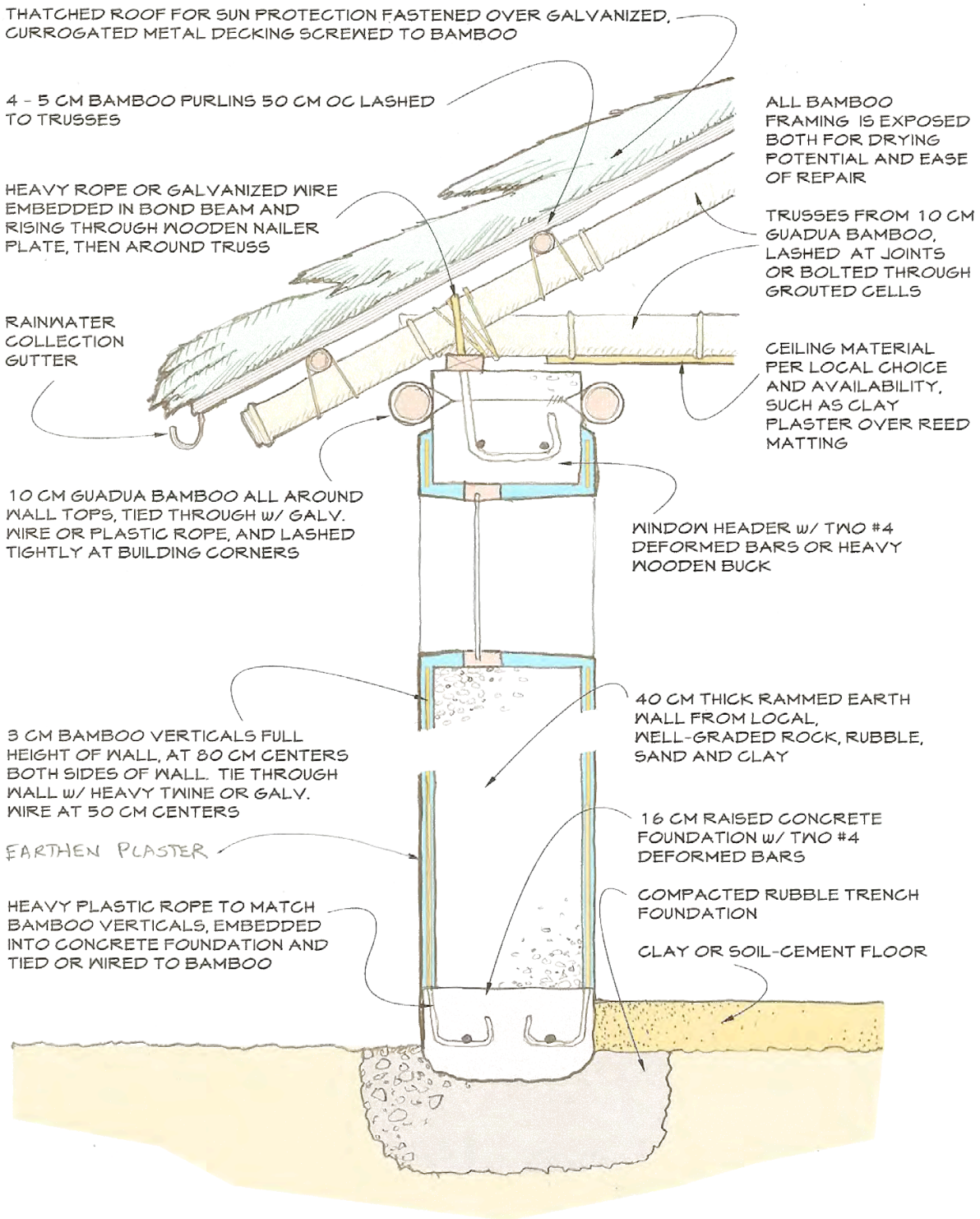
~ rammed earth walls using site soil and/or graded concrete rubble

