ICC SPRING INTERCHANGE

Surfside Florida Building Collapse of June 2021 and ACI 318 Building Code Requirements for Structural Concrete

PART 1 OF 4

ICC INTERNATIONAL CODE COUNCIL®

Surfside, Florida Building Collapse of June 2021 and ACI 318 Building Code Requirements for Structural Concrete: Part 1 of 4

S. K. Ghosh, S. K. Ghosh Associates LLC

Palatine, IL

The Event

On **Thursday, June 24, 2021**, at approximately 1:25 a.m. EDT, Champlain Towers South, a 12-story beachfront condominium in the Miami suburb of Surfside, Florida, partially collapsed. Ninety-eight people died.

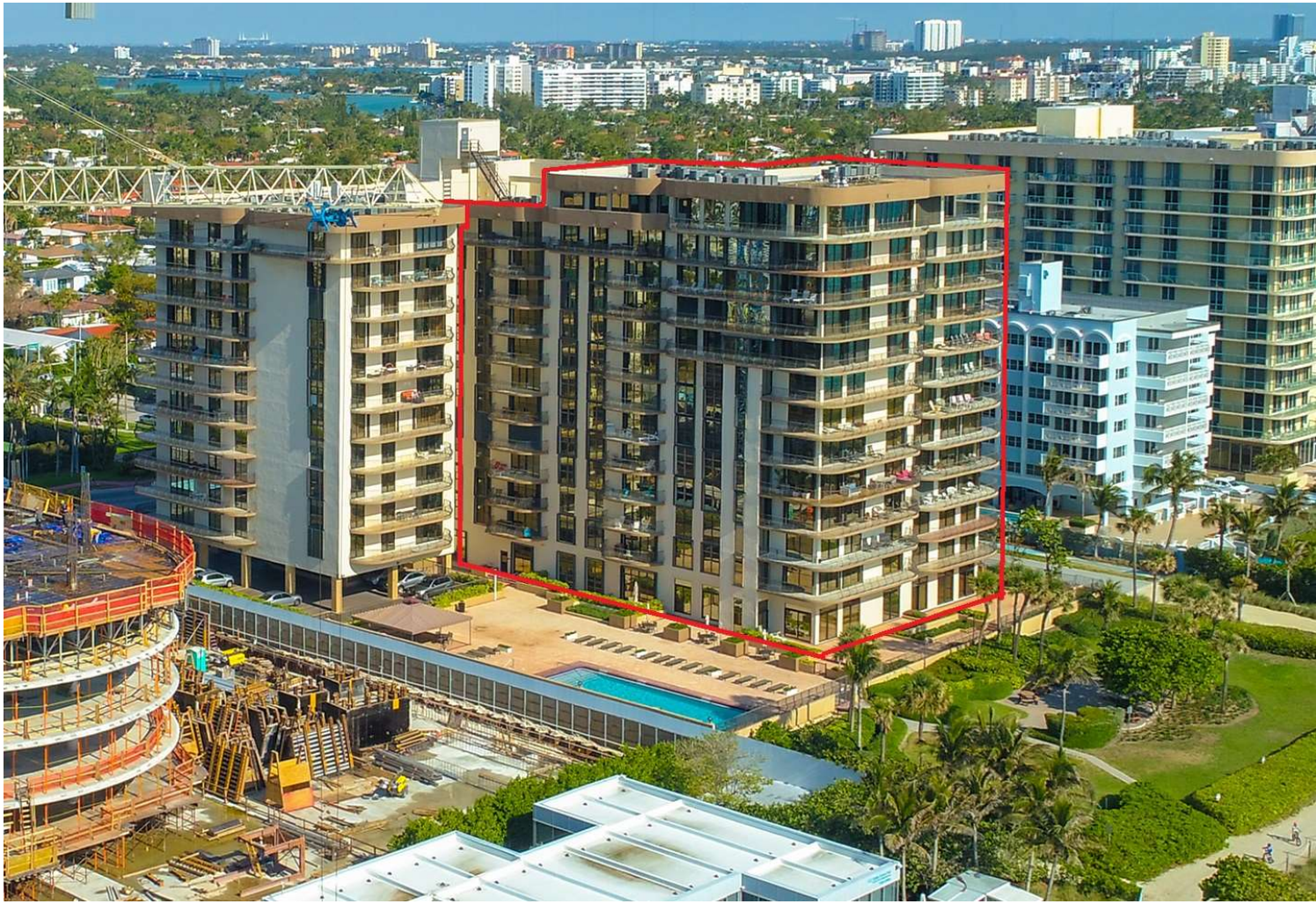
The Event

The collapse of Champlain Towers South was unprecedented. The tower wasn't particularly old or under major construction. There was no earthquake, gas explosion or terrorist attack to blame.

After standing for nearly four decades, the building simply caved in — for no obvious reason.

