

# E2E: Engineering2Empower.org

## The Problem

One in seven people worldwide lives in substandard and unsafe urban housing. As a direct result of a lack of resources, sound design and construction practices, and quality control, these homes create a paradox where the very structure that is meant to protect its occupants instead endangers them. The January 2010 earthquake in Haiti provides a powerful reminder of the fact that high-density urban slums comprised of poorly designed and executed housing have the potential to generate extraordinary death tolls. Engineering2Empower (E2E) overcomes the challenges posed by limited financial resources, the absence of code-compliant designs, and poor quality control in the construction of housing in the developing world. This is achieved through a new frame and panel housing system, built upon prefabricated components, customized progressive payment programs, and standardized plans and construction kits.

## Our Solution

The vulnerabilities posed by the traditional unreinforced masonry homes in Haiti are primarily due to the brittle walls being ill suited to resist earthquake forces. To resolve this issue, E2E offers a light yet resilient alternative system using frames and panels. This mode of construction emulates the human form, where the strength lies in an efficient internal skeleton and walls are used only to cover this frame. This allows the customer's limited resources to be focused on fortifying this skeleton and not all the walls, as would be required to seismically engineer the traditional masonry home. This fortification requires a high level of quality control of the frame's design and construction, which can be difficult to assure in Haiti. Thus, E2E flanks the technical innovations of its frame and panel system with several process innovations to deliver quality control. Standardized plans, prefabricated components, and custom construction kits ensure the quality of the frame, while a simplified manufacturing process is introduced to press locally materials into panels from a single mold. Because both the elements of the frame and the panels are modular, homes can be constructed quickly and efficiently with limited tools and training, and also be procured progressively, similar to competing masonry units currently in the market.

Due to a lack of up front financing, Haitians progressively obtain housing components over time. To reconcile this with the quality control desired, E2E introduces a layaway style retail model through Haitian locally owned and operated housing depots. At these depots, prefabricated frame and panel elements are produced and sold to E2E customers. Each customer receives a customized plan, which lays out a timeline for purchasing the components for a standard E2E home based on their projected cash flow. The lockers provide tangible proof of progress, essential trust, and secure storage until the home is ready to be deployed by local certified crews. Once a customer has accumulated all the components of the frame, it is erected in the first stage and tarped to provide transitory shelter for the customer as they continue to procure and store panels to finish the home. This modular approach supports progressive procurement familiar to Haitians and allows the homes to be quickly erected in each stage, with a significantly smaller construction cost compared to current masonry homes, while using the same local materials and skill sets. More importantly, the customized plans provide a way to predict demand and use just-in-time production, thereby minimizing inventory costs. Strict control over inventory afforded by the standardized designs and layaway model also allows components to be "returned" with no risk to the customer, and resold if families withdraw from the program.

## Shifting the Housing Paradigm

Urban housing in the developing world is commonly constructed of locally produced unreinforced masonry. This is due to three factors, namely, countries like Haiti have limited natural resources,

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masonry is affordable, and it can be procured progressively. Unfortunately, the steel reinforcement required to fortify this typology of construction is too costly for the poorest of Haitians, and without it, these heavy masonry units crumble under earthquake action. Having seen the death of thousands of their friends and neighbors in these houses, the majority of Haitians remain paralyzed by fear and the knowledge that they cannot afford the cost of fortifying traditional masonry wall construction. They have also come to realize the transition from NGO-supplied temporary shelters into a permanent home will be their responsibility. Thus, families need solutions they can implement themselves and that can be sustained without the need for foreign aid, creating a market for solutions that employ local materials and construction techniques and are affordable for all families, while still providing safety. Sadly, in post-quake Haiti, there is no solution that can do so.

## Population Served

In the city of Léogâne alone, thousands of households remain without permanent shelter, a microcosm of the situation in Port-au-Prince and other affected areas. Through E2E's interactions with Léogâne's Internally Displaced Persons (IDPs), a growing frustration spurred by lack of attention to permanent housing in earthquake reconstruction plans was apparent. For these IDPs, the motivation to pursue alternative avenues has grown out of this frustration and has now heightened as IDP camps are being systematically closed.

## Education

Adoption of this alternate housing model is facilitated by ongoing surveys of IDPs by the E2E team, which demonstrate the current understanding surrounding risks to shelters and pathways to rebuilding. This has informed the development of educational programming, including experiential modules, that focuses on individual homeowners, not masons or builders, to motivate investment in seismically-resilient permanent housing.

## Sustainability

An E2E home can provide the safety currently lacking in Haitian housing and retails at essentially the same price as traditional unreinforced masonry construction (\$4000), but at a half the price of confined masonry homes (\$8240). Reduction in materials cost is enabled by the shift to an alternate building typology, while labor costs are minimized by using paraskilled construction and shop prefabrication. E2E depots are owned and operated by motivated Haitian entrepreneurs and all homes are constructed by local crews, certified in this new construction technology, as a supplement to their existing workload.

## Our Team

Led by Notre Dame structural engineering faculty, the team brings their technical expertise in engineering structures against the threat of natural hazards and in forensic analysis of infrastructure following natural disasters. By partnering with Notre Dame's **Kellogg Institute for International Studies**, the **Ford Family Program for Human Development**, the **Gigot Center for Entrepreneurial Studies**, and offices of **Internationalization** and **Global Development (IGD)** and leveraging the established rapport of the university in Léogâne, E2E can make the delivery of safe and affordable housing a viable and sustainable.



### Contact Information

**Tracy Kijewski-Correa**  
(574) 220-3679, tkijewsk@nd.edu

**Alexandros Taflanidis**  
(574) 485-8515, a.taflanidis@nd.edu