Homeowner-Driven Housing Reconstruction and Retrofitting in Haiti

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Lessons Learned, 4 Years After the Earthquake

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build change

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Executive Summary

Build Change and project partners Cordaid, J/P HRO, CAFOD, and the French Red Cross have been building permanent new housing and seismically retrofitting existing housing stock in Haiti. These projects were among the first completed, permanent housing solutions in Haiti after the January 12, 2010 earthquake. **More than 1,330 buildings have been retrofitted or built new, enabling 1,580 families, or 8,150 people to live in safer homes.** Given the 18,500 housed with committed donor funding to be built or retrofit in Haiti[1], this paper presents a summary of lessons learned to date with the intent of influencing the implementation of future post-disaster housing reconstruction programs in Haiti and elsewhere.

Most programs included in this report have been implemented using a homeowner-driven reconstruction approach (HODR or ODR), building upon Build Change's experience in implementing similar new housing programs in Indonesia and China. This approach is more fully described in other resources by Build Change and others[2]; in short, with technical assistance, the homeowner makes decisions about materials and architecture, hires the builder, and procures building materials with funding provided in installments.

Appendix 1 includes steps for project implementation. Appendix 2 contains a summary of the Build Change retrofit evaluation, design, and implementation procedure, using our locally hired and trained staff. During the implementation of the first retrofit projects, many interesting lessons were learned. The process was filled with improvements to account for field realities that hadn't been foreseen and recognition of successes beyond what had initially been anticipated.

Build Change believes that the post-disaster housing reconstruction environment is an opportunity to build disaster-resistant housing and change construction practice permanently so that people continue to build safe houses in the future. We encourage comments and questions on the content in this paper.

Some of the key lessons are as follows:

1. HOMEOWNER-DRIVEN APPROACH

1.1 Homeowners Can Provide Inputs on Retrofit Solution, Which Leads To Greater Homeowner Satisfaction, Participation, and Livelihood Recovery.
1.2 Owner-Driven Approaches Put Money Back in to the Local Economy.
1.3 Retrofitting Puts Rental Properties Back on the Market.
1.4 The Owner-Driven Approach Can be Used for Neighborhood Improvement Projects.

[1] Inter-Agency Standing Committee Haiti E-Shelter/CCCM Cluster & Unité de Construction de Logements et Bâtiments Publics, "Fact Sheet October 2013"; http://www.eshelter-cccmhaiti.info/jl/images/fact%20sheet%20-%20uclbpcluster%20cccm-shelter%20-%20oct%202013.pdf

[2] See Hausler, Elizabeth, "Earthquake-Resistant Houses in Haiti: the Homeowner-Driven Model", *Innovations*, Vol. 5 Issue 4 (Fall 2010); Build Change, "Building Back Housing in Post-Disaster Situations – Basic Engineering Principles for Development Professionals: A Primer" (January 2012); and Build Change, "Basic Engineering and Construction Management: A Primer (December 2010). Two additional Primers addressing basic engineering principles for seismic retrofit in post-disaster situations and site hazard mitigation in post-disaster situations will be released shortly.

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These are powerful lessons, and are applicable to any post-disaster reconstruction program anywhere in the world. Build Change is working now to ensure that these lessons are incorporated into our strategy for dealing with post-disaster reconstruction projects in the future, and we want to share what we have learned so that other organizations can do the same and learning becomes a shared effort with amplified results.

Construction of new housing has been more straightforward than retrofitting, but here, too, there were challenges and lessons to learn, often related to the tightly limited budgets for new housing construction but also due to at times surprising homeowner preferences and frustrating material quality and construction practice inadequacies.

Program Summary Data

More than 1,330 buildings have been retrofitted or built new, enabling 1,580 families, or 8,150 people to live in safer homes:

Location	Partner	Red Retrofits	Yellow Retrofits	New Buildings	Total	Families	People
Villa Rosa, Tisous, Nan Cocteau	Cordaid*	394	462	197	1,053	1,053	5,820
Delmas 32	J/P HRO – WB*	0	43	0	43	97	485
Delmas 32	J/P HRO – CBHF/IDB	0	125	0	125	307	1,219
Delmas 9-13	French Red Cross - IFRC	0	28	1	29	29	191
Delmas 9-13	French Red Cross - EU	0	5	8	13	26	85
Tisous	CARE	0	10	0	10	10	50
Bristout-Bobin	UNOPS	0	1	0	1	1	5
Duval (Kenscoff)	CAFOD / Caritas Haiti	0	0	40	40	40	200
Jacmel	CAFOD / Caritas Haiti	0	0	20	20	20	100
Totals		**426**	**521**	**258**	**1,334**	**1,583**	**8,155**

Table 1: Number of completed red retrofits[3], yellow retrofits, and new buildings and numbers of people living in the buildings

*For the purposes of this paper, data analysis is derived from the first two projects listed on the table. These projects were implemented from mid-2011 until the end of 2012.

It is important to note that the presented figures are derived from more than 1,000 data points collected in four informal neighborhoods of the greater Port-au-Prince. As a result, these averages paint a very accurate picture of the distribution of houses in the neighborhoods in which we worked, but also of the overall conditions encountered in informal neighborhoods of Port-au-Prince.

Size: In the retrofit program, 44% of the red-tagged buildings are less than 25m^2, 37% are between 25m^2 to 50m^2, and the remaining 29% are greater. For yellow-tagged houses, 15% are less than 25m^2, 40% are between 25m^2 to 50m^2, and the remaining 45% are greater. See Figure 1.

Number of stories: Nearly 70% of the buildings are single story. Over 20% are two-story and a few are three-story.

Average household size: The most common household size is five persons, with households ranging from one person to over 11 people.

[3] After the earthquake, damaged buildings were tagged by Ministry of Public Works (MTPTC) engineers with the help of foreign engineers, using the methodology of the Applied Technology Council's Procedures for Post-earthquake Safety Evaluation of Buildings (ATC 20), using colors to designate the safety of the building for immediate reoccupancy. Red=Unsafe, Yellow=Restricted, Green=Inspected. Because this tagging had been carried out, it was erroneously decided that the tagging system should designate which houses should be torn down and rebuilt ("reds") and which should be retrofitted or repaired ("yellows"). From the appendix of ATC 20: "It is very important to understand that the 'red tag' Unsafe posting does not automatically mean that the property has been condemned or will require demolition. Indeed, rarely is damage so severe or the threat to either an adjacent property or important right-of-way so high that an order to demolish a building is issued."

Cost: Average cost for materials and labor for a red retrofit was just over $3,000 for average size of 55m^2. For new construction, the average cost was $3,500 for 18m^2. SeeTable 2* and Figure 2.

