Elizabeth Hausler

Building Earthquake-Resistant Houses in Haiti

The Homeowner-Driven Model

Earthquakes are deadly. Every year, thousands of people in developing countries die when buildings collapse on them, and hundreds of thousands more are left homeless. It's not the earthquake that kills people, it's the collapse of buildings that were poorly designed and built. The potential for tragedy only increases as more people move to cities and more buildings are constructed using concrete, which can be dangerous without good design and building standards. The recent disaster in Haiti is a tragic reminder of these facts. But these are man-made problems, and they have man-made solutions.

People in Haiti who have lost their homes are ideal candidates for homeowner-driven reconstruction, a low-cost, high-impact rebuilding model used successfully by governments in India, Indonesia, and China, and implemented on the ground by Build Change. So far, over 70,000 people in Indonesia and China live in safer homes because of Build Change's work. In Indonesia, houses we helped construct were tested in an earthquake that struck on September 30, 2009. None of the houses that met our minimum standard for earthquake safety was damaged in the earthquake.

In addition to designing earthquake-resistant houses in developing countries, we train builders, homeowners, engineers, and government officials to build them. Working directly with homeowners to choose a design and hire and oversee builders is a rewarding process that results in safer houses and satisfied homeown-

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ers. Empowering homeowners, builders, construction professionals, and local governments to drive change is a more cost-effective and lasting solution than building houses for people.

But people will not build an earthquake-resistant house unless they can afford to, and they need access to technology, materials, and skilled construction professionals. They also need incentives, and someone must enforce the building standards. By addressing all three barriers—technology, money, and people—Build Change encourages the growth of an environment in which earthquake-resistant construction becomes common.

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Why is this work important?

Earthquakes are deadly. They consistently rank among the top three deadliest natural phenomena in the world, battling for top position with floods and windstorms, according to the IFRC World Disasters Reports. In 2004, UNDP estimated that over 130 million people live with the constant threat of being killed by an earthquake.[1]

Earthquakes are expensive. In the 1990s, global losses from earthquakes topped US$215 billion. Over US$8 billion has been requested for reconstruction in Haiti since the 2010 earthquake.

Earthquakes have lasting consequences. People become permanently disabled; women and orphaned children in particular suffer from the effects of trauma, homelessness, and lack of security.

Earthquakes disproportionately affect poor people in developing countries who have no safety net, no savings or insurance, no well-off relatives to take them in. And, because their homes are often their places of business, they often lose all of their assets and their ability to earn an income.

Why do buildings collapse after earthquakes? The answer is those same three intertwined factors: technology, money, and people. In developing countries, the poorest people build simple, traditional houses with their own labor and local low- or no-cost materials, usually mud, thatch, or other lightweight (less deadly) materials. The trouble begins when they upgrade to more formal houses of mud bricks, fired bricks, or stone with heavy slate or concrete roofs. These unreinforced masonry or poorly built concrete houses can kill thousands in an earthquake.

Many factors are driving this shift. First, people want to be modern, and brick and concrete structures represent a step up the socioeconomic ladder. These structures also need less maintenance and are believed to be warmer, dryer, and more secure. Second, timber can be hard to get: many developing countries, trying to rein in illegal logging and preserve forests, have restricted access to timber, driving up the price, and making bricks and concrete cheaper and more accessible. Third, cement is easier to get, even in rural areas, thanks to large-scale development projects (dams, power plants, bridges, and roads), government-driven mass production of schools and government buildings, and aggressive advertising by cement companies. Fourth, traditional building skills are being lost as the skilled stonecutters and carpenters who could build traditional, earthquake-resistant houses have grown old and passed on.

But this shift to modernity is deadly. How can we reverse these trends and help people build safer, cheaper, and yet still desirable, houses? Tragic as it was, Haiti's earthquake presents a tremendous opportunity for change. We now have the opportunity to put in place programs and strategies we have developed through years of experience in Indonesia and China. We have urged the Haitian government to encourage homeowner-driven reconstruction and have offered to share the expertise we have acquired working throughout the world. The models we have developed reflect a clear commitment to building safe houses, and we have already started to create permanent change in Haiti so that when the next earthquake hits, more buildings will stay standing.

In this case narrative, I describe how the Build Change model will work in Haiti and why it is crucial to use a homeowner-driven model rather than a donor-driven one. I describe examples of the work we have done so far in three earthquake-prone countries, and from it draw lessons for building a better Haiti.

THE HISTORY OF BUILD CHANGE

I grew up in a small town outside of Chicago, where I spent summers working as a bricklayer for my father's masonry construction company. After graduating from the University of Illinois with a degree in general engineering, I worked in technical litigation support and environmental engineering. I was halfway through my PhD in earthquake engineering at the University of California, Berkeley, when three things happened in the same year.

First, an earthquake in Gujarat, India, killed over 20,000 people, mostly because unreinforced masonry buildings collapsed on them. This made me question why earthquakes kill so many people in developing countries. Second, the events of September 11, 2001, compelled me to use my engineering skills to make the world a better place. Third, I met Martin Fisher, cofounder and CEO of KickStart.[2] Meeting Martin opened my eyes to a world of opportunity for technology—and the right business model—to impact people's lives. So I finished my doctorate and, in 2002, went to India on a Fulbright fellowship to study and assist with the post-earthquake reconstruction.

India: Observing Reconstruction After Earlier Earthquakes

I landed in India at the end of 2002, with two questions:

1. Were people and organizations building safe houses in the wake of this earthquake?
2. Were construction practices changing permanently, so that people would continue to build safe houses in the future?