… Miami Herald

Champlain Tower South Before Collapse



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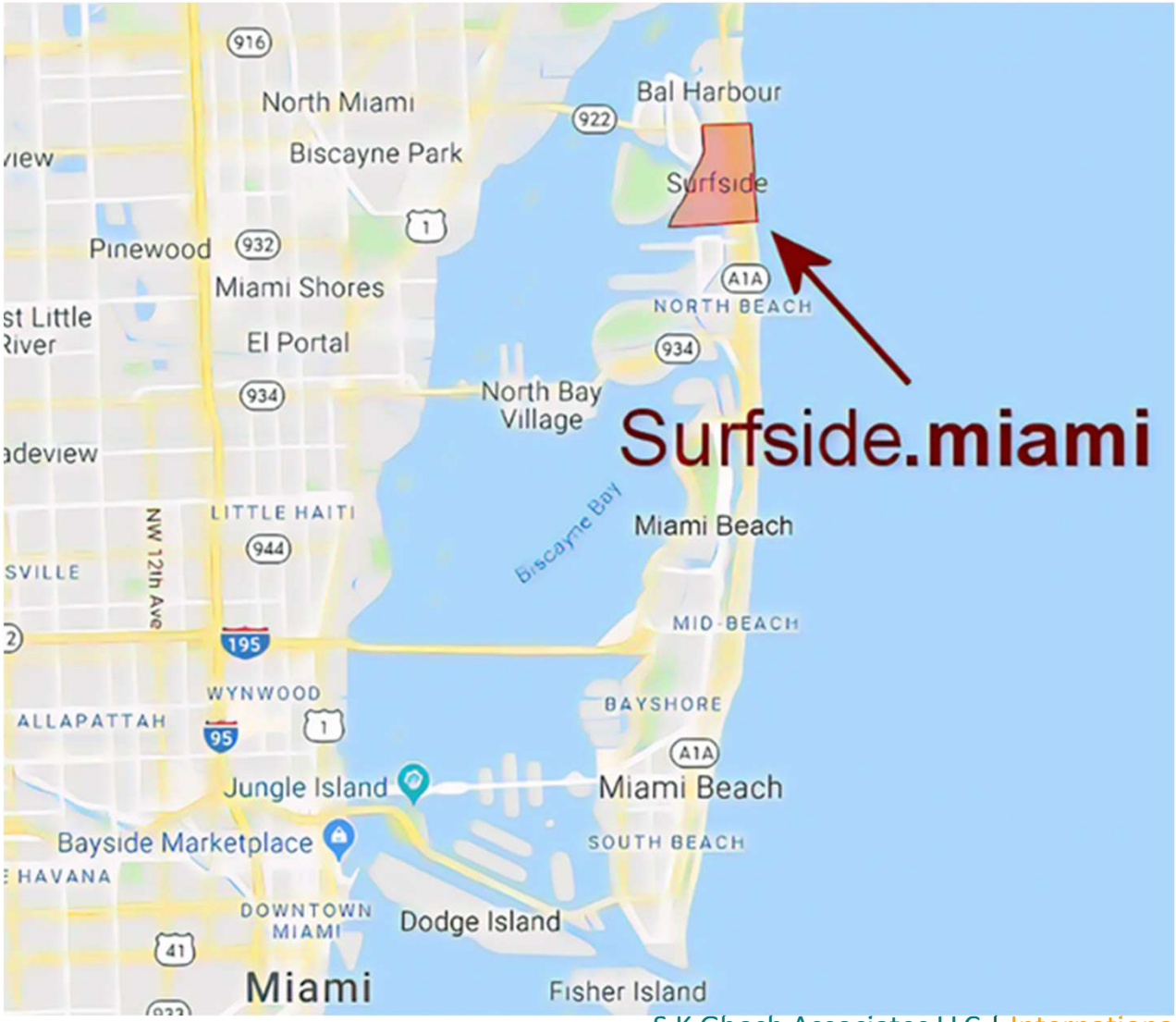

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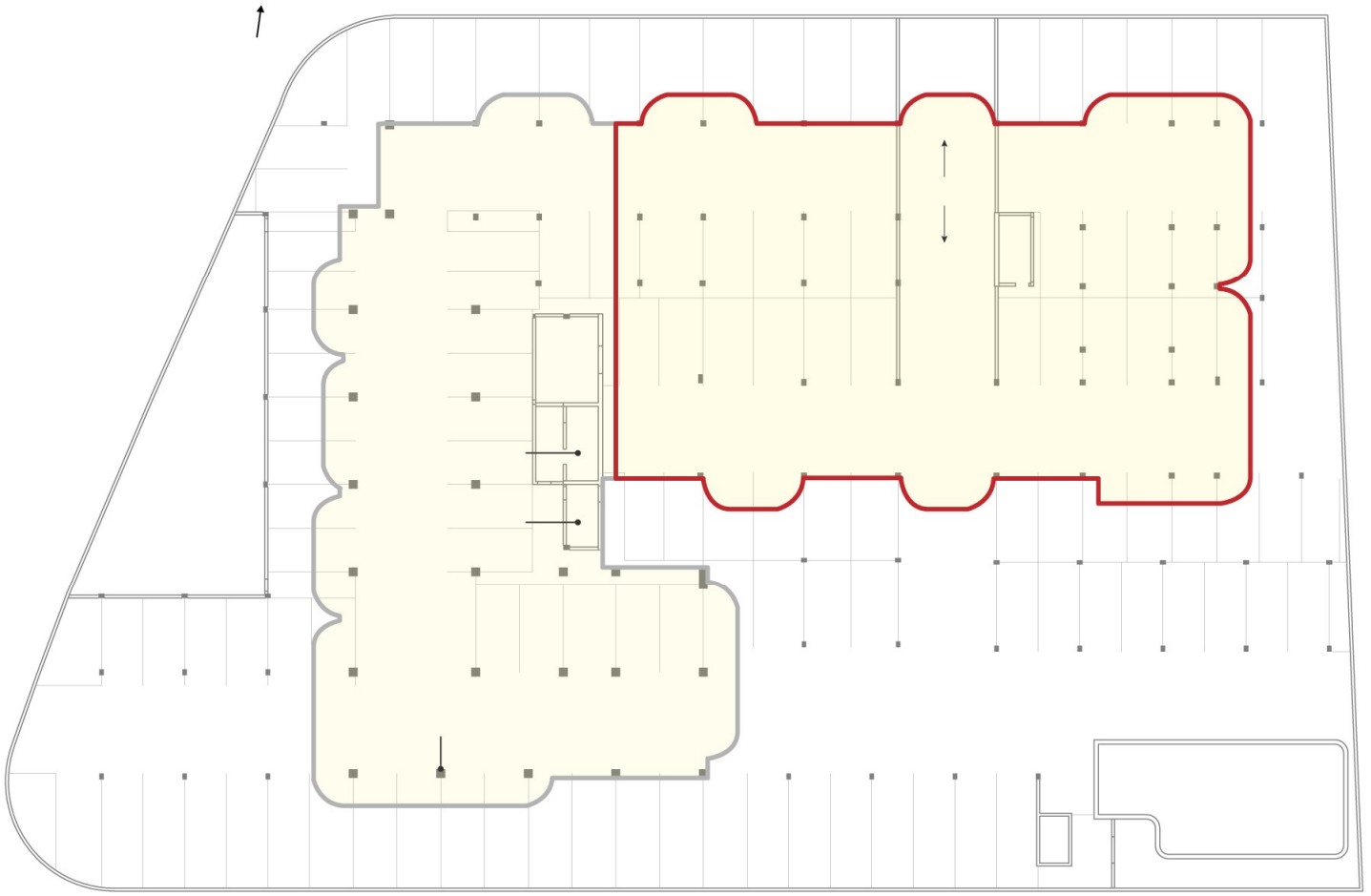
Plan of the Building (NY Times)