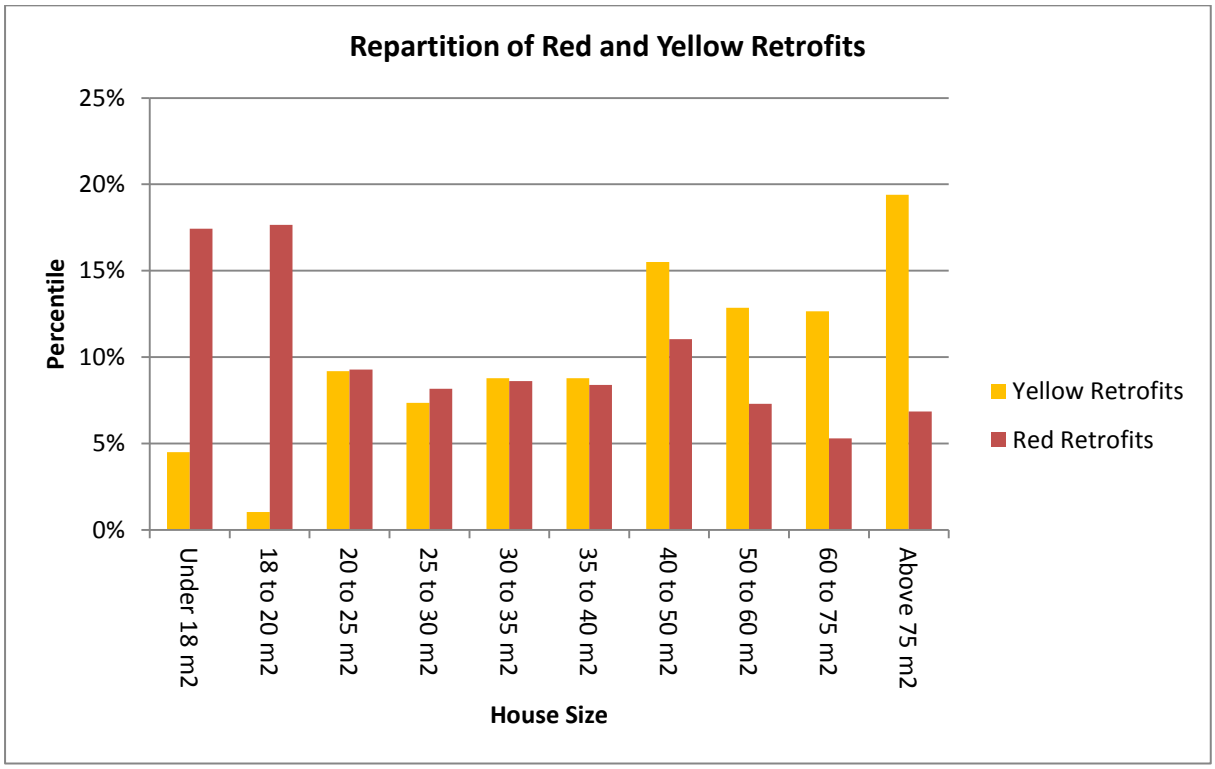

Figure 1: Repartition of yellow and red retrofits per house size

Red Retrofits			Yellow Retrofits			New Construction		
Avg (m2)	$US/m^2	Cost ($US)	Avg (m^2)	$US/m^2	Cost ($US)	Avg (m^2)	$US/m^2	Cost ($US)
36	**126**	**3,226**	**55**	**67**	**3,061**	**18**	**193**	**3,500**

Table 2: Retrofit and New Houses: Average size, cost per square meter, and total cost (based on design packages & BOQs)

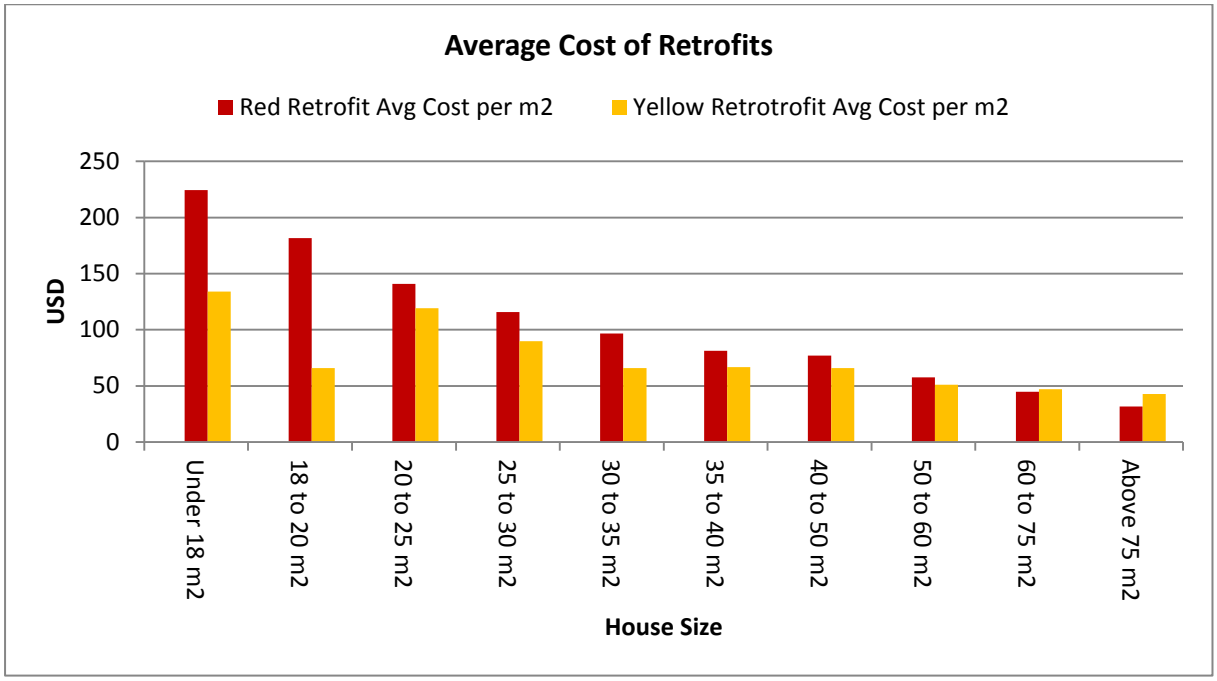

Figure 2: Average m2 Cost of Retrofits per category

1. Lessons on Homeowner-Driven Approach

1.1 Homeowners Can Provide Inputs on Retrofit Solution, Which Leads To Greater Homeowner Satisfaction, Participation, and Livelihood Recovery.

The retrofit procedure provides a range of possible solutions for the homeowner, such as tearing down a damaged wall and replacing it, adding new walls, plastering a weak wall, adding reinforced concrete tie columns and bond beams, infilling windows to add length to shearwalls, and repairing or providing connections between structural elements. The design process involves the homeowner and addresses her priorities for space, light, ventilation, and security. Through this process the homeowner is empowered to make informed decisions that meet the needs of her family. This empowerment leads to a much greater level of homeowner "buy-in," which engages the homeowner at the level required for her to supervise the retrofit of her home.

This is one of the cornerstones that drive the success of the homeowner-driven approach; similar lessons have already been learned about enabling the homeowner to choose materials and architecture for new construction.

The most common input provided by homeowners about the proposed retrofit solution for their house is the request that windows not be filled and the selection of walls to be thickened instead.

The second most common input is to ensure that an area of the house (unusually the porch or the very first room) is open enough to permit operating a small home-business (beauty salon, sewing or tailoring business, convenience store, construction materials store).