Over the next two years, in 80 villages in three Indian states, I talked with homeowners, builders, relief and development workers, and government officials about the effects of several earthquakes. Back in 1993, an earthquake in eastern Maharashtra state (Killari) had killed over 7,900 people and knocked down thousands of houses. The reconstruction was largely driven by contractors and donors who did not consider the homeowners' needs and perspectives. Although community members were involved in land-use planning and selecting beneficiaries, the homeowners did not get to choose their floor plans or types of structures or hire a local builder to build the house.

Visiting Maharashtra in 2004, ten years after the earthquake, I found that some homeowners were still sleeping outside their houses because they were not involved in the construction process and did not trust that contractors had built the houses properly. Few of the houses could be extended or added to in a structurally integrated way. Because homeowners did not control the construction, they could not use their own resources to build a larger house or a different floor plan more appropriate to their family size, home business, or lifestyle. Some of the alternative technologies—like geodesic dome houses—were more earthquake resistant but not appropriate to the culture and lifestyle. They provided little natural light and ventilation, had poor interior acoustics, and the small interior space could not be divided to provide privacy. Some people had abandoned homes—and entire housing developments—that lacked the infrastructure they needed to live there.

Donor-driven approaches were also used after the 1999 earthquake in Chamoli, India. In a few locations, the government introduced a prefabricated plank-and-joist roofing system. Stimulating small business development and generating local income while meeting the need for building materials is a sensible approach often applied after disasters. But the design and quality of construction were less than ideal; homeowners reported that their roofs leaked during heavy rainstorms. In 2004, only one production facility was still active, and it `was working mostly for the government, not the general population. Most homeowners who had the choice built a reinforced concrete cast-in-place roof, which can perform well in an earthquake—if built correctly. So, by focusing on the prefabricated technology, the reconstruction effort missed out on the opportunity to train builders and homeowners to design and build properly with a common, locally appropriate technology that people would continue to use.

On January 26, 2001, in the Kachchh district of Gujarat, India, the Bhuj earthquake caused over 20,000 deaths and destroyed over 215,000 houses.[3] Unreinforced masonry buildings with heavy roofs and poorly designed reinforced concrete frame buildings caused the most damage. Moreover, before the earthquake, the government had used pre-cast concrete panel systems to build 6,000 primary schools; many of them collapsed. Owners of destroyed houses could either rebuild their own homes with cash assistance (the homeowner-driven approach) or move into a house built by a nonprofit or government organization (the donor-driven approach). Approximately 77 percent of homeowners chose to build the house themselves; they later reported being the most satisfied with their new homes. Those whose homes were rebuilt by donors were the least satisfied.

Ten years after the earthquake, some homeowners were still sleeping outside their houses because they were not involved in the construction process and did not trust that contractors had built the houses properly.

In the homeowner-driven approach, the new houses were built on the original sites, and the owners chose the floor plan and building materials that fit their lifestyle and budget. They could build whatever type of house they wanted: stone, bricks, or blocks were common for the walls, and reinforced concrete or timber with clay tiles for the roofs. They could also build a larger house if they could afford it, provided they reinforced it properly and followed government-issued guidelines. Most homeowners didn't actually build a house themselves; instead, they hired local masons or teams of builders and took advantage of technical assistance provided by government-trained engineers. The government provided funds in installments; homeowners had to comply with the guidelines to receive the next installment. And, finally, because they hired the builder and oversaw the construction themselves, the homeowners were more confident that their house could keep their family safe.

In the donor-driven approach, houses were built en masse by contractors working for the government or nonprofit organizations, usually at relocation sites. The homeowners had little, if any, role in the design and construction, and the houses were built primarily with donor funds, and thus not subject to inspections like the other houses. Still, many of the nonprofits followed or exceeded the reconstruction guidelines in order to maintain their reputation and gain the homeowners' trust, and houses built by the government of Gujarat complied with all earthquake-resistant building norms.

But many people in the donor-driven houses were not satisfied with them. Some houses were never occupied. Many had architectural features that were not appropriate for the climate or the culture. Toilets were built inside houses although homeowners preferred them outside, so the toilets weren't used. Doors led to the street rather than to an enclosed courtyard. Many had very low ceilings, making them unbearably hot during the day. These problems demoralized and frustrated the homeowners; some abandoned their new homes or modified them in ways that were no longer earthquake resistant. In 2003, I saw donor-built relocation villages that were still uninhabited. People gave various reasons why: some were waiting for water and power, or for a formal ceremony. In other cases, people had not been chosen to live in the houses or had refused to move in until they had seen the houses survive a year of aftershocks.

These were valuable lessons that would later apply to Haiti: when given the choice, nearly 80 percent of the families with destroyed houses elected to rebuild by themselves, using local builders and the government's financial and technical assistance. These people were the most satisfied because they could choose the materials, architecture, and layout that were appropriate to their lifestyle and budget. They could be actively involved in checking the quality of the construction, which made them more confident that their house would keep their family safe in an earthquake. They could hire local masons and builders, just as they had before the earthquake. And, depending on the technical competence of the government engineers, the houses built using this approach were disaster resistant.

The lessons from Gujarat fall into our three key categories of technology, money, and people.

Technology

Standards: The government issued clear guidelines for common structures.

Capacity: Training programs and third-party technical assistance were available.

Money

Access to capital: The government released enough funds to build a complete basic house.

Incentives: The release of funds was contingent on meeting standards.

Subsidies: These were available on some materials, such as cement.

People

Motivation: Homeowners, the government, and relief agencies were all motivated to rebuild safely.

After India: Creating a Model

I left India intent on improving the process of constructing housing after earthquakes in developing countries. It started with what I called the three S's: safety, satisfaction, and sustainability. Any house built after an earthquake should be safe, the homeowner should be satisfied, and the process should be sustainable: people should be able to build safe houses in the future.