Orientation of the Three Towers

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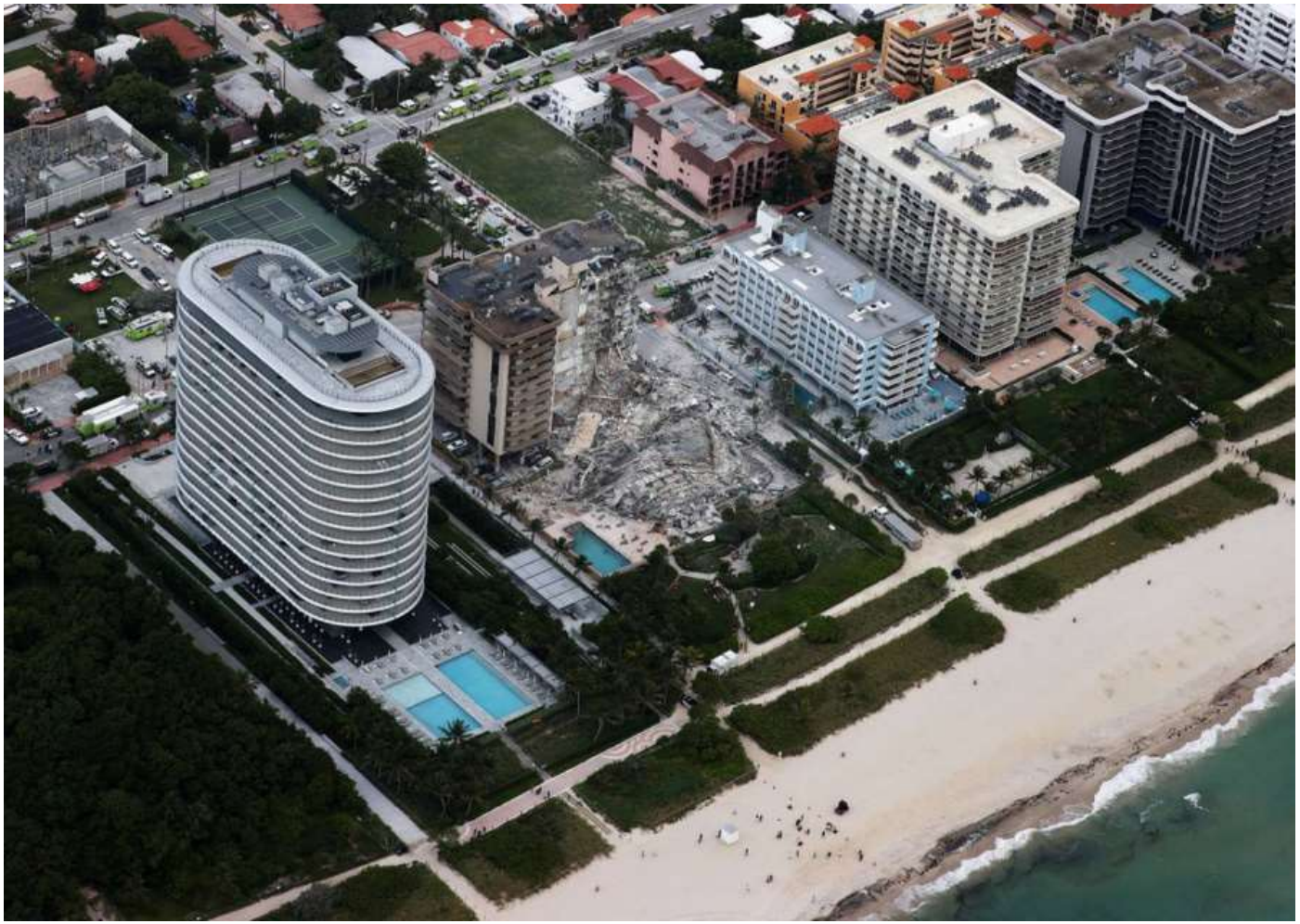
Collapsed Orientation of Champlain Tower South