~ reinforced concrete only where needed

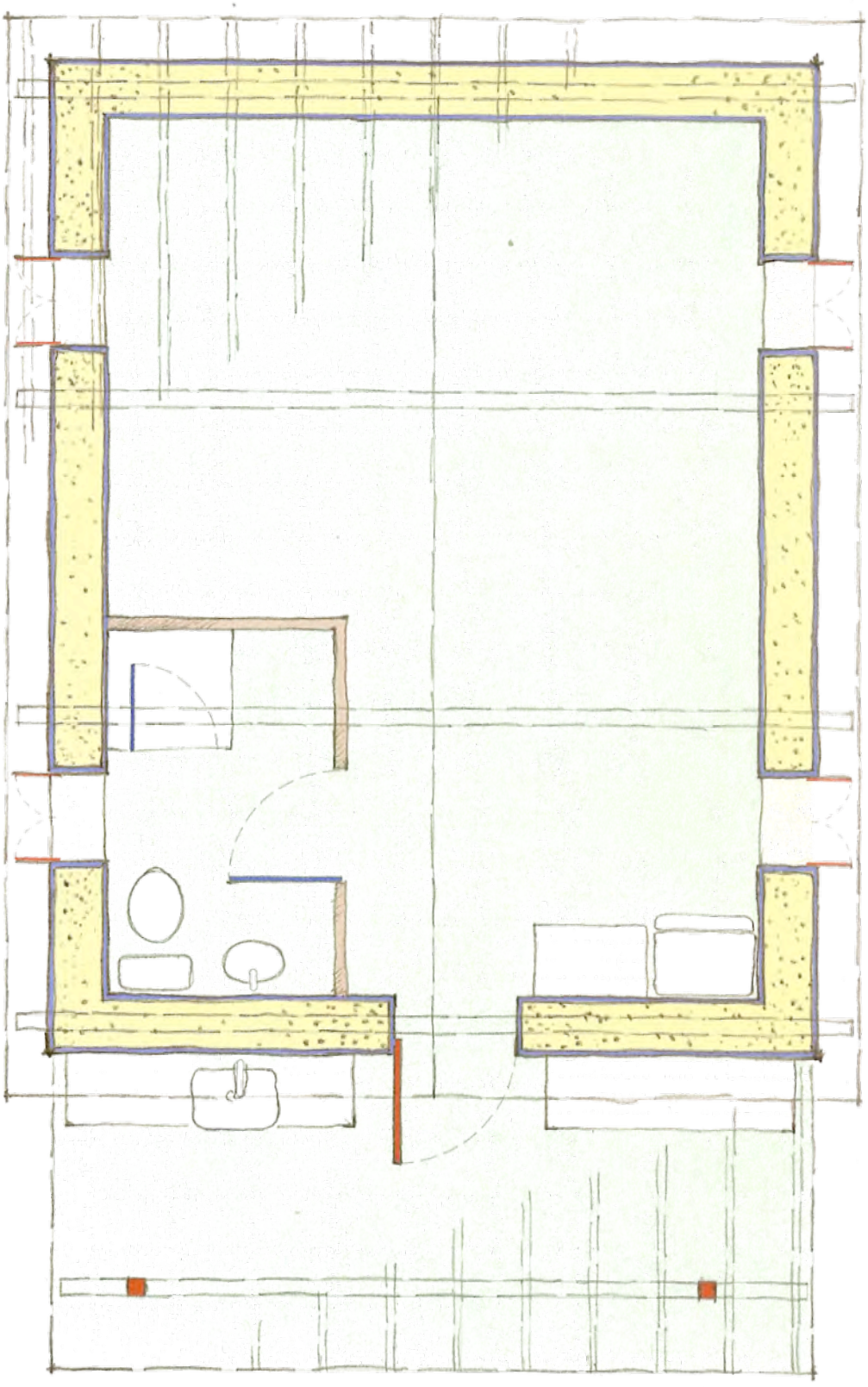
~ site pad built up above flood level with concrete rubble

