

## Engineers urge overhaul of Haiti's archaic building practices

By **CURTIS MORGAN AND JACQUELINE CHARLES**

Miami Herald Staff WriterMiami Herald Staff Writer

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PORT-AU-PRINCE -- A new hospital in the Turgeau neighborhood dissolved into a pancaked stack of concrete floor slabs surrounded by broken toilets. The shell of a nearby high school rested atop its crumbled first floor.

But just across Avenue Jean Paul II, a gleaming aluminum-and-glass skyscraper escaped almost unscathed.

Digicel's headquarters, the tallest building in Haiti completed a little more than a year ago by the country's largest phone company, stands out even more than it did before a powerful 7.0 earthquake left much of this city in ruins. A First World tower in a Third World city, it was designed using American building codes to endure 7.2 shock waves or higher. It did.

"You don't call the structural engineer in at the end of your drawing. You start with the structural engineer before it's built," said architect Christian Dutour, pleased after surveying his 12-story building. "Otherwise, it doesn't work."

In a way, that also explains why so many other structures in its shadow collapsed.

Most buildings in Haiti go up without engineers, standards or inspections. The earthquake is only the latest, and worst, tragedy to expose the largely unregulated and slapdash construction long accepted on the island -- practices that structural engineers believe added to a staggering death toll that could reach 200,000.

While extensive death and destruction would be expected from a 7.0 temblor so close to a densely populated and dirt-poor city, earthquake experts have nonetheless been shocked by the catastrophic failure of so many prominent and critical buildings.

It wasn't just humble shacks and turn-of-the-previous-century icons like the historic Roman Catholic Cathedral of Port-au-Prince, but new and newly renovated schools, police stations, bank branches, high-end hotels and hospitals. The U.S. Agency for International Development reported Thursday that 13 of 15 government ministry buildings had been destroyed.

"This was pseudo-engineering. It was terrible," said Eduardo Fierro, a California-based forensic and seismic engineer who was among the first experts to survey the damage.

"For the poor people who do their own building, you shouldn't expect better," said Fierro, who spoke from Santo Domingo after nearly a week in Haiti. "For the people who have a four-story building, for the Hotel Montana, a fancy hotel where all the foreign visitors stay, you should expect better. There is complete ignorance of seismic behavior."

Only last month, the Organization of American States completed a study concluding that a far less serious natural disaster would destroy many of Haiti's buildings. It detailed a litany of flaws: weak or missing reinforcement, structures on steep slopes with unstable foundations, inadequate or nonexistent inspections, poor designs, materials and techniques.

The findings, which the agency has not yet released, would surprise no one in Haiti. They're common across much of the Caribbean and in developing communities.

"The people tend to do whatever they want to do. If I want to build my house, I can just go and do it," said Pierre Fouche, a Haitian working on a doctorate in earthquake engineering at the University of Buffalo, with the goal of finding affordable methods to strengthen his country's lax standards and structures.

But woeful building seems a particular plague for Haiti. Last year, for instance, a church-run school in Pétionville

suddenly collapsed -- with no push from nature -- killing 91 students and teachers and injuring 162 others.

#### PATTERNS IN THE RUBBLE

Most Caribbean countries, Haiti included, have building laws based on the Caribbean Uniform Building Code, said Cletus Springs, director of the OAS' Department of Sustainable Development in Washington. But in many places, rules exist only on paper.

Few people in Haiti build to resist major hurricanes that routinely rake the island. And almost no one drew blueprints for a major earthquake, which hadn't hit in more than two centuries.

The Digicel building was one notable exception.

The office tower, which would look at home along Miami's Brickell Avenue, was designed with what engineers call "ductility" -- the capability of bending, but not breaking, under violent side-to-side shaking of seismic waves.

That requires construction that balances flexibility with strength -- particularly at key stress points, Brandan Ahern, a structural engineer who served as Digicel's project manager, said outside the building. The exterior aluminum framing or "curtain wall" can flex like a snake, but its lateral movement is held in check by large, interior circular columns and L-shaped, heavily reinforced concrete corner braces.

With all of the elements working together, the building remained upright and sound, escaping with only minor cosmetic blemishes.

But Haiti's prevailing form of construction, lightly or unreinforced masonry that is rigid but brittle, ranks among the most vulnerable to seismic shocks. The cheapest and most common building materials are homemade cement and blocks of inconsistent strength. Reinforcing steel, or rebar, is often disdained as an expensive luxury.

Even some Haitian architects admit to undervaluing it. One of them, Philip Magloire, now is glad he lost an argument with his engineer on a project that withstood the tremors.

