

Steel-framed buildings performed well under significant seismic loading.

Steel Structures in Haiti One Year Later

ARTICLE AND PHOTOS BY
STEVEN M. BALDRIDGE, S.E., P.E., LEED AP

IN THE LATE AFTERNOON of January 12, 2010, an earthquake struck the eastern portion of the Caribbean island of Hispaniola. Poor construction materials combined with lack of engineering and quality control were a recipe for disaster in concrete and masonry structures in Haiti. Steel structures on the other hand, with lighter seismic mass and better quality control, fared well, and in most cases remained in operation as part of the infrastructure required for relief efforts.

The earthquake's epicenter was located 15 miles southwest of Port-au-Prince, the capital city and largest population concentration of Haiti, which occupies the western third of the island. According to official U.S. Geological Survey estimates, 222,570 people were killed, 300,000 injured and 1.3 million displaced. The resulting widespread damage was crippling to Haiti's infrastructure.

▼ Summary of building damage classified by severity and locale.

Building Types

The most prevalent building type in Haiti, particularly in the Port-au-Prince region, consists of non-engineered, lightly reinforced concrete frame structures with concrete masonry block infill. These low-rise buildings are used for single-family dwellings and small businesses. Large openings for windows and reduced wall area caused numerous floor collapses, both at the ground level and at singular floor levels above.

These building types are typically one or two stories, although three-story structures are not uncommon. Concrete blocks are the prevailing masonry unit utilized. Floors and roofs are reinforced concrete slabs, typically 4 in. to 6 in. thick with a single layer of bidirectional reinforcement. Concrete blocks are commonly cast into the slab to reduce the use of concrete. In many areas of Port-au-Prince, damage to these building types was in excess of 25%. Corrugated steel over a sparse wood or steel truss was also common but performed much better than the masonry and concrete buildings.

UNITAR/UNOSAT Building Damage Classification Summary by Commune Section (v2)

Commune Section	Total Building Count	Destroyed	Severe	Moderate	No Visible Damage	Total Affected Buildings	Percent Damaged
6ème Turgeau	53,366	7,565	6,605	3,515	35,673	17,685	33.2
7ème Morne l'Hopital	9,971	1,263	1,341	838	6,529	3,442	34.5
8ème Martissant	26,977	1,133	2,222	873	22,748	4,228	15.7
Totals	90,314	9,961	10,168	5,226	64,950	25,355	28.1

Data source: Remote sensing damage assessment: UNITAR/UNOSAT, EC JRC and World Bank.

◀ Steel-framed warehouse buildings have long played an important role in humanitarian efforts in Haiti and were an indispensable component of relief efforts after the 2010 earthquake.

Steel Buildings

Most industrial or warehouse buildings in Haiti are constructed of long-span steel trusses and metal deck roofs with perimeter masonry walls. The vertical support consists of either steel columns or the perimeter masonry walls. The steel for these buildings is imported from a variety of countries in the Caribbean basin. The warehouse buildings have been an important part of the humanitarian efforts of numerous non-profit groups performing work in Haiti. They were performing an integral role in food and medical distribution in Haiti prior to the earthquake and were an indispensable component of relief efforts after the earthquake.

Fortunately in the majority of the steel warehouse buildings where vertical support was provided by steel columns, damage was limited to non-load-bearing masonry walls and the structures were able to continue to play a role in the relief efforts. One such warehouse was an older steel structure with brick infill. This structure was used by the U.S. military to help distribute supplies to rural areas just south of Port-au-Prince that were hit hard by the earthquake. Another was a relief kitchen that had been providing cooked meals to families. An adjacent covered eating area constructed of concrete did not fare as well, collapsing completely onto itself.

A commercial building near the U.S. Embassy is another example of a structural steel-framed building whose non-load-bearing masonry walls were severely damaged. The renovation and reopening of this building included removing the non-load-bearing masonry walls and replacing them with lightweight metal panels. The renovated building will have a lower mass enabling it to better withstand future seismic events.

Steel warehouse buildings supported by perimeter masonry walls did not fare as well as their steel-framed counterparts due to weaknesses and poor quality construction in the load-bearing masonry construction. One CMU pilaster we witnessed had so much void space that bees had set up honeycombs within the voids. While



▲ In warehouse buildings where vertical support was provided by steel columns, damage was limited to non-load bearing masonry walls and the structures were able to continue to play a role in the relief efforts. The top photo shows an older steel structure with brick infill used by the U.S. military to help distribute supplies to rural areas just south of Port-au-Prince. Another served as a relief kitchen. The bottom photo shows an adjacent covered eating area constructed of concrete that did not fare as well, collapsing completely onto itself.

Steven M. Baldrige, S.E., P.E., LEED AP, is president of Baldrige & Associates Structural Engineering, Inc., with offices in Honolulu, Chicago and Guam. He also is a Professional Member of AISC.





- ▲ The non-load-bearing masonry walls of this steel-framed commercial building near the U.S. Embassy were severely damaged. The masonry walls were removed and replaced with lightweight metal panels, resulting in a usable structure with a lower mass that will better withstand future seismic events.

there were instances of portions of load-bearing masonry walls collapsing under seismic loading, much of the roof structure remained relatively intact. That allowed badly needed supplies to be removed from these buildings. Some of these buildings have been investigated for the possibility of shoring back up the existing roof and bringing these warehouses back into operation by replacing load-bearing masonry with steel columns.

Going forward, contributions from the U.S. government to aid in the rebuilding of Haiti should focus on providing steel structures designed and fabricated in the U.S. and exported to Haiti for erection. The benefits of this approach are significant and include:



▼ Even where masonry walls had collapsed due to the earthquake, in many buildings the roof structure remained relatively intact, allowing the removal of badly needed supplies.



▲ There was so much void space in this pilaster that bees had moved into it.

- ▶ Some of the aid will create jobs in the United States.
- ▶ A high level of quality is assured through using AISC-certified fabricators.
- ▶ Structural integrity for the area will be ensured because adequacy of design for both seismic and hurricane forces is a fundamental requirement of the IBC and AISC standards used by licensed U.S. engineers.
- ▶ The combination of U.S. steel with local Haitian labor for foundation work, erection support and floor deck pours will stretch the amount of building stock that can be built.
- ▶ Haitian workers can learn new building trades as part of this process. **MSC**