From that I developed a theory of change. At that point, I assumed that governments would not be in a position to enforce building standards and that the

Design Criteria for Permanent Housing Reconstruction

Technology
- Disaster resistant design—compliant with standards and guidelines
- Disaster resistant construction—built with quality workmanship
- Durable and permanent
- Built with locally available materials and skills
- Easily expanded and maintained using locally available materials and skills

Money
- Competitive in cost with common local (but vulnerable) building methods

People
- Environmentally neutral, using no illegal materials
- Suitable to the climate
- Culturally appropriate in architecture, space, and features
- Secure from break-ins and pests
- Designed and built with the participation of the people
- Trusted by inhabitants, who must believe their house will survive a disaster

only way earthquake-resistant houses would be built was if the right technology became locally available, widely known, and culturally accepted. Such technology also had to be cost competitive with existing but vulnerable building methods. Once again: technology, money, people.

To make this something we could implement, and drawing on my observations about what not to do, I developed and published a list of design criteria for permanent housing reconstruction.[4] New houses should meet 12 criteria in those three key categories, as spelled out in the text box above.

Finally, I set up our implementation model: we would promote and implement homeowner-driven reconstruction by providing technical assistance and training only; we would not build houses for people. We would work in environments where funding was available from some other source, such as a government grant program or relief agency. This would reduce our need to raise funds, and thus enable us leverage our niche expertise.

In 2004, with a fellowship from Echoing Green, I started the Center for Earthquake Resistant Houses. In 2005, seeking a name that was less academic, an Echoing Green staff member asked, "Well, what do you do?" and I answered, Build earthquake-resistant houses and change construction practice permanently." Build Change. That has been our name ever since. We had plans to work in Bam, Iran, and Uttaranchal, India, near the Himalayas. But in December of 2004, the first tsunami hit Aceh, Indonesia, which changed everything.

Post-Tsunami Aceh: The Donor-Driven Model Trumps the Homeowner-Driven

On December 26, 2004, an earthquake on the Sunda trench caused the Indian Ocean tsunami. Seismologists said this made it more likely that another strong earthquake would occur on Sumatra's other major fault, which runs right along the edge of the most populated area of Aceh province. Given this huge seismic hazard, I went to Aceh in March 2005.

In Indonesia I met members of Mercy Corps, who ran successful cash-for-work programs to clean up tsunami debris. People had started to ask for housing, and Mercy Corps needed a partner to provide it; they decided to fund a pilot project in three villages. There we proposed to homeowners that they would choose the structural system and layout for their home, and we would create the architectural drawings and estimate the quantities and costs of the materials. Homeowners would then receive a cash grant in installments, which they could use to hire builders and buy materials, just like the homeowner-driven approach I had first seen in Gujarat. We would be with them every step of the way, checking construction quality. But the homeowners thought this sounded like a lot of work—people in other villages were getting complete houses built for them by other agencies—so they said no.

I appealed to some of the other agencies involved in housing, sharing the lessons I had learned in India about homeowner-driven reconstruction and the pitfalls of donor-driven approaches. But the second tsunami arrived—that of donor-driven development models. The massive funding that poured into Aceh blinded everyone to lessons of the past. Many agencies used top-down models, settling on one floor plan and hiring contractors to build similar houses for everyone, with no homeowner involvement. Most agencies applied community-based approaches for land-use planning and beneficiary selection, but usually a small group made the decisions for everyone—not how homeowners normally make decisions.

So, we set out to make our donor-driven program as homeowner-driven as possible. Since we were using donor funds, we had to work carefully to determine who was a legitimate beneficiary. Using lists from village chiefs of eligible homeowners, we inspected each plot, looking for signs of a house, and compared satellite images taken before and after the tsunami. Some plots clearly had had no house on them before the tsunami, and one village chief wanted us to build some houses he could rent out to generate income. While we were involved in this due diligence process, another agency came in and snapped up one of the villages where we had hoped to work.

But we persevered. We identified four typical structural types common or viable in Aceh: confined brick masonry, reinforced concrete block masonry, stilt-type traditional timber building, and timber frame with a masonry skirt wall. Confined masonry is one of the most common ways of building a house in Asia, Latin America, and Hispaniola. It consists of a brick, concrete block, or stone masonry wall that is tied together by reinforced concrete tie columns and bond beams.[5] The walls resist the earthquake forces and support the roof, so it is essential to build a strong, good-quality wall. The tie columns and bond beams provide extra capacity so that if the wall cracks, the entire building does not collapse. It's a bit like putting an enormous rubber band around the building. The wall is built before the concrete for the tie columns is cast: this ensures a good connection between the wall and the confining elements. Confined masonry buildings can withstand earthquakes if they are designed and built properly. They also can fail if designed and built poorly, as we have seen repeatedly in Haiti.[6]

We organized a volunteer group of structural engineers from San Francisco-based engineering firms to do the seismic design. We then sat down with each homeowner and asked which type of house they preferred. They could choose the structural system and roof type, the layout (within government guidelines), and the paint color. All homeowners wanted to choose for themselves. They could build the house themselves, recommend a builder, or leave it up to us to hire a builder. They all chose the third option.

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We completed the engineering designs, developed a construction inspection checklist, recruited builders, and worked with Mercy Corps to procure building materials. Our Indonesian technical supervisors were on site every day, checking quality and providing hands-on training. Some builders thrived in this environment, vastly improving their skills under our mentorship and guidance. Others quit; they could work for another agency with less stringent quality standards and the same, or sometimes higher, wages. Our supervisors diligently checked the quality of materials, often rejecting bricks that had not been fully fired, steel that was smaller than the specified diameter, and sand with too much mud in it. But the demand for building materials was so high and the oversight of quality was so low that the truck drivers would just drive down the road with the materials we rejected, and dump them off at the project of another agency that wasn't checking quality so closely. Some agencies had to tear down or retrofit entire villages because of problems with construction quality, and some homeowners felt so alienated from the process—unable to control the quality of their own house or get a job on a construction team—that they protested. These are some of the pitfalls of donor-driven reconstruction programs and an important lesson for Haiti: donors should allocate a significant portion of their funds for quality control oversight and use the homeowner as an asset to help check the construction.