1.2 Owner-Driven Approaches Put Money Back in to the Local Economy.

100% of homeowners purchased their materials from a Haitian materials provider. When comparing retrofitting to the construction of T-Shelters the difference becomes much more striking: It is estimated that of the $500 million spent on T-Shelters for Haiti, 80% was spent outside of Haiti, for the purchase and transport of materials[4]. This $400 million spent abroad is almost double the total investment on permanent reconstruction in the first three years after the earthquake ($215 million[5]). Obviously spending money for materials in Haiti develops local technical and economic capacity, and saving money on transport reduces environmental impacts and makes more funds available for reconstruction.

ODR's reliance on domestic materials providers encourages Small and Medium Enterprise (SME) development, and from a livelihood and neighborhood development perspective these statistics compare favorably to donor-driven models, where for ease of logistics materials are typically purchased from the fewest big suppliers possible. This situation can specifically be illustrated by the following experience:

[4] Adrian, Jean-Christophe, "Urban Resilience"; http://www.urd.org/Urban-Resilience?artpage=2-4

[5] Sontag, Deborah, "Rebuilding in Haiti Lags After Billions in Post-Quake Aid", *New York Times*; http://www.nytimes.com/2012/12/24/world/americas/in-aiding-quake-battered-haiti-lofty-hopes-and-hard-truths.html?pagewanted=1&_r=0&ref=deborahsontag

In the Greater Port-au-Prince neighborhood of Nan Cocteau (Carrefour), a local community member went into the business of selling gravel in the neighborhood as demand had been fueled by the construction of 50 ODR houses. Build Change tested the concrete made from this gravel, and after finding it adequate for earthquake resistant construction, allowed its inclusion on worksites in the neighborhood.

1.3 Retrofitting Puts Rental Properties Back on the Market.

"Room for rent" signs are now appearing on retrofitted buildings in Tisous and Villa Rosa. The exact number of units and people accommodated by such units is not certain at this time. Informal surveys of the initial phase of Villa Rosa show that homeowners are now building, with their own funds, second stories on houses that were retrofit by Build Change early in the project. Many of these additions have already or will become rental units[6].

At the beginning of our retrofit experience in Haiti we encouraged the use of light weight wood-framed roofs. From an engineering perspective this made sense because it avoided the seismic load of an elevated concrete slab. However, we soon realized that most people will add a story to their house when they have the means to do so, particularly in a dense neighborhood like Villa Rosa where lateral expansion is almost never an option. We changed our methodology so that every retrofit design could accommodate the addition of one more story without compromising structural integrity. We also began encouraging homeowners who wanted a concrete slab roof to do it as part of the retrofit of the lower floor(s), with our design and construction supervision support.

Densification is a difficult but necessary goal in urban reconstruction. In Port-au-Prince it has largely been left unaddressed during the humanitarian and early reconstruction phases. By including the addition or provisions for future addition of one story to every structure retrofitted this dilemma can be confronted much sooner. Poor, dense urban environments are usually low-rise to begin with, so the addition of one story to as much as possible of the existing residential stock actually represents a large densification effort as a percentage of housing extant pre-disaster.

1.4 The Owner-Driven Approach Can be Used for Neighborhood Improvement Projects.

The Villa Rosa neighborhood improvement project (funded by Cordaid) successfully demonstrated that retaining walls (sometimes large enough to support several houses), pathways, drainage channels, and other public infrastructure such as benches and public squares, can all be funded and upgraded in an owner-driven manner. This was done by asking neighbors to select one representative among themselves to be the recipient of all tranches of funding related to non-housing projects. It is promising that no case of fraud (fund recipient taking the money and not delivering the public good) was observed, which demonstrates that the group pressure exerted by neighbors is a very good compliancy watchdog. Donors can use this mechanism, coupled with the tranche distribution system, to invest securely in neighborhood projects where the dollar amounts are quite large.

[6] It is important to keep this within the wider context of rental subsidies being distributed to IDPs throughout the earthquake affected area, indirectly fueling the construction sector to meet subsidized rental housing demand with swift supply.

1.5 Land Ownership Issues Can be Satisfactorily Overcome.
Whenever possible, homeowners who can prove ownership do so, by displaying land ownership documents. This remains a rare occurrence among the homeowners with whom Build Change has been working thus far, since ninety-three percent of the houses which received technical assistance are located in informal neighborhoods. For the vast majority who cannot prove ownership, a community testimony is organized by NGOs working in the area. This procedure consists in obtaining a declaration signed by at least three neighbors stating that the homeowner in question was living in the house before the earthquake.

Problems related to proof of land ownership can be a significant setback to housing reconstruction programs. Retrofitting provides a major advantage over new construction in this context, because most often a family is living in the damaged house and the testimony system is straightforward. For new construction the process is more challenging, as the land is generally unoccupied and the owner must be found. Quite often the land is occupied by squatters in makeshift housing, presenting competing claims to ownership.

1.6 Owner-Driven Reconstruction can Introduce Disadvantaged Segments to the Banking Sector.
Several different methods were used by Build Change's partners to deliver funding tranches to the beneficiaries. The most successful of these, implemented in Delmas 32 in partnership with J/P HRO with funding from the Clinton Bush Haiti Fund, involves creating joint accounts between the beneficiary and the partner agency whose task it is to disburse subsidy tranches. The account is opened at a local Fonkoze branch into which the funds are disbursed in tranches.

This set-up provides many advantages:

- Beneficiaries no longer have to take the security risk of having large amounts of cash with them.
- The partner agency can freeze the account until work that did not meet standards was corrected, thus increasing leverage on homeowners.
- It introduces a population that is either unfamiliar or untrusting of the banking system to the banking sector in a beneficial way. And homeowners can keep their accounts solely in their own name after the project was complete.
- The cost of wiring each tranche to the homeowner is relatively low ($1 to $3).

2. Lessons on Cost

2.1 The Cost of New Construction is Consistent with Previous Estimates.

The most common new houses supervised by Build Change were 18.5m^2 in area and cost $193 per square meter, for a total labor & materials budget of $3,500[7]. An informal survey of construction costs for these small houses built during the same period (2011-2013) by other organizations showed that Build Change houses were at the low end of the range, which runs approximately from $200-$400 per square meter. New housing designed and supervised by Build Change also compares favorably to the cost of building transitional shelters ("T-Shelters") whose average cost is close to $250/m^2[8]. These new houses are permanent solutions, designed not only to last many years, but to survive future earthquakes. By contrast, the useful life of a T-Shelter is predicted to be 3-5 years[9].

2.2 Retrofitting is Cost Effective When Compared to New Construction and Transitional Shelter.

The average cost per square meter to retrofit a yellow-tagged house was $67. The average cost per square meter to retrofit a red-tagged house was $126. One of the immediate benefits of retrofitting existing stock over building new is that buildings that are still standing and dangerous, and often have people living in them anyway, are made safe in a cost effective manner.

For red-tagged houses the cost to retrofit was less than half that of equivalent new construction and for yellow-tagged houses it was less than one third! These savings are significant, allowing two to three times as many people to be housed under a safe roof for the money invested.

Seismic retrofit of existing housing represents a huge economy over the construction of T-Shelters. On a per square meter basis, retrofitting yellow-tagged houses costs just over a quarter of what it costs to build T-Shelters, while retrofitting red-tagged houses costs less than half the cost of building T- Shelters. This calculation only considers initial cost and does not account for the useful life of the structure. On a life-cycle basis retrofitting is even more of a bargain.

