A Critical Assessment of Concrete and Masonry Structures for Reconstruction After Seismic Events in Developing Countries

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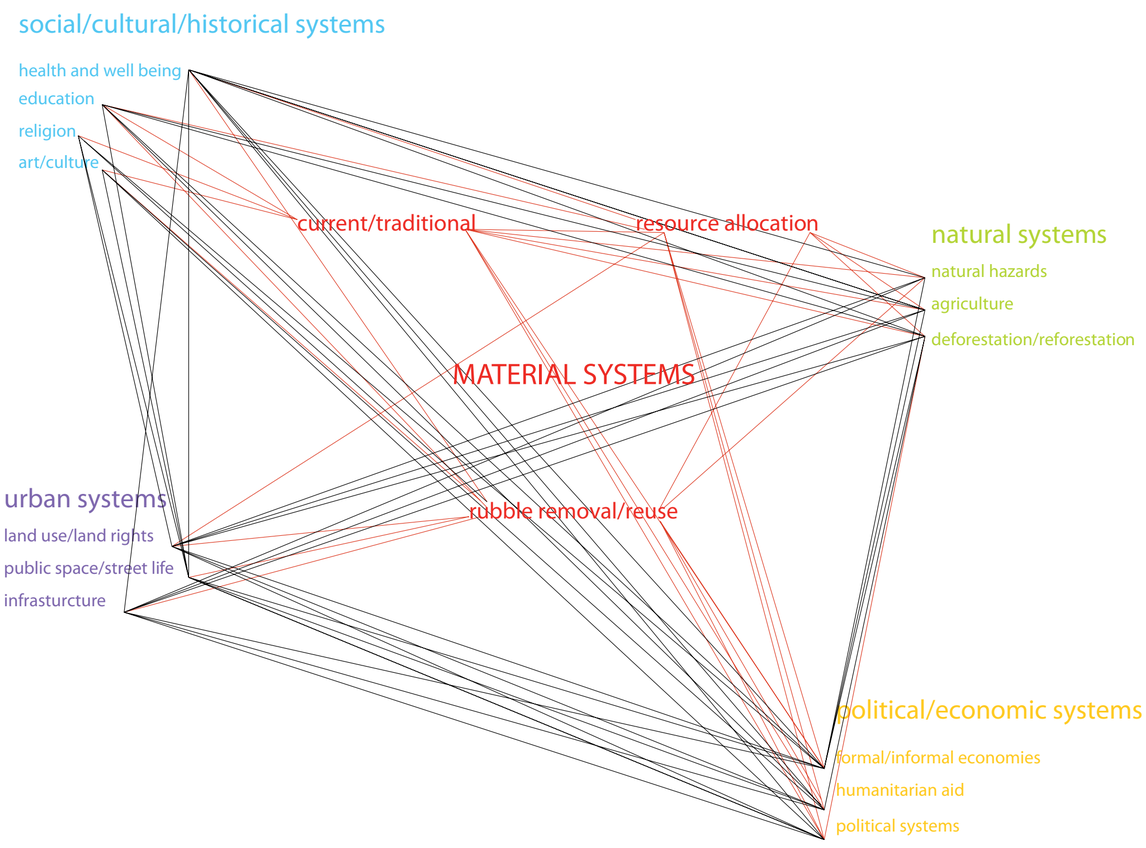
Overview

The infrastructures of developing countries, old and new, are in severe danger of the next natural disaster, only due to the fact that there is zero concern for the overall use of materials. And although the awareness of poor construction techniques have been presented, engineers and architects are continuously proposing systems that are destined to be hazards once the next disaster hits. Not only is the use of concrete economically unsustainable, but it is also the most vulnerable material when seismic activity hits the surface.

As the international community helps developing countries such as Haiti rebuild, they should utilize the knowledge they have in the technology of science and engineering, let the know-how of materials for work come from locals, and use sustainable structural systems that cannot be easily compromised within code compliances.



Precedent : Haiti

In Haiti, you will typically find modern block and cement houses in both provincial villages and urban areas. Research has proved that the structure of these cement houses are both unreliable and ineffective when natural disasters occur.

Precedent: Philippines

With non-engineered and non supervised building examples, the construction of the Philippines is generally reinforced concrete with hollow brick infill. And although strict building codes are in effect there is a common act of code violation which ultimately makes the reinforced concrete vulnerable to any seismic event

Images: The roof rests on columns and between those the walls are built with hollow blocks. The walls are reinforced with steel bars but the wall is still the weakest link

Locally Sourced

Concrete Debris

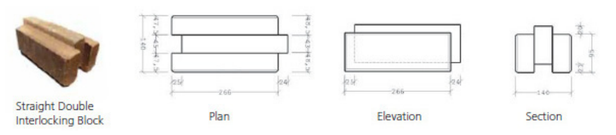
Can be effectively used as recycled course aggregate in new construction and there is an overwhelming abundance following the Haiti earthquake.