Our confined masonry design won an award from the Structural Engineers Association of Northern California. Indonesian academics and reputable practicing engineers visited our project and called it the best in Aceh. But we had only built 11 houses.

Buoyed by our success, we decided to build seven more houses ourselves, train more builders, and provide engineering design and inspection services to other agencies. We won another grant from Mercy Corps, along with income-earning contracts for services from other agencies. We produced a design and construction guideline, reviewed the designs of other agencies, inspected their houses, and provided mentorship and training to over 100 builders in a four-month-long apprenticeship program rebuilding 15 houses. In about 18 months, our work improved the design and/or construction of another 4,200 houses, and earned income on all contracts except the one for building houses. We knew we were on to something when our technical resources and ideas started to appear in others' publications.

By the end of 2007, there were more new houses built in Banda Aceh and Aceh Besar than people who needed them. It was time to move to an environment where we could go back to a homeowner-driven model. The Aceh post-tsunami reconstruction illustrated some of the challenges and shortcomings with donor-driven models:

Technology

Standards: Guideline was incomplete and applied to a more expensive, less common structural system
Capacity: Some organizations did provide training

Money

Access to capital: Agencies and government had significant funds
Incentives: None existed to ensure safe construction
Subsidies: None existed

People

Motivation: Homeowner involvement was minimal, government provided no enforcement, and third parties provided only limited supervision

West Sumatra: The Homeowner-Driven Model Works

In January 2008, we relocated to Padang, West Sumatra, and set up a field office in Padang Panjang, near the area affected by the March 2007 earthquakes along the Sumatra Fault. We later expanded to areas affected by the September 2007 earthquakes near Bengkulu. These earthquakes had not captured the attention of the international relief and donor community, so here we could return to the homeowner-driven model of providing technical assistance to homeowners and training builders. We gave no funding or materials to the homeowners; they rebuilt with the cash grant of 15 million rupiah (about US$1,700) from the Indonesian government, and their own resources.

Before we started the program, we surveyed 76 homeowners in three of the most affected regencies (similar to counties) to be sure they wanted our assistance. Of the 91 percent who did, a large majority wanted hands-on practical training and on-site supervision; a lower percentage wanted classroom-type seminars. We did not need to select beneficiaries or document land tenure, which simplified things. We worked with any homeowner who was building a house, regardless of their income level and whether or not they had lost their house in the earthquake. It was up to the government to decide who was eligible for the cash grant—so our relationships with the homeowners were only about the technical aspects of housing reconstruction. Now Build Change could be a trusted advisor, not a patron. We stopped calling the people we worked with beneficiaries. They were homeowners, builders, technical high school students, and government officials.

> When the homeowner is the owner, they will spend only what they have, use recycled materials, and conserve their resources. They will take pride and ownership of their home; they will not steal from themselves. When the donor is the owner, they are perceived to have deep pockets. If the donor does not have robust internal controls—which are expensive to implement—they will no doubt lose resources.

We sent our trained Indonesian technical supervisors to the villages to provide hands-on technical assistance. We helped each homeowner select the structural system, draw layouts, estimate costs, check the quality of materials, and monitor the construction. We also trained and mentored builders. We held single-day homeowner training courses, on-the-job training for builders in masonry, barbending, and carpentry, and offered multi-day training courses for government officials and technical high school students and their teachers. We are now holding similar training programs in Haiti.

Using this model meant more diverse engineering and design challenges than we had faced in Aceh. There, we were essentially reproducing the same blueprint several times, but in West Sumatra, each homeowner decided on the layout of their house. So, we developed a series of layout rules. For example, how long could a wall be without bracing? Where could windows and doors be placed?

Allowing homeowners to choose the type of structure they wanted led to a different outcome from the one in Aceh: almost half chose to build a simple timber-frame house with a masonry skirt—a structure that had been rejected in Aceh when well-funded relief agencies built larger, fancier houses from masonry and reinforced concrete. The timber-frame house can be finished to resemble a modern masonry house and it is also easier to build safely, especially with limited financial resources. We then developed technical resources to build timber houses, which was not difficult, as the building technology is well known in Indonesia and several of our Indonesian staff had ample skill and experience. We identified reasons why these structures sustained damage in earthquakes and developed a simple checklist to ensure that the main structural features were done right. Some organizations that worked in West Sumatra after the 2009 earthquake are already promoting this type of construction in Haiti; our website has examples of drawings and checklists.

But confined masonry was still popular, and we had gathered a wealth of data on how these houses performed during earthquakes in Indonesia. Many such buildings, though built to a lesser standard than the one we applied in Aceh, had performed well in earthquakes, and the houses we designed in Aceh now appeared to be too conservative and too expensive. It clearly was possible to build a simpler, less expensive house and still ensure that it would not collapse. We called the standard we used in Aceh the "Build Change Standard" and shelved it for the time being. We developed the "Minimum Standard" for safe confined masonry construction, which established a set of minimum interventions to prevent part or all of a house from collapsing in an earthquake. In West Sumatra, we started mass marketing safe construction practices, producing a simple construction booklet and other tools.

A shortcoming to the homeowner-driven model emerged. If people did not complete their homes or meet minimum standards, the reason usually was lack of funds. At that time the government was providing only 30 percent to 50 percent of the funds that people needed to build a safe home. Over 93 percent of the homeowners rebuilding with the timber frame could meet our minimum standard, but only 52 percent of homes built from confined masonry did so.