[7] $3,500 is based on a bill of quantities produced in late 2011. In early 2013, due to inflation Build Change revised its estimated costs in its bill of quantities, and the same housing model cost approximately $4,100.

[8] According to Priscilla Phelps, housing adviser to the now-defunct Interim Haiti Recovery Commission and one of the chief authors of *Safer Homes, Stronger Communities: A Handbook for Reconstructing After Natural Disasters*, which was compiled by the World Bank just before the earthquake, over $500 million has been spent on T-Shelters (http://www.nytimes.com/2012/08/16/world/americas/years-after-haiti-quake-safe-housing-is-dream-for-multitudes.html?pagewanted=1&_r=1&smid=tw-share). According to UCLBP, the Shelter Cluster co-operation between NGOs and the Haitian government, 110,964 T-Shelters had been built by November 2012. $500 million / 110.964 = $4500 per T-Shelter. $4500 / 18m^2 = $250/m^2. This estimate is conservative, despite NGO claims that T-Shelters cost between $2,000 and $3,000. Elsewhere Phelps claims that the real cost is probably between $6,000 and $10,000 (http://www.thenation.com/article/170929/ngo-republic-haiti).

[9] H. Kit Miyamoto, http://www.nytimes.com/2012/08/16/world/americas/years-after-haiti-quake-safe-housing-is-dream-for-multitudes.html?pagewanted=all&_r=0

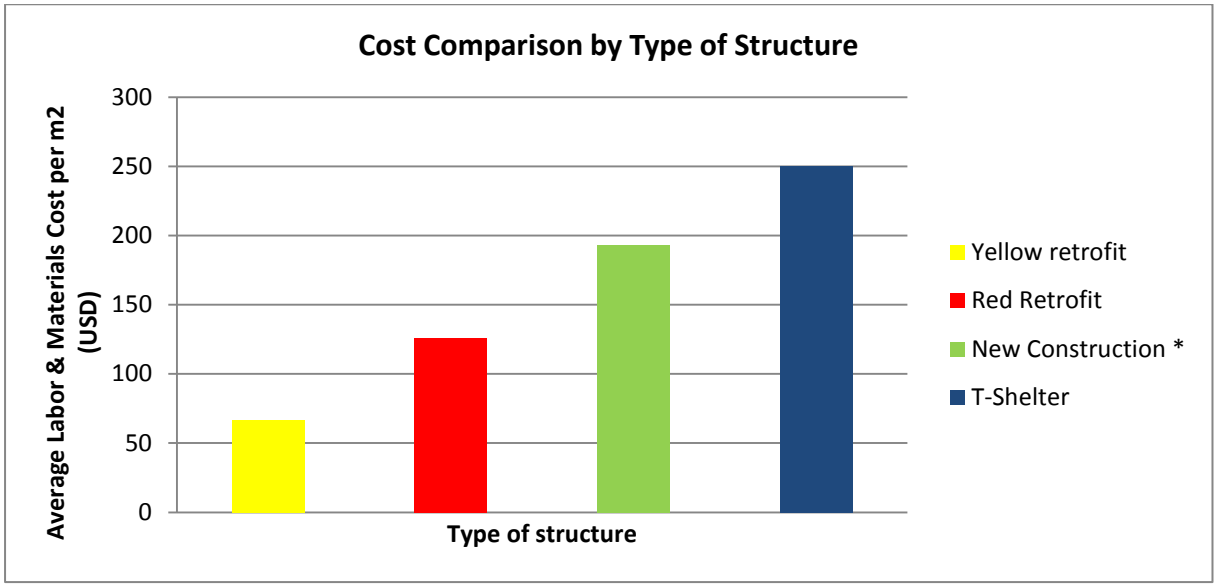

Figure 3: Cost Comparison between retrofits, new construction, and T-Shelters

* ODR new construction implemented under Build Change technical assistance.

2.3 House Reconstruction Budgets Should be Assigned by Family Rather than by Structure.

In early projects where budgets were assigned by the funding partner on a per-house basis, larger structures often could not be addressed because the budget was insufficient. These larger structures often housed multiple families. In later projects funding was allocated on a per-family basis, meaning that many of these larger structures could be addressed. This translates directly to more people under safe roof at the end of the project.

Let us compare yellow retrofit cost vs house size data from two different projects:

- Villa Rosa (Cordaid), with subsidies of up to $1,500 per house;
- Delmas 32 (J/P HRO – Word Bank), with subsidies of up to $1,500 per family;