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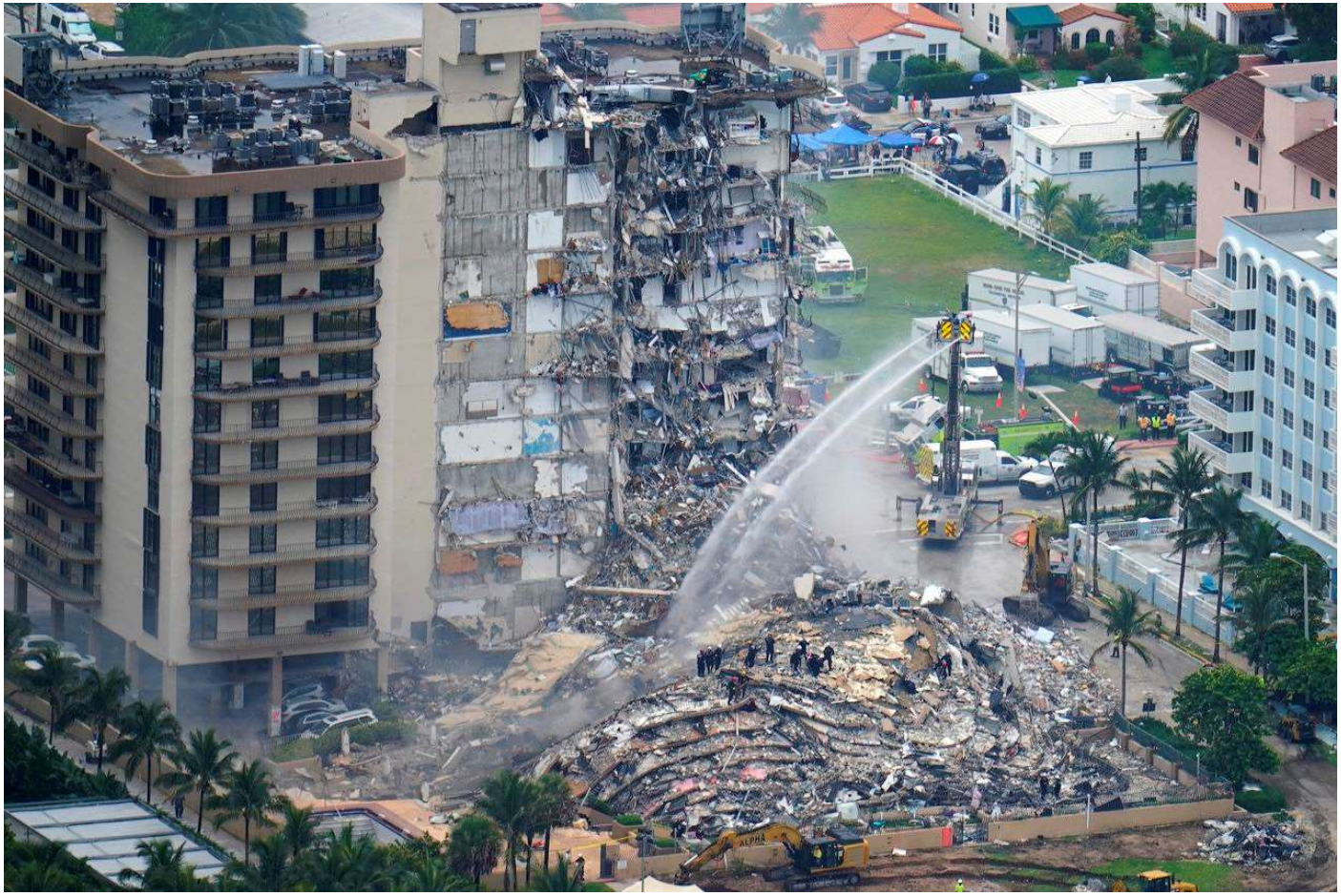
Collapse View from the Ocean Side (East)

Collapse View from the Ocean Side (East)