Inspired by Hernando De Soto's[6] point that land rights provide access to capital, we conducted a survey of homeowners' land rights and willingness to use land certificates as collateral. We found that 95 percent had no land certificate, 57 percent wanted one, and 68 percent would use such a certificate as collateral if they had one. Based on these results, we went searching for banks or microfinance institutions that would provide loans to our clients. Commercial banks would only give loans to homeowners with formal sector jobs and significant collateral. Rural finance institutions were also risk averse, providing loans only for small business creation and to people with collateral.

At the same time, we explored what level of financial incentive or bonus it would take for more people to comply with our minimum standard. An additional $10 to $200, which could be given in the form of materials like steel reinforcement, would have likely resulted in substantially higher compliance and completion rates. But we didn't have this kind of money, and the program was nearing completion.

By the fall of 2009, most homeowners had either stopped or finished rebuilding. We had demonstrated that homeowner-driven reconstruction can produce low-cost earthquake-resistant houses. An earthquake-resistant house in West Sumatra, including the government grant, the homeowner's contribution, and our technical assistance, cost between $3,000 and $8,000. In Aceh, the same product cost $12,000 to $20,000 and more. Using a homeowner-driven approach is an excellent way to stretch donor dollars.

When the homeowner is the owner, they will spend only what they have, use recycled materials, and conserve their resources. They will take pride and ownership of their home; they will not steal from themselves. When the donor is the owner, they are perceived to have deep pockets. If the donor does not have robust internal controls—which are expensive to implement—they will no doubt lose resources.

West Sumatra: Homeowner-Driven Reconstruction After the 2009 Earthquakes

On September 1, 2009, we gave notice to all but four of our Indonesian staff that their last day of work would be September 30. On September 30, an earthquake off the coast just north of Padang killed 1,115 people and destroyed or severely damaged over 135,000 homes.[7]

Luckily, none of our staff or their families was injured, and they all came back to work. This new quake hit an area where we had provided technical assistance, and when we surveyed the houses in that area, we found no damage on those that had met our minimum standard. A few that did not meet the standard were damaged. Going back to some of these villages six months to a year after we had left them, we found new homebuilders using the same techniques we had promoted on houses built with their own resources. This kind of long-term change is our ultimate goal.

Unlike the situation in 2007, this time the central government in Indonesia and the relief community paid attention. A major international donor, Indonesian government officials, and experts from outside West Sumatra heavily promoted the building of reinforced concrete frame buildings, with masonry infill and masonry gable walls. This structural system, uncommon in rural areas, is expensive and difficult to build properly without highly skilled builders and sufficient construction supervision. Unlike our experience in Aceh, though, this time we were ready to answer the challenge. At this point we had four years of experience in Indonesia and were armed with data and experience from 20 months of work in West Sumatra. In partnership with government officials and academics from West Sumatra, we lobbied the central government to allow confined masonry and timber frame with a masonry skirt wall, and they eventually agreed. Because the government has limited expertise working with timber frame, they asked us to develop resources and train technical supervisors in this method. Although the release of funds has just started, 85 percent of homeowners currently are building walls of timber frame with a masonry skirt. If the numbers remain at this level, we will have an impact on 57,000 houses.[8]

At the same time, other donors and agencies were promoting the short-term solution of transitional shelter. The government discouraged this, believing its people could cope with this disaster by staying with extended family, finding alternative accommodations, or building a transitional shelter with their own resources. The government also recognized that it could not provide enough funding for permanent houses, so it encouraged agencies to save their resources for the permanent housing phase. Few could do this, given the short grant periods their donors imposed on them.

The government also discouraged them from using donor-driven models and building houses outright, as some did in Aceh, arguing that providing permanent houses in one community but not another would result in conflict and social tension. Instead, it asked agencies to provide the government with financial resources that it could distribute to homeowners to build permanent housing, and to provide technical assistance. Agencies had stepped away from permanent housing after the Aceh experience but were now returning, looking for ways to add value through capacity-building programs. In partnership with other agencies, we trained the homeowners, technical supervisors, and builders. In Haiti, we see the same opportunity to work in partnership with other agencies to build the capacity of homeowners, builders, and engineers to rebuild safe houses.

But once the transitional shelter period was over, most agencies left West Sumatra. Reconstruction is only just starting, and now our biggest challenge is raising funds to support our technical assistance programs, which are less attractive to donors because of their long turnaround time. This points to an important lesson for both West Sumatra and Haiti: agencies should spend less on short-term (emergency) building and save more for the permanent reconstruction phase.

Homeowner-driven reconstruction was effective in West Sumatra but would have been moreso with government enforcement of building standards and greater access to capital:

Technology

Standards: Build Change developed minimum standards (minimum to prevent collapse)
Capacity: Build Change did hands-on training

Money

Access to capital: The government provided maximum US$1,700 per house, not enough to rebuild safely
Incentives: None to ensure safe construction
Subsidies: None

People

Motivation: Many homeowners were motivated, but government enforcement was very limited

China: Succeeding with the Homeowner-Driven Model

The quake that hit Sichuan, China, on May 12, 2008, killed over 80,000 people and leveled buildings over an unprecedentedly wide area. My former colleagues at the University of California, Berkeley arranged for me to visit Sichuan through the 10 + 10 Strategic Partnership between the University of California system and 10 universities in China.

There I found some compelling examples of confined masonry buildings constructed according to more recent codes; they survived unscathed in this earthquake. But, they were surrounded by piles of rubble from older buildings made of unreinforced masonry and pre-cast plank roofs. Clearly, the Chinese already had the expertise to design and build safer houses. The challenge would be getting that expertise out to the rural areas and the people who needed it most.