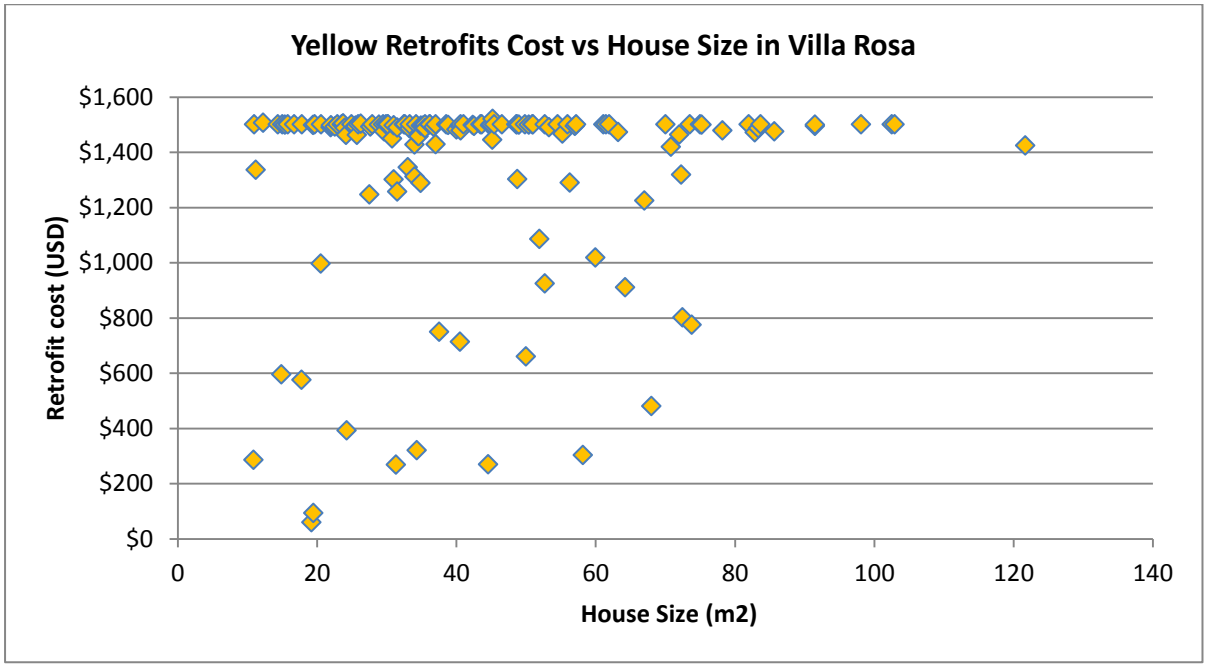

Figure 4: Villa Rosa - Yellow retrofit Cost vs House Size

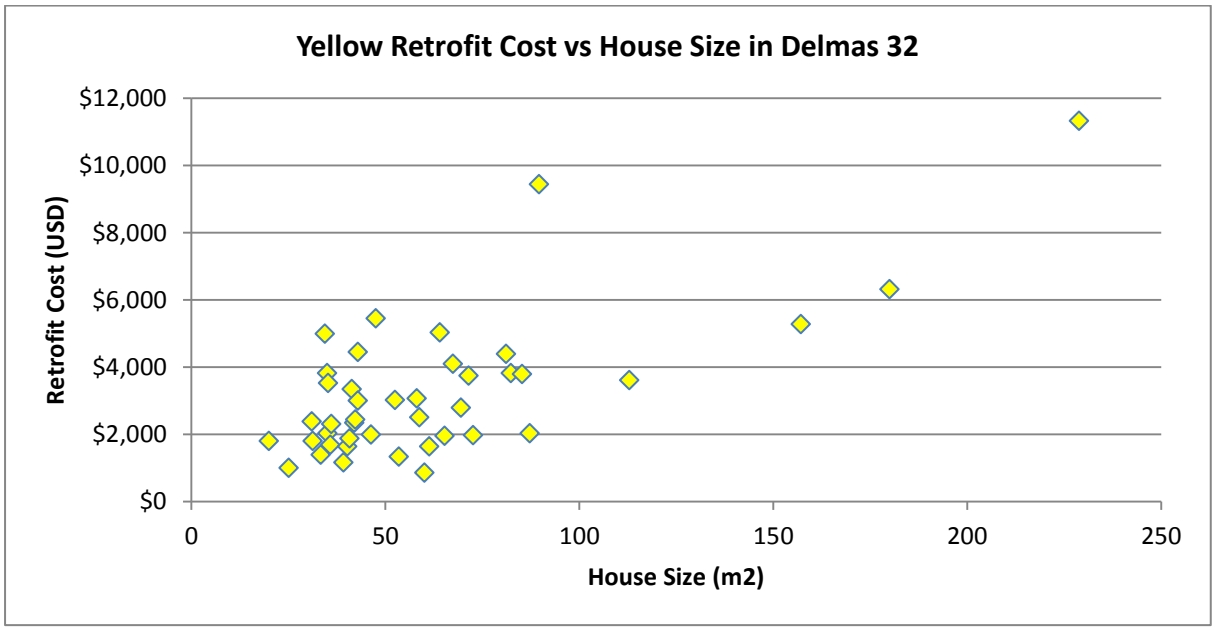

Figure 5: Delmas 32 - Yellow Retrofit Cost vs House Size

In the neighborhood of Villa Rosa, capping the subsidy at $1,500 per building resulted in the great majorities of bills of quantities to be calibrated at or around $1,500. This could only apply to structures that could technically be retrofitting for $1,500 or less, and resulted in 70% of the houses being smaller than 50m^2.

In Delmas 32, on the other hand, the per family subsidy permitted that 50% of the building retrofitted be greater than 50m^2, which is much in line with the overall distribution of yellow house size we encountered across all neighborhoods we work in.

2.4 How Much Does Homeowner-Driven Reconstruction Really Cost?

The total cost of the homeowner-driven reconstruction projects implemented in Haiti includes of the following:

A- Labor and materials subsidies to homeowners;

B- Technical assistance, including design services, homeowner awareness, on-the-job training, selection of quality materials, and site supervision (in this case provided by Build Change);

C- Beneficiary selection, community outreach, and tranche disbursement (in this case provided by partners such as Cordaid and J/P HRO);

In Haiti, Build Change's technical assistance services (B) have consistently ranged around $2,000 per house/family, while direct subsidies to homeowners (A) have averaged at $3,200 (retrofits and new construction).

The cost of activity (C) has proven the hardest to track, as it consists of cost of activities undertaken by partners involved in broader neighborhood improvement projects, whose full scope is very much neighbourhood and partner specific, and of which ODR was only one segment. It has therefore proven easier to look at specific projects, to shed light on the relative weights of (A), (B), and (C), rather than relying on broad averages.

Let us look at the specific example of the J/P HRO-World Bank "Helping People Home" project to retrofit yellow houses for 100 families in Delmas 32 (2012):

Activities		Cost per Family	
A	Direct Cost (labor and materials subsidy to homeowners)	$ 2,183	39%
B	Build Change Technical Assistance (design, training, supervision)	$ 1,948	35%
C	J/P HRO (project management, beneficiary selection, community outreach, tranche disbursement)	$ 1,465	26%
TOTAL		**$ 5,596**	**100%**

Table 3: Example Cost Breakdown of ODH Project (J/P-HRO/World Bank, Delmas 32)

As we can see, these costs are in line with donor-driven reconstruction standards, while donor-driven deliverables do not include such capacity elements as on-the-job training and homeowner awareness.

2.5 Owner-Driven Reconstruction Unlocks Financial Contributions from the Homeowner.

In the broad majority of cases homeowners have contributed their own funds to the reconstruction or retrofitting of their house. Homeowner investment represents leverage on donor funds: more can be done in a neighborhood for a given amount of donor money.

It is important to distinguish between two types of homeowner contributions: non-structural and structural contributions.

Non-structural contributions are most common and can be found in just about every owner-driven construction. For both new construction and retrofit homeowners took pride in their newly reconstructed houses, and late in the process were willing to contribute their own money for exterior plaster[10], decorative plaster, windows and doors, electrical wiring, and other items not included in the basic new house package or retrofit scheme. Such contributions do not occur all at once, but rather occur incrementally over time, during construction and also after the work is complete. As such, the dollar value of non-structural contributions increases over the months and years. This allows new construction and retrofit design to focus donor dollars on required structural elements and leave important but non-essential items to the homeowner on her own schedule.

Structural homeowner contributions, on the other hand, must be contributed at once while construction work is ongoing. For new construction homeowners often contributed money early in the process to expand the footprint of the new building, understanding that this was an investment that needed to be made at the foundation stage.

In 2012, such structural contributions occurred in 5%[11] of the instances, and ranged from $250 to $1,000. In the case of new construction, the most common structural contribution was the addition of $600 to the $3,500 subsidy to turn an 18.5m^2 house into 30m^2. In the case of retrofits, the most common contribution was to change a light-weight roof into a slab. This contribution ranged from $250 to $1,000 depending on the size of the slab. It is important to note that homeowners who make structural contributions also make non-structural ones.

[10] For new construction design based on 4.8MPa concrete blocks, Build Change requires structural plaster on one side of each wall at the time of construction. Build Change adds structural plaster to existing walls as a retrofit solution on an as-designated basis.

[11] In 2013, structural contributions accounted for 15% of houses addressed in our projects.

3. Lessons on Design and Construction Quality

3.1 In the Absence of Fully Developed Building Codes, Design Procedures Can Be Developed Using Simplified, Locally Applied International Standards.

Seismic retrofit of existing buildings was a new program for Build Change. With the help of Degenkolb Engineers, an American seismic and structural engineering firm and an authority on the evaluation and retrofit of structures using ASCE 31 & 41, a retrofit methodology for Haiti was created. The provisions of ASCE 31 & 41 were simplified and targeted at typical Haitian masonry construction[12].