Collapse View from South East



Aerial View of the Collapse

Aerial View of the Current State

Before and After Collapse

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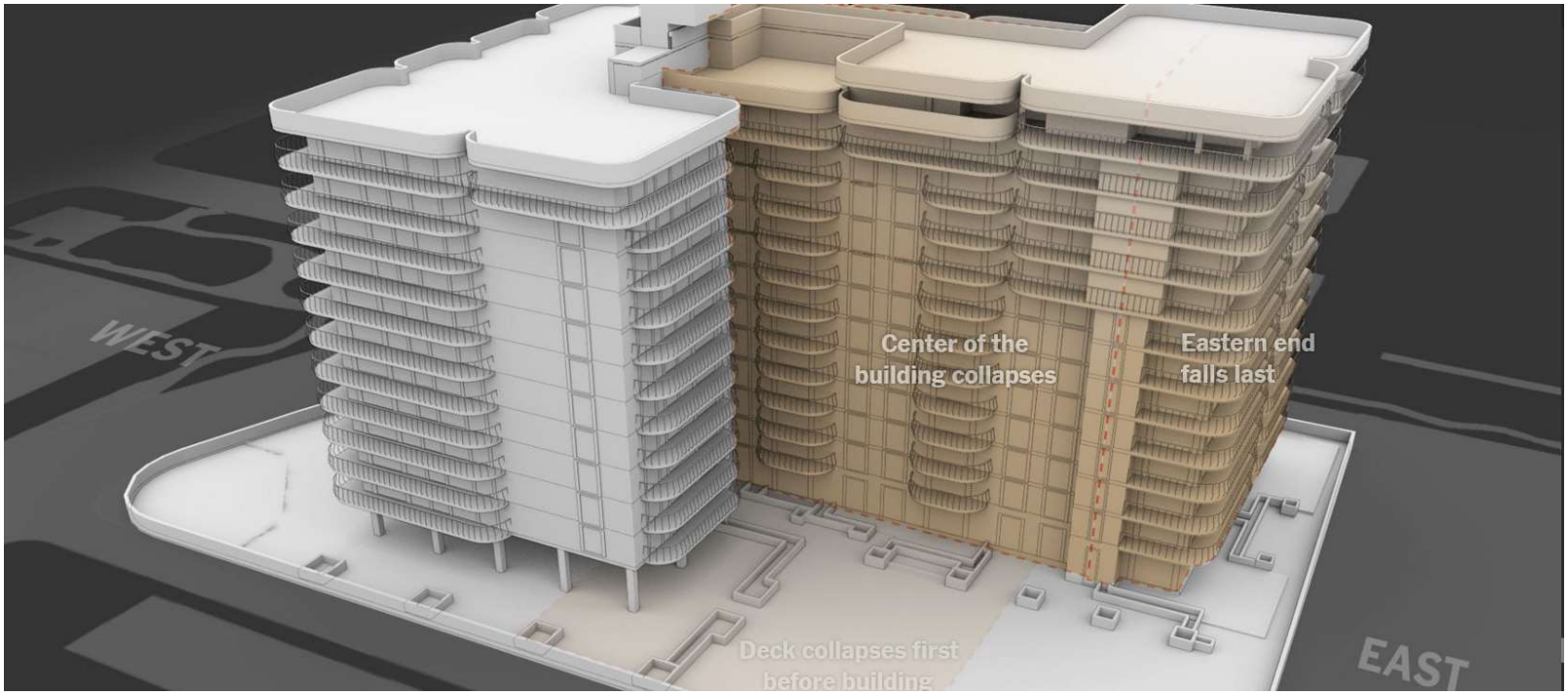
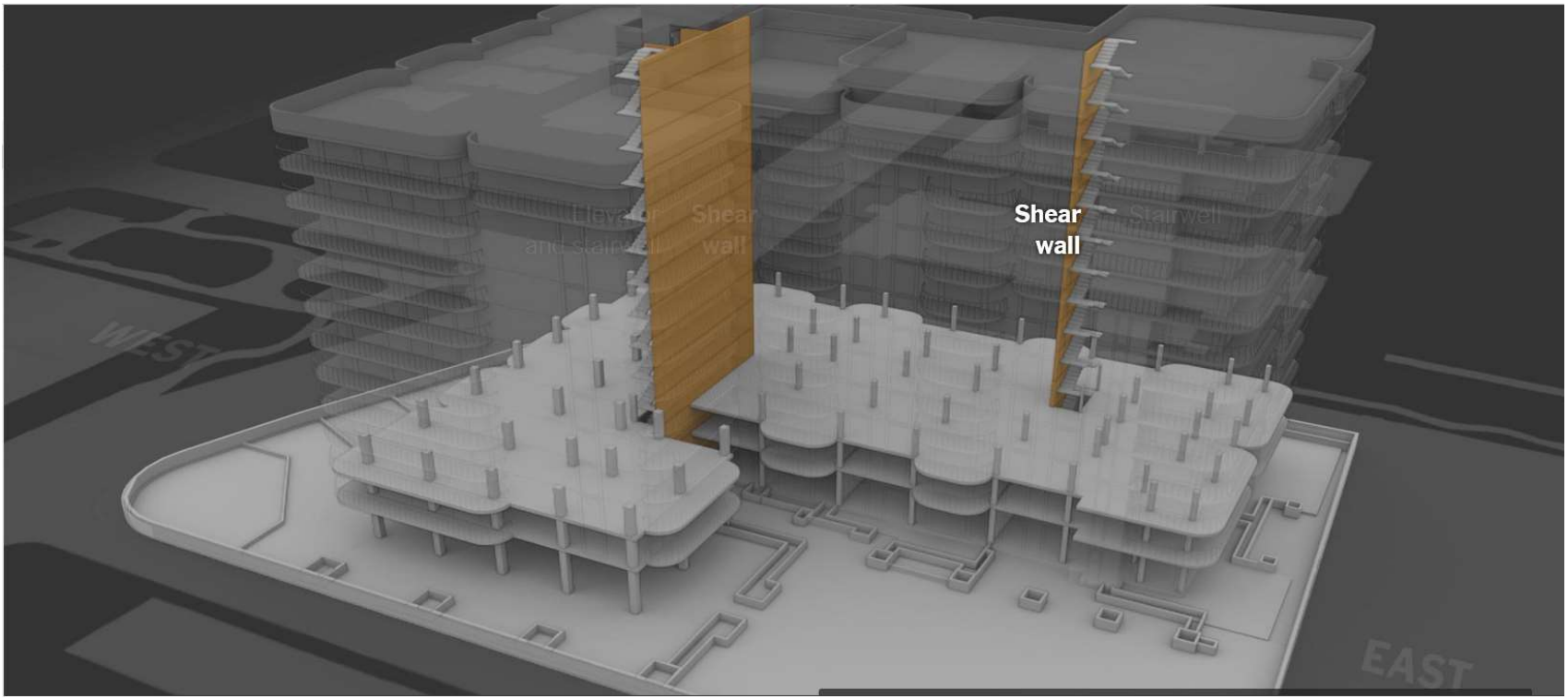
Portions of Building That Collapsed