We hired local engineers and graduates of construction trade schools, identified local partners, and sat down with each homeowner to draw an earthquake-resistant layout, estimate costs, and provide supervision of the construction. We applied the same homeowner-driven reconstruction model we had applied in West Sumatra and plan to use in Haiti. The Chinese government provided funds directly to small groups of homeowners to pay for the building materials. The homeowners hired local contractors to rebuild their houses. We provided only technical assistance and training.

Xing Dayan lost her mother when her house collapsed on May 12. When we met her, she had already started building her new confined masonry house. One wall was going up out of plumb, and another wall had very large openings. We talked her through what she needed to do—tear down the tilting wall and add a reinforced concrete lintel beam over the window and door, tied into the tie columns—and she convinced her contractor to make these changes. We didn't provide any money or materials, just information. She told us that after her neighbors saw her lintel beam, they all wanted them too.

We started work in Tumen township, in partnership with a Chinese NGO. We found that homeowners were signing incomplete, confusing, contracts with builders. We developed simple contract templates that explained the technical details—translating the concrete strength requirement into number of bags of cement, number of wheelbarrows of sand, and number of wheelbarrows of gravel, which enables the homeowners to check the construction. These templates are available on our website. We are revising them for use in Haiti.

The township party secretary came to one of our homeowner trainings. He then invited us to work in partnership with the government to supervise construction. The first barrier we had to overcome was the perception that our standards were higher because I am a foreigner, even though our engineering design work and standard development were based largely on Chinese standards and practices. We reached consensus on a minimum standard that was simple enough to implement but would prevent houses from collapsing. We monitored construction, providing hands-on training when needed, and reported back to the government every week. The government called in contractors who were doing a bad job and provided incentives to those who complied with the standards. Having the government behind us certainly made our job easier. In the end, 76 percent of the homes we worked on complied with our minimum standard.

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In rural areas in China, as elsewhere, the lack of resources is a significant obstacle to implementing safe housing reconstruction programs and creating long-term changes in construction practices. Not enough personnel have enough technical backgrounds; not enough vehicles and infrastructure are available to facilitate inspections, and the list continues. Build Change is now working with construction trade schools in China to develop a prestigious internship program in which technical high school students will be placed in rural areas for one year to work with governments to mentor local builders and enforce building standards.

Homeowner-driven reconstruction worked very well in China, as all of the components—technology, money, and people—were in place.

Technology

Standards: Government issued the guideline, and Build Change partnered with local government to develop minimum standards (minimum to prevent collapse)

Capacity: Build Change did hands-on training

Money

Access to capital: The government provided sufficient grant and loan access in most areas

Incentives: Some existed for contractors

Subsidies: Prices of some materials were controlled

People

Motivation: Many homeowners were motivated, and the government enforced standards in Build Change work areas

We believe a homeowner-driven implementation model will work in Haiti, and now we describe why and how.

LESSONS FOR HAITI

The six-step Build Change model will work in Haiti. We understand why buildings collapsed on January 12, 2010 (Step 1: Learn) and we have already identified low- or no-cost improvements to existing ways of building (Step 2: Design). We are hiring local professionals, partnering with local and international agencies, and rolling out large-scale training and technical assistance programs for builders, homeowners, and construction professionals. We are working in partnership with buildings materials producers to produce better, locally available materials (Step 3: Build Capacity)

We have met homeowners who are already taking steps to improve their homes and asking plenty of questions about how to build a better building. Using mass marketing and social media, we are kicking off a strategic communications program designed to bring simple messages about house repair and safe reconstruction to the masses (Step 4: Stimulate Demand). We are promoting financing models that conserve resources while using incentives, such as grant funding in installments or lower interest rates on loans, to improve construction quality. We are working to convince agencies and governments that a homeowner-driven reconstruction approach is the lowest cost, most efficient method of producing safe houses, satisfied homeowners, and a sustainable change in construction practice (Step 5: Facilitate Capital). Step 6: Measure, will follow as we do the work.

Our work in other countries holds many lessons for Haiti, which I've organized using our six steps.

The Build Change Implementation Model

Step 1: Learn First. Why did houses collapse in this earthquake? Why did some not?

Build Change begins with forensic engineering studies after earthquakes to understand why buildings collapse and how to build them better. We have studied housing performance after 12 earthquakes in six developing countries. Please visit our website to download these reports.

For any type of structure, safe construction depends on the three C's: configuration, connections, and construction quality. Configuration: simple, square, symmetric building layouts are best. Connections: tie upper structure to foundation, roof to walls, and walls to the frame or confining elements, and tie them to each other. Construction quality: concrete blocks need good raw materials, and enough cement, and proper curing. Masons must completely fill the joints between blocks.

Step 2: Research and Design for Earthquake-Resistant Houses. What types of houses do people want to build here now? With what materials, skills, and tools? How can we design them to resist multiple hazards?

It's easier to make minor, low-, or no-cost improvements to existing ways of building than to introduce a completely new technology or reintroduce a traditional building method that has gone out of style. Build Change completes detailed housing sub-sector studies to design and build safe houses that are culturally appropriate, preferred by homeowners, low cost, locally sustainable, and disaster resistant.

We also develop building manuals that are specific to the practices in the developing countries where we work and distribute them to local builders and homeowners. A set of resources for Haiti is already available at www.buildchange.org.

Step 3: Build Local Capacity. How can we disseminate this knowledge to masses of engineers and builders?

The best designs in the world will not save lives unless they are built properly, local engineers know how to design them, and local producers can produce enough quality building materials.