3.2 Compliance with Minimum Standards for Earthquake Safety is Higher when Funding is Distributed in Tranches, and when the Last Tranche remains Relatively Important.

The number of houses which do not meet minimum standards for earthquake resistance, out of to the number of sites supervised to completion or near completion by Build Change, is just under five percent.

Subsidy disbursements to homeowners must be designed is such a way that site supervisors maintain leverage on the builders and the homeowner until the construction is complete. Based on the results of various arrangements tried, Build Change recommends that subsidies be disbursed in a minimum of three tranches and that the last tranche be at least fifteen percent of the total cost of labor and materials, and be given after full completion of the works.

In some neighborhoods, two factors did not enable continued leverage on the roof finishing, and resulted in fourteen percent of completed houses not being fully hurricane-resistant: First, in many cases, homeowners received the subsidy in two rather than three tranches; and second, in the case of three tranches, the 60%/35%/+5% on completion three-tranche system did not enable the supervising engineer to maintain adequate leverage to ensure that the roof was finished as designed. In other words, homeowners could save more than the five percent tranche by building the roof wrong, so they often did and forfeited the final tranche.

Another arrangement that has worked very well is to hold back a percentage of the labor, to be paid upon completion. This approach has been implemented in the latest J/P HRO-Clinton Bush Haiti Fund funded project in Delmas 32 in the following way: a minimum of four tranches where all but the last tranche account for materials and labor, while the last tranche consists of labor payment withholdings. Approximately 25% of the labor amount corresponding to each previous tranche is withheld and paid to the head mason in a final payment that occurs once the entire job is completed. This system allows for more leverage on the final stages of implementation.

[12] The retrofitting resources created by Build Change and Degenkolb were approved by Haiti's Ministry of Public Works, the Ministère de Travaux Publics, Transports et Communications (MTPTC), and are included as a technical appendix to the MTPTC's Retrofit Guide, which was published in January 2013.

4. Lessons on Training and Disaster Risk Reduction

4.1 Engineers can be Trained to Implement a Streamlined Retrofit Evaluation Procedure.

Local engineers should be trained as quickly as possible to implement ATC 20 evaluations and simplified retrofit evaluation procedures. Building the capacity of local construction professionals is a critical step in reaching scale with homeowner-driven retrofit programs.

4.2 Owner-Driven Approaches Facilitate On-the-Job Training of Builders.

Through the implementation of owner-driven retrofit and new construction programs, Build Change has provided on-the-job training to 200 builders. The most common shortcomings in skill levels of the builders employed in the reconstruction projects have to do with connections, inconsistent and inadequate concrete mixing and pouring, and block laying. In the four-day training courses Build Change conducted, builders were taught the basics of earthquake- and hurricane-resistant construction and were given the chance to practice proper building techniques. However, it was the on-the job training by Build Change supervising engineers during actual construction that really made the difference. We quickly came to realize that it is not sufficient to *tell* a builder how to do it correctly; he must be *shown*, and sometimes more than once. ODR provides the perfect opportunity to do this. The distribution of funds in tranches incentivizes the builders to pay attention to and learn from on-the-job training.

On-the-job training is one of the best ways to maximize the indirect impacts that a reconstruction program can have. Build Change has the stated goal of changing construction practice permanently in areas where it is clearly substandard. On-the-job training helps reach this goal both directly and indirectly. The direct benefits are that the builder is trained to build correctly and the house is built correctly so that it is safe. The indirect impacts are that the builder will continue to build houses using what he has learned after the donor is gone, he will train those who work for him in the future to build correctly, and others in the neighborhood see a correctly-built house and hopefully see the construction process. These indirect impacts are difficult to monitor qualitatively as well as quantitatively, but they can be extremely far-reaching.

Based on extensive technical observations conducted by Build Change after the January 2010 earthquake, low quality workmanship was established as a common factor in houses that suffered the most damage and collapse. With the objective of improving construction quality through improving builder skills, Build Change has continuously provided on-the-job capacity development in all of its projects.

While the skill level of builders in Haiti is extremely varied, the skillset of builders in the neighborhoods in which Build Change works is considered well below international and earthquake-resistant standards.

The following table, referring to a 6-month retrofit project implemented in partnership with the French Red Cross, compares the number of builders with a pre-existing and specific practical skill vs. the number of builders with the same specific skill after receiving on the job training. Although this table is relative to one project only it has been observed to be representative of the level builder skills in all other Build Change projects in Haiti.

Specific Skill Description (Builders are considered skilled when each specific activity is completed habitually up to Build Change Earthquake Resistant Standards)	Builders with Observed Preexisting Skill (out of 48)	Builders with Verified New Skill After On the Job Training (out of 48)	Total Builders with Skills Upon Project Completion (out of 48)
Practical competence in site selection and set up:			
A1 Verifying the site slope and setting foundation levels.	0	0	0
A2 Determining right angles by using the 3,4,5 method or measuring diagonals.	0	0	0
A3 Testing soil to determine the required depth of the foundation .	0	0	0
Practical competence in steel detailing:			
B1 Cutting, bending and correctly installing rebar stirrups.	2	19	21
B2 Cutting, bending and correctly overlapping steel connections.	5	16	21
B3 Assembling a correct connection between columns and beams.	7	13	20
Practical competence in the production and use of concrete:			
C1 Using the correct concrete ratios and mixing methods.	2	17	19
C2 Making and installing concrete spacers.	4	16	20
C3 Vibrating concrete well during pouring.	4	16	20
C4 Properly curing concrete after pouring.	8	11	19
Practical competence in masonry work:			
D1 Using the correct mortar ratios and mixing methods.	3	4	7
D2 Building a good stone masonry foundation wall.	1	1	2
D3 Constructing a block wall with overlapping blocks and adequate joint size.	3	15	18
D4 Ensuring a good connection with toothing between the columns and walls.	4	14	18
D5 Making sure that all wall tops are level.	3	13	16
Practical Competence in carpentry:			
E1 Correctly inserting hurricane straps into the ring beam.	4	12	16
E2 Making a good formwork for concrete pouring.	8	8	16
E3 Installing trusses and lathes with the correct spacing.	4	11	15
E4 Effectively nailing all wood connections.	4	11	15
E5 Being able to make strong scarf joints.	4	11	15
E6 Correctly installing CGI sheeting.	4	11	15
Practical competence in plastering and finishing:			
F1 Using the correct mortar ratios and mixing methods for plaster.	11	6	17
F2 Plastering with an adequate thickness and to a straight smooth finish.	12	4	16

Table 4: Builder Skill Improvement Resulting from On-the-Job Training (Delmas 9-13)

5. Lessons on Retrofitting

5.1 Retrofit is not the Same as Repair. Retrofitting is a Safer Alternative than Repair and a More Cost Effective, Long-Term Solution.

The retrofit procedure addresses not only damage to a structure from the earthquake, but structural inadequacies that may have existed before the earthquake. Undamaged structures may have gotten "lucky" in the most recent earthquake based on geology and seismic wave propagation, and still need to be retrofitted to be safe for the next one. Similarly and ideally, structures in at-risk parts of the world that are structurally deficient could be retrofitted before disaster strikes.