Shear Walls in High-Rise Portions of Building



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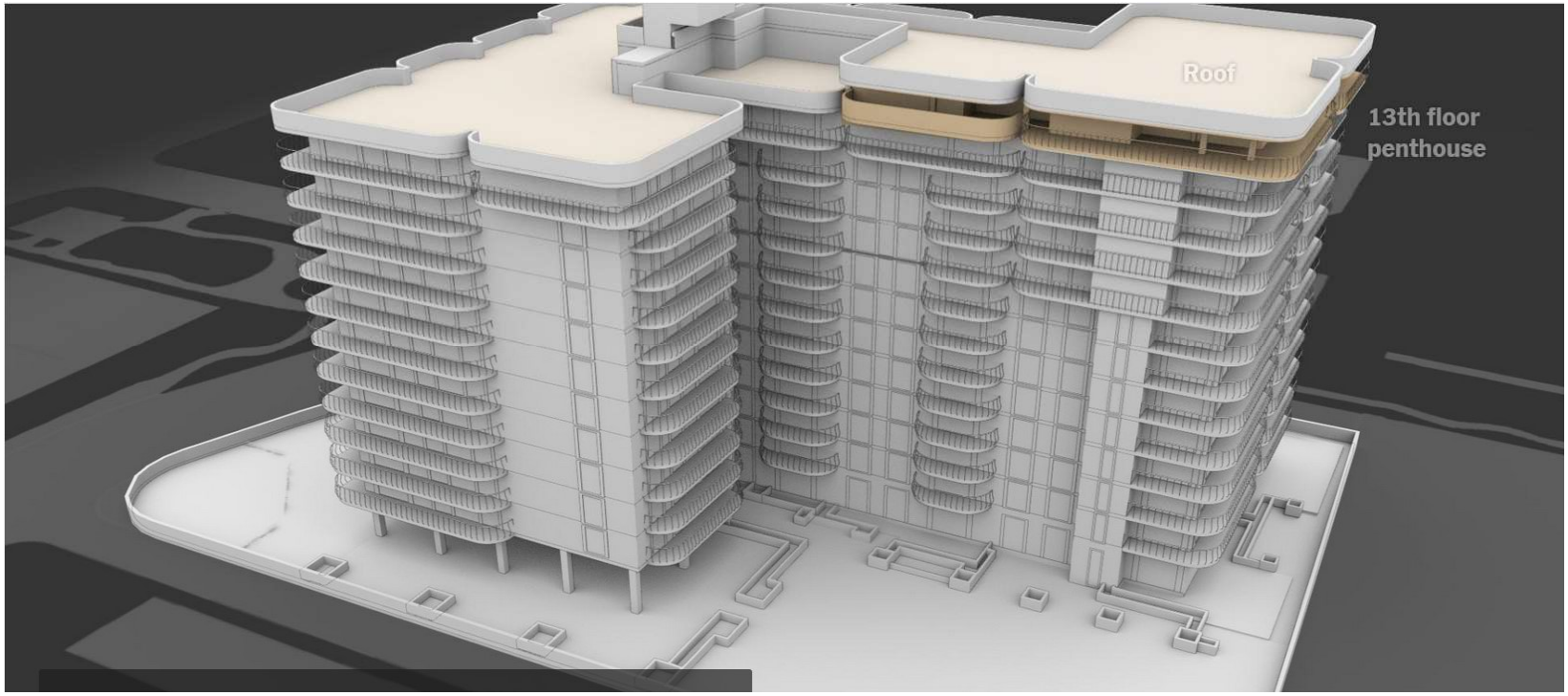
“Questionable” Partial 13th Story Penthouse