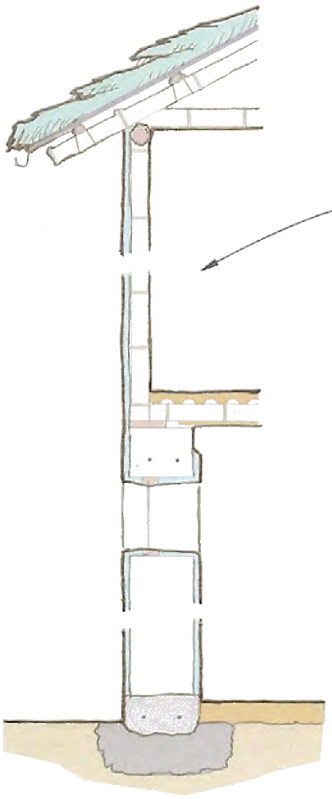
~ architectural forms per local preference, such as covered porch, outdoor kitchen, shuttered windows

~ basic provisions for potable water supply lines (using solar-powered pump from cistern), sanitary lines to leach field



One story house / wall section July 12, 2010

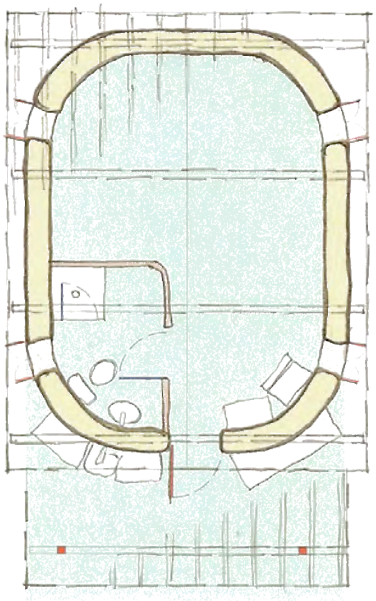


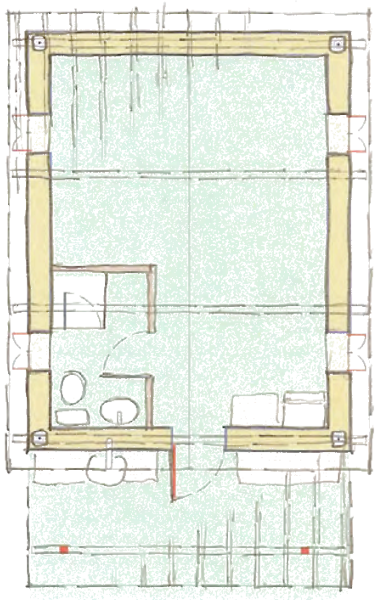


TWO STORY
ADD METAL DECK FLOOR w/ SOIL-CEMENT TOPPING, AND BAMBOO FRAME + WATTLE & DAUB INFILL PANELS ABOVE 2nd FLOOR

COB
BUILD CURVILINEAR WALLS, OMIT PLASTER & VERTICAL AND HORIZONTAL BAMBOO WALL REINFORCING (ROOF REMAINS THE SAME)

MASONRY (SITE-BUILT) BLOCK
BUILD WALLS WITH HOLLOW BLOCKS MADE FROM SITE SOILS, AND GROUT/REINFORCE CORNERS + TOP BOND BEAM. OMIT PLASTER & SOME VERTICAL AND HORIZONTAL BAMBOO WALL REINFORCING





Alternates July 12, 2010

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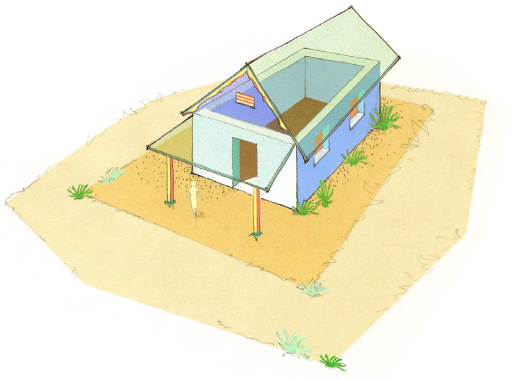
Better than a basket of fish for tonight's meal
Teach a man to fish, and he will feed his family forever



Safe, native and affordable

This is not a basket of fish

This is learning how to fish