Hanil Visitors Center in Danyang, Chungbuk Korea. Concrete is broken and recast in various materials. The design uses cast fabric-formed concrete; where two fabric layers have a structural fine aggregate concrete pumped between them.

Interlocking Stabilized Soil Block

Manufactured by compacting raw material earth mixed with a stabilizer such as cement or lime under a pressure of 20 - 40 kg/cm2 using manual soil press.

Makerere University in Uganda, East Africa. The manual ISSB machine is manufactured in Kenya. ISSB blocks are used for the construction of buildings, latrines, wells, septic tanks, and water tanks



Bamboo

Currently rare, but on an incline towards local production, bamboo delivers more usable fiber, faster than any conventional softwood.

For wall construction for this bamboo house in the Philippines are used wall panels, assembled from split bamboo grids and chicken steel mesh and plastered with cement mortar. Bamboo houses when properly constructed are ductile i.e. being able to sway back and forth during an earthquake, without any damage to the bamboo poles

Industrial

Reinforced concrete

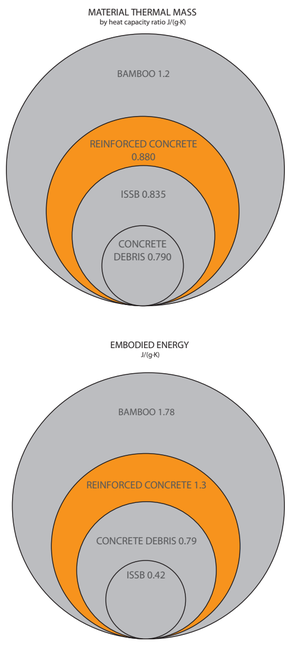
A reliable building system - if its done correctly. It has historically not been constructed properly in Haiti, by every measure. To rebuild with concrete in developing countries would require widespread training and the introduction of quality control.

Steel

A durable, well proven material for building in seismic zones. Steel is much more flexible cost effective than concrete but not cost effective for developing countries such as Haiti

Structural lumber

Is now nearly exotic in a place like Haiti. Wood buildings perform well in earthquakes and badly in fires. Most importantly, large fires occur more frequently than earthquakes.



System Barriers

The re-use of concrete debris is hugely problematic. More work must be done to characterize the recycled materials, and test additional performance parameters. **Compressive ratios** need to be exact in order to be sustainable

Component	Quantity (kg)
Coarse aggregate (12–25 mm)	5.415
Midsize aggregate (2.36–9.5 mm)	1.415
Fine aggregate (1.2–0.15 mm)	3.120
Portland cement	1.800
Water	1.080
Compressive strength (MPa) at[a]	
1 day	7.4 (0.9)
3 days	14.4 (1.2)
28 days	28.3 (3.1)

a Number in parenthesis: standard deviation.

The quality of the block depends on the properties and mix of soil types, the amount of force applied for compaction, and the addition of chemical or natural products to further stabilize and strengthen the blocks. Because of the climate ISSB might not have a very long lifespan due to lack of-**weatherproofing and thermal activity**

Dimension (L x W x H) (cm)	26.5 x 14 x 10 cm	40 x 20 x 20 cm
Weight (kg)	8-10 kg	12-14 kg
Blocks needed to make up a sq.m.	35	10
Wet Compresstive Strength (mps)	1 - 4	0.7 - 5
Density (kg/m3)	1700 - 2200	1700 - 2200

Bamboo cultivation appears to be the best target for a "**construction agronomy**" strategy. Once cut, insects may attack bamboo or wood. For that reason it is highly recommended that bamboo, once cut go immediately through a special immunization and drying process.

Steel reinforced bamboo brace panels are used in each building and then bolted securely to engineered foundations. But as a result of this system, steel is expensive to import and bamboo becomes weak, both issues that Haiti cannot withstand.

System Solutions

Rubble/Rice ash Hybrid

Rice hull ash is a by-product of the rice processing industry that is either burned in the field or goes directly to landfills. When burned at low temperature it is an outstanding pozzolan, extensive material testing has demonstrated that it can **replace up to 90% of limestone** in addition to being used as biomass to generate electricity.
Adding the ash makes concrete stronger and more resistant to corrosion.

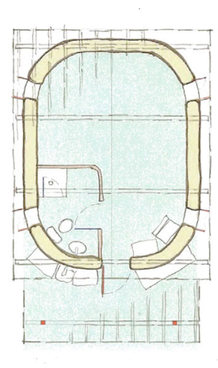
8 x 16 face of a typical concrete block with Rice Ash

Cob Construction/ Recycled Rubble Hybrid

Involves packing a moist earthen mixture by hand into walls; no formwork is required.

-Laborious but easy
-Time consuming but well proven

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.



Cob is fireproof, resistant to seismic activity, and inexpensive

Cob/Bamboo Hybrid

Bamboo Houses are designed to exceed seismic and hurricane requirements of international building codes. Intense research has resulted in a significant increase in strength and durability. It has also extended maintenance intervals compared to other traditional approaches.