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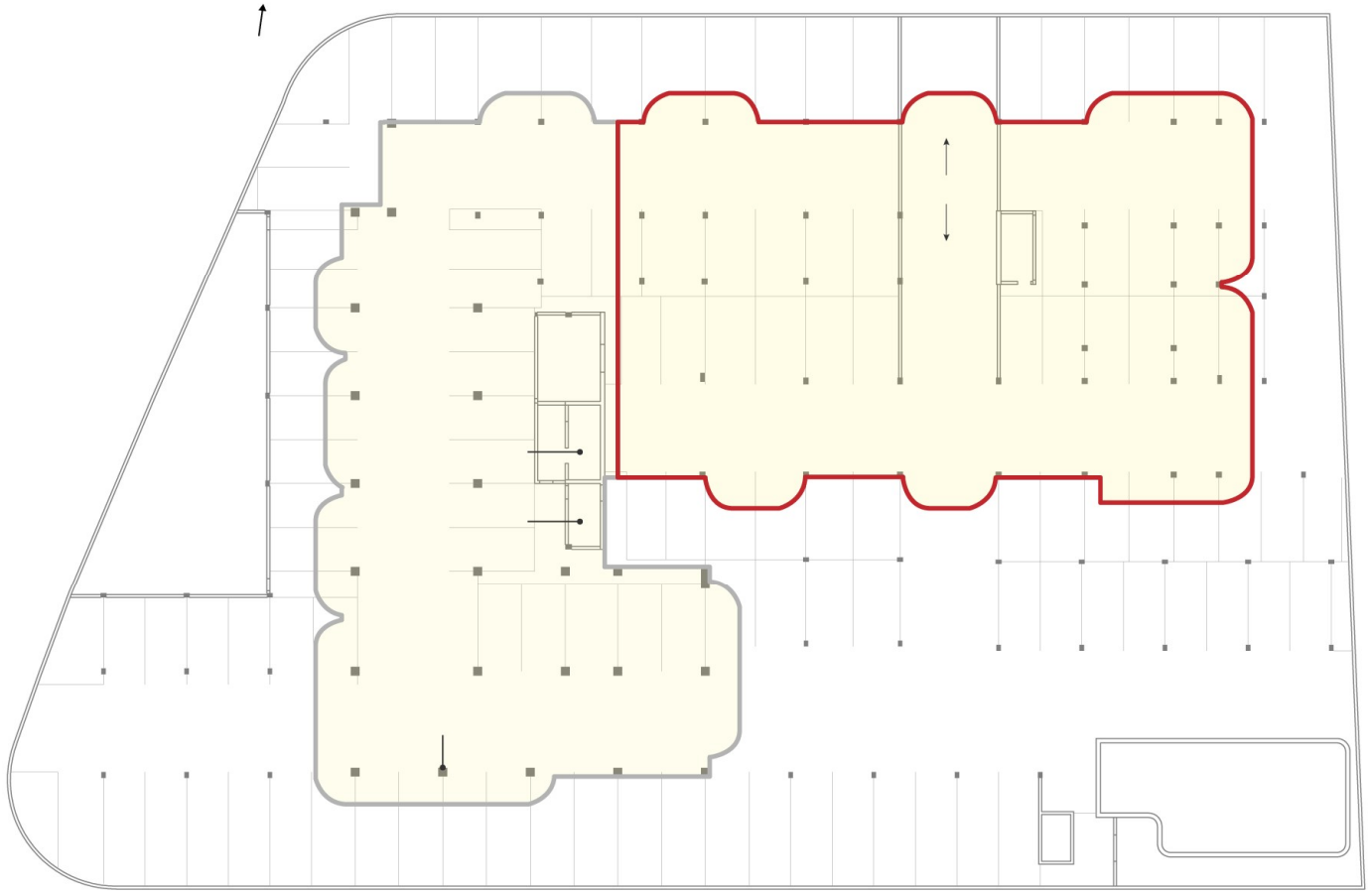
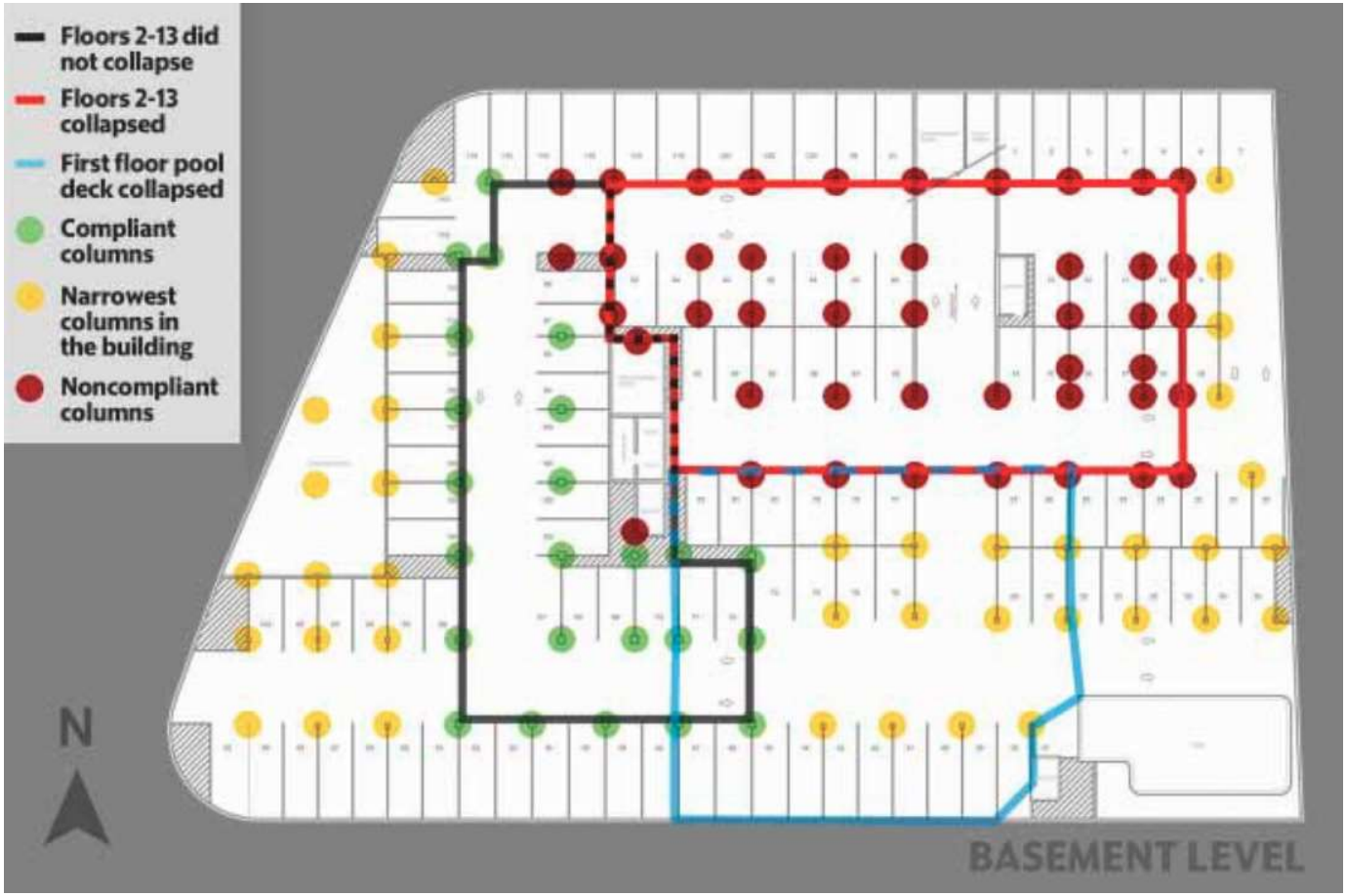
Plan of the Building (NY Times)