While repair addresses visible earthquake damage, retrofit analyzes a building to ensure that it meets code-specified life safety performance criteria. This does not mean that it needs to remain standing only long enough for the occupants to exit safely during an earthquake. Nor does it mean that the building will not be damaged in the next code-specified design-level earthquake. The life safety standard means that the building will perform well enough in a design-level earthquake so that it does not pose a threat to human life. This is important, because earthquakes don't kill people; poorly built buildings do.

Repair fixes damage from the last earthquake. Retrofit saves lives during the next one.

5.2 Red-Tagged Buildings Can Be Retrofitted.

Build Change is the first organization to successfully and safely retrofit red-tagged buildings. As of June 2013, of the buildings retrofitted by Build Change, 426 or 45% were red-tagged. It is estimated that at least 25,000 additional red-tagged buildings exist in the earthquake-affected area[13]. If these can be retrofitted instead of demolished and rebuilt there is cost savings as discussed above. Please see footnote #1 for a discussion of the ATC 20 tagging system as it relates to suitability for retrofit.

5.3 The ATC 20 Tagging Methodology is not a Retrofitability Evaluation Tool.

Making decisions about how to reconstruct housing according to the ATC 20 system for designating the safety of buildings for occupancy proved to be a bad idea. The viability of retrofitting red-tagged houses and the difficulty of retrofitting yellow-tagged houses that were not heavily damaged but structurally inadequate shows that assigning project budgets based on ATC 20 evaluation does not allow enough flexibility to maximize retrofit funds. A system of early retrofit evaluation, even if just for suitability and estimated cost, would allow donors better to allocate their funds to maximize impact. To accomplish this, training local engineers to do retrofit evaluation should start early after the disaster, at the same time the ATC 20 methodology is being taught and at the same time the rubble is being removed.

[13] MTPTC has estimated that there are 72,000 red-tagged buildings still to be addressed (MTPTC – Bureau Technique d'Evaluation de Batiments (BTEB) – Inspections du 2010-03-11 au 2011-09-20). From Build Change's experience in several neighborhoods around Port-au-Prince, it is likely that at least one third of these are still standing and could be retrofitted. In Villa Rosa and Tisous we were able to retrofit over half of the red-tagged houses.

5.4 Retrofitting Can Start Earlier in the Rubble Removal Process.

Because houses that require a retrofit are largely occupied already, most of the rubble has already been removed by the homeowner and therefore does not impair the construction process. For new construction however, the opposite is true. Often the lots that available for new construction are filled with rubble from the collapse of the buildings on that lot *and* from the rubble deposited there by homeowners who clear their own retrofittable houses that they are living in. In addition to existing rubble on a property, new construction creates more rubble through the demolition process. Delays in reconstruction due to rubble removal can be significant. In Port-au-Prince, the rubble removal process after the 2010 earthquake took more than two years to complete.

5.5 Retrofitting Can be Done Fast.

Retrofitting is faster and less disruptive to the homeowners and tenants than new construction. A family will be displaced for construction for less than half the time in the case of retrofit, and in many cases can live in part of the building while the rest is being worked on. Evaluation and retrofit design for a typical thirty square meter house can be done rapidly. As illustrated in Figure 6, the time lag between house evaluations and design completion has been, at scale, on average under two weeks.

5.6 Retaining Walls Must be Addressed.

In neighborhoods built on hillsides, site hazard mitigation must be addressed. In order to build new houses, new retaining walls are often required. In retrofitting existing structures, the evaluation and retrofit of existing retaining walls (often including foundation walls and basement walls) is required. Build Change implemented a retaining wall evaluation/construction/retrofit program as part of reconstruction[14]. Engineers were able to evaluate the retaining wall hazard at the same time as the building was being evaluated and include retaining wall retrofit as part of the overall retrofit scheme.

5.7 The Retrofit Procedure Can Be Applied to Complex, Multi-Unit Buildings Up to Three Stories.

In Delmas 32, 56% of the buildings retrofitted in 2012 were two or three stories, housing multiple family units with an average of 3.25 families each. This proportion is also found in the ongoing retrofits being implemented in the same neighborhood at the time of writing, with 58% of two story buildings housing on average 2.92 families each. These buildings were skipped over in prior yellow-tagged house repair projects due to their complexity. The homeowner-driven approach was successfully implemented in this context, by entrusting the entire subsidy to one designated household out of the many living in one building. In one case, one household became responsible for the subsidies of nine families.

It is estimated that 21,000[15] yellow-tagged two- and three-story, multiple unit buildings remain to be retrofitted in the earthquake-affected area[16]. Even if heavily damaged, these buildings represent

[14] Build Change is finalizing a Primer for USAID on Site Hazard Mitigation in Post-Disaster Contexts; it is expected to be published shortly.

[15] MTPTC – Bureau Technique d'Evaluation de Batiments (BTEB), "Inspections du 2010-03-11 au 2011-09-20" (2012).

valuable investments for the owners and they are extremely reluctant to tear them down, particularly since donor reconstruction budgets are typically only sufficient to build a new building that is a small fraction of the size of the original building.

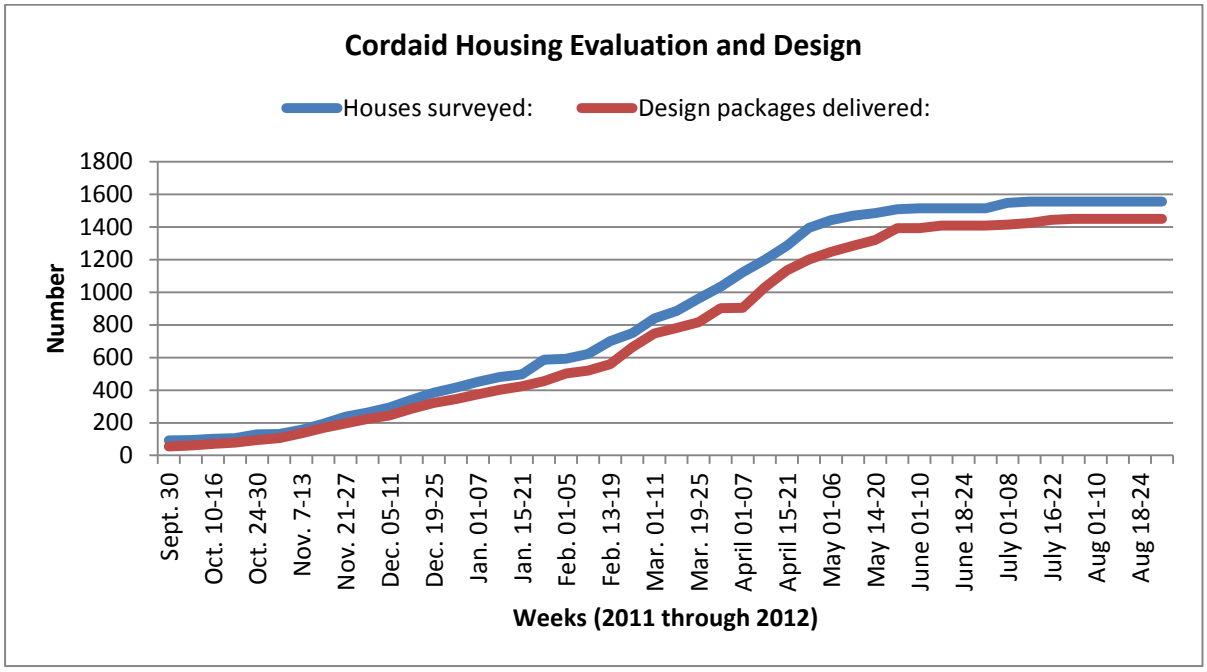

Figure 6: Cordaid-funded owner-driven reconstruction & retrofits – house evaluation and design completion over time (corresponding to years 2011 and 2012)

Once construction starts, if tranches are delivered quickly and as needed, the project can be completed in two to three weeks. This obviates the need for a temporary housing scheme for tenants during reconstruction. On average, the work on a $1,000 tranche takes less than 10 days.