"I was always fighting with him, 'You are putting in too much rebar,' "he said during an interview in Port-au-Prince. "I will never fight with him again."

Aside from streaks of destruction starkly visible on ravines and hillsides, where buildings, houses and walls collapsed in top-to-bottom cascades, ruin can seem random on the street. For every collapsed building, another of similar age and design seems to have survived with minimal damage -- sometimes across the block from each other.

But Fierro and other experts see clear patterns amid the rubble. Dozens of images Fierro posted for analysis on the website of the Earthquake Engineering Research Institute highlight common flaws: spindly support columns snapping under too much weight; weakly attached buildings slipping off unstable foundations; unbraced joints separating; loose, load-bearing block or stone walls spilling like toy blocks.

"The buildings, as they are built, they're very fragile," he said. "As soon as they go, they go completely."

And where there is steel, there is almost always too little or the wrong kind, said Cynthia Perry, a partner with Fierro in a Van Nuys, Calif., seismic engineering firm.

Some unfinished columns on the top floor of a school under construction in Léogane reflected a common standard. The rebar, she said, was half the diameter called for under California codes, and poorly tied together -- suitable for no more than a light residential building. The finished columns holding the floors below broke like twigs.

"They're all too small for major construction," she said.

A host of other factors certainly contributed to extensive damage on the island, including loose, sandy soils and Haitians' penchant for adding floors atop existing private homes, government buildings and even schools. In Port-au-Prince, like many other crowded Caribbean cities, the only place to grow is often up.

That added mass can prove fatal, said Amir Mirmiran, engineering dean at Florida International University.

"You can think about the entire ground shaking," he said. "If you have a bigger mass, you're going to attract a larger force with it."

The dangerous practice is so common that when Haitian architect Philippe Léon builds a house, he always tops it with a pitched roof if he has calculated the structure won't support more weight.

"I know my clients," he said during an interview in Port-au-Prince.

Leon and others in Haiti blamed the island's grinding poverty for rampant construction problems. Outside experts agree it's unreasonable to apply stateside standards to one of the poorest nations in the Western hemisphere.

#### THE WAY TO PROGRESS

But they also argue that the country must change its ways -- starting with essential 'lifeline buildings' like hospitals and schools -- if it hopes to weather inevitable future disasters.

Haiti has taken stabs at beefing up building codes in the past. Ironically, said architect Magloire, one expert brought in recently to work on the code died in the collapse of the Hotel Montana.

If history is a lesson, change will be difficult.

Farzad Naeim, president of the board of directors of the Oakland, Calif.-based nonprofit Earthquake Engineering Research Institute, said he is usually disappointed when he returns to devastated cities in developing countries.

"It is mind-boggling," he said. "All the attention to earthquakes right now, in six months, is going to dim. I am practicing now in a field where the cure is known. It is not rocket science, but people go back to building the buildings that killed people."

The OAS' Springer said overhauling Haiti's building code alone won't do much without broader education, retraining programs and financial support. "There is no quick, cheap or easy path to resolving the multiple issues that were so harshly exposed by last week's earthquake," he wrote in an e-mail response to questions.

Frantz Verella, Haiti's former minister of public works, said the government must move to make all schools and critical structures quake-resistant. "We can do it," he said, "with the help of the international community."

As the devastated country struggles to fill its citizens' basic needs, it also will require strong political will.

With many of its government buildings in rubble, the Haitian government has begun looking for new offices. It has directed the minister of tourism, an architect, to lead a safety evaluation. Citibank and the United Nations, both formerly housed in buildings that suffered horrific failures, have already inquired about moving into the Digicel building.

American teams also are assisting. Mirmiran of FIU said he will join other experts in Haiti working on structural surveys and long-term planning.

The goal for most buildings in Haiti, engineers say, shouldn't be to build to the expensive standards of the Digicel building, but to simply reduce the house-of-cards collapses that claimed so many victims -- the minimum standard of many quake codes.

"The question is, do we have an affordable, economic solution to save lives?" Mirmiran said. "The answer is yes."

Kit Miyamoto, a California structural engineer who went to Haiti last week to do reconnaissance work for the nonprofit Pan American Development Foundation, echoed that view.

He believes that several buildings he surveyed, including the presidential palace, could be repaired and retrofitted with bracing and supports that might add 1 percent to the cost. Others say seismic fixes could add 5 to 10 percent to construction bills.

There is a lesson to be learned from the catastrophe, Miyamoto said, one that applies not just to Haiti.

"No code, no engineering, means death," he said. "Hopefully, those lives lost will trigger something."

Miami Herald Staff Writer Jacqueline Charles reported from Port-au-Prince. Staff writer Curtis Morgan reported from Miami.

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