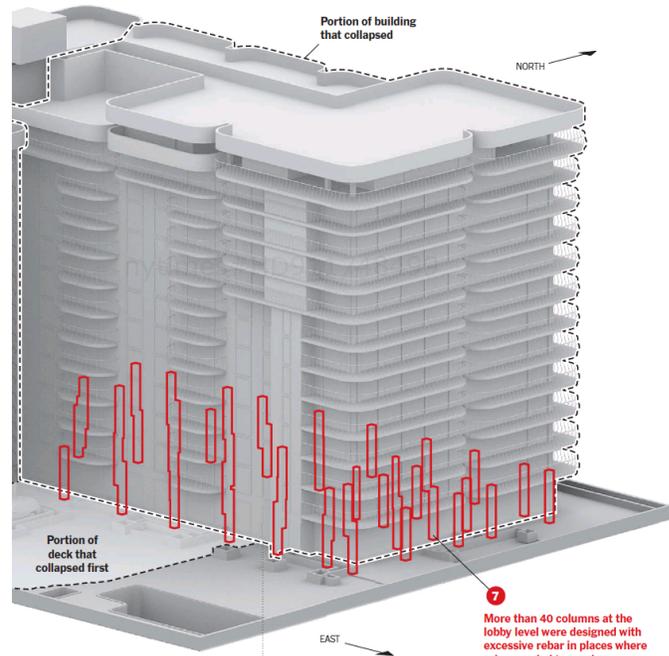


The Champlain Towers South condo collapsed in the early morning of Thursday, June 24, in Surfside, Fla.

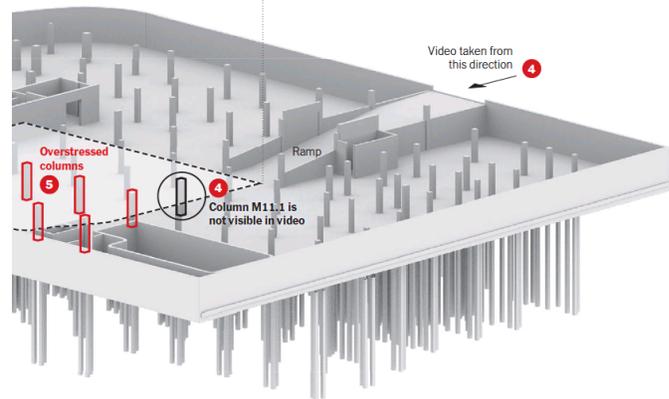
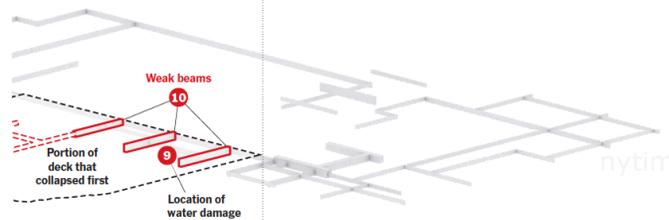
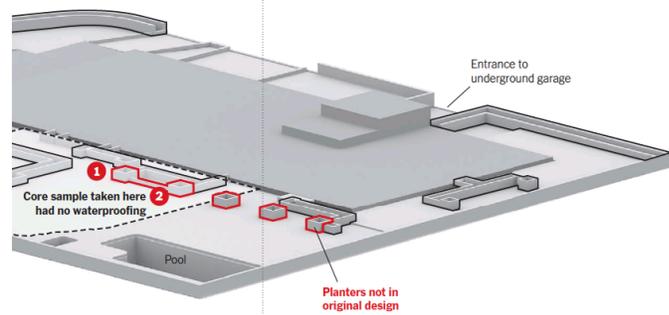


Portion of building that collapsed

MARCO BELLO/REUTERS



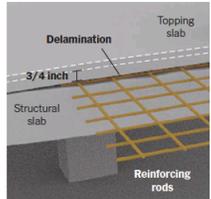
7 More than 40 columns at the lobby level were designed with excessive rebar in places where rebar needed to overlap.



Flawed Reinforcing Steel

The steel reinforcing rods, called rebar, that connect the horizontal slabs and vertical columns are especially crucial to a building's integrity. There are signs, though, that the builders may not have placed reinforcing steel in the way it was specified in the design drawings.

- 6 Too little rebar** The design for this column on the west side, pictured below — one of the thickest in the building — called for four steel rods at the top, going in each direction. But in photos after the collapse, only two or three were visible where there should have been four, a potential construction flaw.
- 7 Too much rebar** On the east side, the building's thinner columns were designed with excessive steel reinforcement, violating codes seeking to ensure that there is enough cohesive concrete to give the column its strength. This problem was first reported by The Miami Herald. For example, a column in the parking garage, below, was designed to have 12 bars of vertical reinforcing steel. But at places where the steel bars were supposed to overlap, it would have had much more, exceeding the maximum steel-to-concrete ratio in the column.



- 8 Rebar too shallow** For the ground-level deck, the plans called for steel rods to be buried three-quarters of an inch below the surface of the structural slab. Some engineers said that may have been too shallow to meet code requirements, but others said a secondary slab that sat on top of the deck would have provided sufficient cover. Steel that is too shallow inside the concrete can be exposed to the elements, causing corrosion and disrupting the essential bond between steel and concrete, a problem known as "delamination."

Weak or Missing Beams

A network of support beams sat just below the pool deck. Engineers emphasized the importance of keeping these beams well-maintained for structural stability, but evidence suggests that there was deterioration near some beams, and that some were too weak to support the necessary loads.

- 9 Water damage near beams** A video of the building in 2020 captured a view of the parking garage, showing the ceiling near the beams. Water damage was visible on the ceiling next to column M11.1, which was below the section of the deck that collapsed first.



- 10 Weak beams** Engineers said three beams under the planters, including one that connected column M11.1 to another column directly under the building, were not designed to be as strong as they should have been. The beams were shallow, the engineers said, designed without enough reinforcing steel, called stirrups, to hold the weight of planters.
- 11 Beams left out of construction** The original designs of the ground-level deck called for extra beams to support it, according to records reviewed by The Times. Those beams were removed in later drawings, including at least four beams that would have been under the area that collapsed.

Sources: R. Shankar Naik, member of the National Academy of Engineering and former chairman of the Council on Tall Buildings and Urban Habitat; Joshua Portac, professional engineer and president of Consult Engineering; Dawn E. Lehman, professor of structural engineering at the University of Washington; Roberto T. Leon, professor of construction engineering at Virginia Tech; Mehrdad Sazani, professor of civil and environmental engineering at Northeastern University; David Darwin, professor of engineering at the University of Kansas; Alvin E. Kishorinec, a professional forensic engineer at KCE Structural Engineers; Jinal Doshi, a structural engineer in Washington State; Evan Bentz, professor of structural engineering at the University of Toronto; Matthew Bray and Tim Wright of SatSense, a satellite-data research firm; Champlain Towers public records, Town of Surfside.