Step 1: Learn First

On my first trip to Haiti in March 2010, I spent most of my time learning, observing why houses collapsed and why they didn't, and understanding how people build houses here and now. Many houses built in Haiti were an incomplete or imperfect version of confined masonry. Confined masonry buildings in Haiti violated some of the three C's, described below.

First is configurations. The best configurations for surviving earthquakes are simple, square, symmetric building layouts that are the same from the first story to the second. In Haiti, some buildings had second and third stories larger than the

We train local masons, carpenters, engineers, and homeowners to use earthquake-resistant building techniques that are culturally accepted and easy to adopt with limited training and education. We target workers involved in construction before the disaster, who are committed to staying in it for the long term, and partner with local agencies to train such people. On-the-job training courses are led by Build Change's local engineers and master masons or carpenters.

Build Change also works with local building materials suppliers to produce better building materials, and meanwhile increase profits.

Step 4: Stimulate Local Demand. Someone has to want the house to be earthquake resistant. Homeowners, government officials, and relief agencies are in a position to demand safe construction. But how can we convince a rural homeowner with limited resources to invest more in building a safe house? Make it affordable and easy to implement, and leverage the window of opportunity right after a disaster.

How can we make it easy for local government officials to enforce building standards, without letting corruption—and limits on their resources and time—get in the way? Create simple building codes and guidelines, training seminars, and inspection systems that work in areas with little infrastructure, budget, time, and personnel.

Step 5: Facilitate Access to Capital. Build Change does not build houses for people and does not pay for materials and labor. Usually funding comes as grants from governments or relief agencies. But if that funding is inadequate, Build Change partners with financial institutions so homeowners have the funding they need to build safely.

Step 6: Measure the Change. Our ultimate test will be an earthquake in an area where we have worked. Meanwhile, we build in intensive monitoring and evaluation. Every day, using paper and digital cameras, field staff documents the recommendations made and the changes implemented on each house. This detailed tracking lets us tally the number of changes each homeowner makes and how well the house meets—or exceeds—standards. For training programs, we give pre- and post-tests to measure how people's skills have changed.

first. A lightweight roof can make be crucial in reducing earthquake damage. In Haiti, many buildings have a weak concrete block masonry wall and a heavy roof to reduce hurricane damage. During the earthquake, that combination proved deadly.

Second is connections. For a building to survive an earthquake (or a hurricane), all of its structural elements must be connected. That means the upper structure is tied to the foundation, the walls to the frame or confining elements, the frame or confining elements are tied to each other, and the roof is tied to the walls. In Haiti, walls were not tied and they separated easily from the confining ele-

Two common house types suitable for Haiti
Top: Timber frame with masonry skirt wall
Bottom: Confined masonry, done well

ments. In addition, steel reinforcements must be tied together at every corner. Every earthquake-related building disaster seems to involve insufficient steel connections—and Haiti is no exception.

The third C is construction quality. Poor construction quality and materials played a very large role in the damage in Haiti. Sand had too much mud, gravel was smooth rather than angular, and concrete blocks were of poor quality, made with poor quality raw materials or insufficient cement or improperly cured.

All these are lessons for Haiti: everyone involved must check designs and quality.

Step 2: Research and Design for Earthquake-Resistant Houses

For Haiti, we are developing several kinds of guidelines. First, in partnership with U.S. and Haitian engineers, we have compiled a list of design criteria for Haiti, available on our website. It includes a list of applicable codes and guidelines, sources of materials, unit costs and strengths, and architectural criteria, such as ways to ensure that a covered porch will resist both wind and earthquakes.

Second, we are working in partnership with the Ministry of Public Works, Transportation, and Communications to improve the guidelines for repairing damaged houses and to develop new guidelines for the five specific building types that are most common in Haiti:

1. Confined masonry (single- and two-story houses with timber, lightweight steel and reinforced concrete cast-in-place roof options)
2. Reinforced masonry (single- and two-story houses with timber, lightweight steel and reinforced concrete cast-in-place roof options)
3. Timber frame with various wall options (single- and two-story houses made of masonry, earth, plastered wire mesh, plastered bamboo mat)
4. Two- and three-story mixed-use buildings, with ground floor for shops and upper floors for residential use (structural system to be suggested in the analysis)
5. Retrofitting (strengthening) of damaged one- and two-story confined concrete block masonry.

Third, we are developing two sets of resources for different audiences. For donor-driven reconstruction, the detailed engineering plans include a set of generic floor plans, with complete bills of quantity, construction quality checklists, and technical specifications, in case donors want to mass produce similar houses for everyone. For homeowner-driven reconstruction, the set of design rules and component drawings can be applied to a variety of floor plans, plot sizes, cultural and architectural preferences, and budgets, and they include simple ways to estimate costs and quantities in the field.

Step 3: Build Local Capacity

Haiti presents an enormous opportunity—and need—to build capacity while providing job opportunities. Build Change is working in partnership with local institutions such as the Institute of Professional Training and IDEJEN to improve existing training courses by adding modules on earthquake-resistant design and construction. In addition, we are partnering with relief and development organizations to train construction personnel and place them in apprenticeships and income-earning reconstruction jobs.

Like a house and the implementation model, a successful builders' training program that produces permanent skills improvement and lasting change in construction practice is a matter of technology, money, and people.

Technology: The best training courses for builders keep it simple and follow up with on-the-job training.

People: For the trainers, we are using local professionals to train local builders. This is the best way to develop local capacity, and to ensure that only locally sustainable materials, skills, and tools are used. Build Change is hiring Haitian technical professionals, who will deliver the training courses.

For the trainees, we target workers who were already in the construction sector before the disaster and are committed to staying in it for the long term. We find those folks simply by asking in the neighborhoods and by recruiting trainees who have already invested their time and money in a training course by another agency.