[16] It is estimated that an additional 4,000 red-tagged multi-story residential buildings could also be candidates for retrofitting. This would bring the total number of retrofittable multi-story buildings to 25,000, including 21,000 yellow-tagged and 4,000 red-tagged buildings.

Appendix 1: Project Implementation

Build Change implements the following activities as part of owner-driven retrofitting and new construction:

A- Site Screening Evaluation: Build Change engineers visit the site with the homeowner to verify whether it is suitable for construction. During the screening Build Change engineers will also check the dimensions of the property, note any building obstacles or access restrictions, and note other pertinent information such as unsafe slopes and drainage.

B- Design Services. In the case of retrofits, Build Change engineers complete a detailed retrofit evaluation of the home and prepare retrofit options in collaboration with the homeowner. Build Change engineers also estimate the required quantities and the cost of the materials and labor for the project.

In the case of new constructions, Build Change engineers, with the input of the homeowner, design a housing layout that is earthquake-resistant. Build Change engineers also estimate the required quantities and cost of the materials and labor.

Houses are designed to support the later addition of another story, to a maximum of two stories for new construction and three stories for retrofit. This accounts for expected future behavior of the homeowner as well as meeting early densification requirements of expanding vertically as well as horizontally.

In all cases, the homeowner is provided with a design package which includes complete structural plans, details, and a bill of quantities.

C- Homeowner Training. Build Change trainers conduct awareness training with homeowners. This workshop empowers homeowners with the knowledge how to construct a disaster-resistant house so that they can purchase quality materials, supervise construction work for their house and have confidence their house will keep their family safe.

D- Builder Training. Build Change trainers deliver a four day training course to groups of builders from the community to introduce them to the basics of earthquake-resistant housing construction. This course will be complemented with on-the-job training by construction supervisors (Build Change-trained engineer/trainers) throughout the duration of the program.

E- Construction Supervision. Build Change engineers provide construction site supervision, inspecting each stage of the construction process for compliance with the construction documents and documenting compliance with photos and checklists. Checklists are signed off by the homeowners as well as Build Change.

F- On-the-Job Training. Throughout the construction supervision, Build Change engineers provide hands-on, on-the-job training to builders if and when further instruction is

required. In addition, when construction supervisors notice that similar mistakes are being made by several builders in a neighbourhood, Build Change provides supplemental group training seminars.

Appendix 2: Retrofit Evaluation and Implementation Procedure

In order to identify whether a given house can be retrofitted, and if so, which retrofit solution is adequate, Build Change conducts site evaluations with the prospective homeowners. During the site evaluation, Build Change performs a technical survey of the site and structure as well as a qualitative homeowner survey. The technical evaluation survey determines whether the structure conforms to Build Change's retrofit guidelines, which have been developed in partnership with Degenkolb Engineers[17] and are based on ASCE-31 and ASCE-41, the American Society of Civil Engineers' retrofit guidelines. ASCE-31 and ASCE-41 have been adopted by reference into the International Building Code, which is one of the acceptable building codes referenced in the Code National de Bâtiments d'Haiti. Additionally, for the seismic retrofit of small buildings, the MTPTC has published the Guide de Renforcement Parasismique et Paracyclonique, in which Build Change's retrofit guidelines are included as the technical appendix.

The technical evaluation survey reviews the structure's foundation, construction system, walls, configuration, structural elements and geological hazards (eg: slopes, drainage, soils), and includes a visual inspection of the property to ensure both the site and structure are safe for retrofitting. The visual inspection also notes the dimensions of the property and checks for building obstacles or access restrictions. Build Change engineers sketch an existing site plan and building plan onsite during the evaluation, which will later be redrawn and included as part of the retrofit design package.

The homeowner survey establishes non-technical building conditions such as the owner's building preferences, the availability of water, power, and sanitation for the house, the history of any problems before the earthquake and the homeowner's future plans for the house, such as reroofing or expansion. The survey also confirms the homeowner's willingness to participate in the program, asking whether she can contribute money, labour or materials for construction and validating she would like technical assistance from Build Change and will follow Build Change/MTPTC guidelines for construction.

Based on the evaluations conducted by Build Change, if the homeowner is willing to participate in the owner-driven retrofit program and the site and structure proposed are suitable for retrofit, Build Change will produce a design package for the house, with input from the homeowner. The retrofit design package will be produced by Build Change's evaluation/design team and reviewed and approved by a senior engineer who seals the construction documents as approved by Build Change. Each design package will include a complete building evaluation including retrofit calculations and hypothesis, the scope of work, existing plan, site plan, retrofit plan, details, and bill of quantities (BOQ), which estimates the required quantities and cost of the materials needed for retrofit. The BOQ will be separated into funding tranches.

[17] Degenkolb Engineers is an American earthquake engineering firm that has led or participated in the development of every US-based seismic code in use today. Degenkolb has evaluated tens of thousands of buildings for seismic vulnerability, and performs more seismic evaluations and retrofits yearly than anyone in the world.

Appendix 3: About Build Change

Build Change is an international non-profit social enterprise that designs earthquake-resistant houses and trains builders, homeowners, engineers, and government officials to build them. Build Change's award-winning design and capacity building programs in post-earthquake reconstruction programs in Indonesia, China and Haiti have improved nearly 20,000 houses. To date in Haiti, Build Change has trained over 4,300 homeowners, 2,500 builders and 140 engineers in the basics of earthquake-resistant design and construction. In addition, Build Change has provided technical assistance for retrofitting and new construction of over 1,300 houses, impacting more than 1,580 families or 8,100 people. Lastly, Build Change has also developed the capacity of 64 small and medium enterprise (SME) block makers to produce high-quality concrete blocks that meet minimum standards for construction.

Build Change works closely with the Haitian government to execute its training and technical assistance programs; Build Change and the MTPTC have a Memorandum of Agreement to collaborate, develop technical resources and share experiences on housing reconstruction and other activities of mutual interest. Build Change has trained MTPTC engineers and trainers in earthquake- and hurricane-resistant retrofitting and seismic design quality control, and advised in the production and revision of the MTPTC guide for the retrofit of small houses, to which all parties performing retrofit work in Haiti now have to conform. Build Change's structural engineering technical resources on confined masonry, reinforced masonry and reinforced concrete frame with masonry infill mixed-use have been approved by the MTPTC, and Build Change was an active member of the retrofit working group chaired by MTPTC. In addition, Build Change is an active member of the Unité de Construction, Logements et Bâtiment Publics (UCLBP)'s working group on homeowner-driven reconstruction.

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