

The deadly catastrophe was entirely preventable, experts say.

The substandard construction methods that are suspected of triggering the deadly collapse of an eight-story building in Bangladesh on Wednesday are a common problem in developing countries, where construction materials can be expensive and building inspections infrequent, experts say.

The catastrophic collapse happened around 9 a.m. local time in an industrial suburb of the Bangladesh capital city of Dhaka. Ranza Plaza housed four garment factories, as well as some shops and a bank.

More than 150 people are confirmed dead, and more than a thousand injured. Many are still trapped in the rubble, buried beneath broken concrete slabs and twisted steel rods.

Scenes from the disaster show rescue workers and volunteers digging through the rubble by hand and clinging to makeshift ropes made from knotted, colorful strips of fabric as they search for survivors.

Officials have blamed the collapse on shoddy construction methods. The upper four floors of the plaza, for example, were reportedly constructed illegally without permits, and a crack was seen on the building exterior a day before the collapse.

"The building was not built in compliance with the [safety] rules and regulations," Bangladesh Home Minister Muhiuddin Khan Alamgir told CNN.

"Stern legal actions will be taken against the people who built the structure defying the codes or laws."



Uneven Footing

The exact cause of the collapse has not yet been determined, but Henri Gavin, a civil and environmental engineer at Duke University, speculated that the building's foundation was substandard.

"It could be that one edge of the building was on much softer soil than the other, so that part of the building settled down a little bit more," Gavin explained. "That could easily lead to an instability that would precipitate a collapse."

Another possibility is that weight on the top factory floors—where the crack was spotted—was unevenly distributed.

"If this building had very large open spaces the way a lot of factories do, and if the floors had long spans without lots of [reinforcing] columns ... then the building could start to lift

one way or the other" if heavy equipment was not spaced evenly throughout the floors, Gavin said.

When designing a building, engineers are supposed to consider different combinations of how loads are placed in the structure. "The intention is to require the engineer to consider as many cases as possible," Gavin said.

Such modeling is easy to do—if one has the right computer and software. In developing countries such as Bangladesh, however, calculating different load distributions can be a time-consuming process, and as a result might be skipped.

Construction Problems

Poor building design is only one part of the problem, however. The best building design in the world is for naught if a construction firm doesn't follow the plans precisely.

That may have been the case with Ranza Plaza, which appears to have been built largely out of concrete.

Concrete buildings require large amounts of reinforcing steel, called rebar, to prevent excessive cracking. Depending on the country, steel can be costly.

"In developing countries, steel is relatively expensive in comparison to the labor and concrete," said Dan Jansen, a civil engineer at California Polytechnic State University.

"In the U.S., steel is not that huge a factor. It's easy to add more steel to make [the building] more ductile and stronger, and so we do it here."

But in developing countries, less steel is often used than is recommended because of the cost.

"Reducing or changing the reinforcing steel without the building official's approval is never acceptable whether you're in a developing country or the U.S.," Jansen said.

From looking at photos of the collapse, Jansen said he suspects not enough rebar was used in the building's construction.

"The way it collapsed, and the fact that so much of it came down, suggests there was a lack of redundancy," he said. "The amount of reinforcing steel used didn't allow it to transfer the load from one section to another, and that's why so much of it came down."

In addition to possibly being under-reinforced, the concrete mix may not have had enough cement, said Gavin of Duke University.

"Many of the casualties from the 1999 Kocaeli earthquake in Turkey were in medium-rise concrete apartment buildings," he added.

"Investigations following this earthquake revealed that the concrete had more sand and less cement than required by typical design standards."

A Fatal Crack?

Whether it was the rebar or the cement that was insufficient, a crack was indeed spotted on Rana Plaza's seventh floor by workers on Tuesday, a day before it collapsed. Upon hearing the news, managers at the factories supposedly told workers not to report to work on Wednesday, but later reversed the order, according to CNN.

But a crack in a concrete building by itself is not necessarily a cause for alarm, said Ben Fischetti, a senior engineer at the California-based engineering firm Penfield & Smith.

"There's a saying: There are two kinds of concrete, there's cracked concrete and concrete that hasn't cracked yet," Fischetti said. "Concrete cracks ... but generally cracks are not a cause for concern unless you can see it moving over time or it seems to be excessive."

In the U.S., building codes set a minimum standard for the use of rebar in the construction of concrete buildings as a means of creating structural redundancy and controlling failure mechanisms.

"The number one thing that structural engineers in the U.S. are trying to avoid is sudden, catastrophic failure. We design structures to fail, but they must fail in a controlled manner," Fischetti said.

"Concrete structures that include an adequate amount of rebar are more likely to yield in a ductile behavior, rather than folding like a deck of cards."

If Ranza Plaza lacked redundancy because it was built with insufficient rebar, then the building would have been a disaster waiting to happen. "When concrete without reinforcing steel cracks, you better run," Fischetti said.

If the crack was big enough, it could have been enough to precipitate the overall collapse of the building, experts say.

"It could be that the top floor fell on the floor beneath," Gavin said, "and that impact was too strong for the lower story to withstand, and the entire structure collapsed."

From photos of the scene, it also appears as if sections of the plaza were still under construction when the disaster happened. Some floors lacked walls, for example, and exposed columns with protruding rebar are visible on the upper levels.

"It looks like the building was partially built and used," Jansen said. "Occupying a building under construction is just a recipe for disaster."

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