It is crucial to target the right group. There is always a push to train engineers, but the key is to train the builders and trade school graduates, as they will be the ones involved in housing construction. Engineers see no money in it, they like to build commercial buildings, and they often have a hard time designing a simple house without a building code or standard to follow.

Money: We will attract the most dedicated trainees by charging people to come to the training, consistent with training programs in place in Haiti prior to the earthquake.

Step 3 also involves building the capacity of building materials producers to produce better quality materials. Concrete blocks are widely used for construction in Haiti; but their quality is inconsistent. We are working in partnership with the national lab to check materials strengths and develop simple methods for assessing materials quality in the field.

Step 4: Stimulate Local Demand

The earthquake itself increased the demand for safe housing; before it happened, few homeowners, builders, engineers, or government officials in Haiti were aware of the seismic risk. But now, people know. In March we met a group of residents on the edge of Leogane who were building a new single-story building for a water-treatment facility. They were using the same materials used to build so many of the collapsed buildings—concrete blocks, steel, concrete—but they had made some significant improvements, such as using reinforced concrete confinement around the walls, windows, and doors. It wasn't perfect, but it was a start. They opted for a lighter timber-truss roof, which is a positive step toward earthquake safety but will present a challenge during hurricanes unless the roof is properly connected to the walls. As we were looking at this building, the builders and local residents gathered around us with questions about construction details and quality. These residents had seen what the earthquake had done to poorly constructed buildings and were already taking steps to build back better with their own funds and their own skills. They just needed a little more information and technical expertise in order to do so. These residents are ideal candidates for the homeowner-driven reconstruction model: hiring and training local professionals to work with the homeowners to design and build better buildings.

A key to stimulating demand is mass marketing—getting the word out—and one key piece is a poster, mentioned earlier and available on our website, that lists six ways to build a stronger house for Indonesia. These points also apply to Haiti.

1. Build from timber instead of masonry. If you build a masonry house, build confined masonry (don't build unreinforced masonry). At least put a ring beam on top of your walls. Haitians may find it hard to build from timber because so little is available, and people prefer masonry. But it still has to be confined, and it still needs a ring beam.
2. Don't build your gable wall from masonry, build it from timber or use a hipped roof. In Haiti, use a lightweight roof and connect it to the walls. If you build a reinforced concrete roof, make sure to follow rules for steel detailing and construction quality.
3. Build a good, strong masonry wall by filling the joints between bricks (or blocks) completely with mortar, using enough cement in the mortar and soaking the bricks (or blocks) before building the wall.
4. If you prefer to have many large windows and doors at the front of your house, put reinforcement over them.
5. Connect the confining elements together properly.
6. Connect the wall to the confining elements.

Stimulating demand through working with donor agencies and government officials, as we have shown in China, is also a powerful way of building back better.

Step 5: Facilitate Access to Capital

Without sufficient funding, a trained builder and an empowered homeowner will still not be able to build a safe house. Estimates of the cost to rebuild a disaster-resistant house in Haiti range widely, from $3,500 to over $20,000. Build Change is working in partnership with donors and other implementing agencies to prove that the homeowner-driven model will work, and to identify the price point at which a homeowner can combine their own resources with donor funding to achieve a house that is safe, satisfactory, and sustainable.

Step 6: Measure the Change

Checking construction quality as the house is being built is one of the easiest ways to confirm that building standards are met. Build Change's simple inspection checklists are available on our website and are being revised for use in Haiti. We are working in partnership with other organizations to streamline this system by collecting and transmitting data on a handheld device.

Based on all these experiences, we have a list of recommendations about the homeowner-driven approach that we hope will be helpful in Haiti for donors, relief agencies, and the government.

RECOMMENDATIONS FOR HAITI'S RECONSTRUCTION

Lessons from Step 2: Research and Design for Earthquake-Resistant Houses

- Release clear, complete, consensus-based guideline(s) for each common structural system.
- Give people, and agencies, options. Be flexible about the structural system. Do not dictate the type of structure or layout; instead empower homeowners to choose and establish a set of criteria that each structure should meet.

Lessons from Step 3: Build Local Capacity

- Train everyone on the construction value chain—builders, engineers, site supervisors.
- Work with materials suppliers in the private sector to facilitate access to common materials.
- Provide hands-on technical assistance and/or building inspectors. Consider finding a third party to check construction quality. Distributing flyers and holding classroom-type seminars can help but is not enough.

Lessons from Step 4: Stimulate Local Demand

- Require homeowners to meet minimum standards in order to receive financial assistance.
- Require agencies that intend to build houses to meet some minimum qualification for technical competency and internal controls.
- Require all building projects to have at least three independent parties: owner, contractor, and designer/inspector.

Lessons from Step 5: Facilitate Access to Capital

- Be clear about when funds will be released. Stick to the commitment, but do not overcommit. There are several options:
  – Provide grants in installments, contingent on construction quality.
  – Provide access to loans, with some incentives for good quality reconstruction.
  – Provide an incentive bonus. For example, if building to the top of the wall meets a minimum standard for safe construction, then the homeowner receives an extra small cash grant and/or a specified but limited amount of materials.

- Don't rush it. Give people time to get back on their feet economically. Once they have a stable income and job, they can contribute more to building a permanent home.

Lessons from Step 6: Measure the Change

- Make it easy for agencies to monitor and report on their work.
- Consider using handheld or automated systems.

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6. See http://www.time.com/time/subscriber/2004/time100/scientists/100desoto.html; accessed September 20, 2010.
7. See www.antaranews.com/en/news/1255472809/number-of-fatalities-in-w-sumatra-quake-now-1-115.
8. We assume that 50 percent of the 135,000 homes will be rebuilt, and of those, 85 percent will be built with walls of timber frame and a masonry skirt.