Plan of the Building (Miami Herald)



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Punching Shear Failure of Parking Structure Slab

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Punching Shear Failure of Parking Structure Slab

(PHOTO BY SAUL MARTINEZ FOR THE WASHINGTON POST)

The standing columns here suggest the columns “punched through” the deck.

First Indication of Failure

In the months since the collapse on June 24, the Miami Herald reconstructed the event through the eyes of 10 key witnesses … .

Guided by what each person saw, what they didn't see, and especially what they heard, the Herald worked with engineering professor Dawn Lehman from the University of Washington to identify where the collapse could have started, and how it spread to become one of the deadliest building failures in modern history.

First Indication of Failure

Lehman said the witnesses' collective memory, along with computer models informed by the building's history and damage observed after the tragedy, suggest that the collapse likely began when corroded steel reinforcement fractured in the first-floor slab, at or near the southern edge of the pool deck.

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First Indication of Failure

Whatever made the first, distinct booming noises wasn't big, or obvious or dusty — so, probably, it was not a large chunk of concrete falling from the pool deck into the garage below, Lehman said.

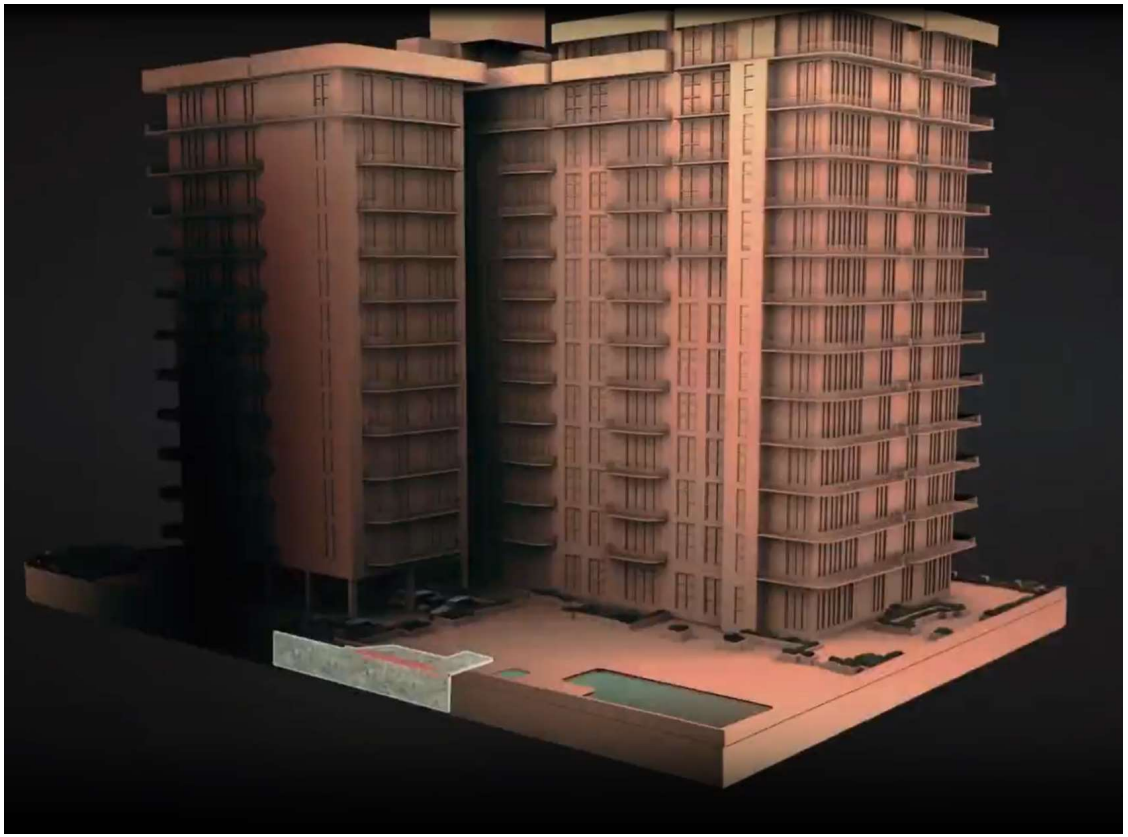
She began to look for a less obvious starting point.

"Something that makes sound but you can't see is almost always reinforcement — rebar — failing [inside the concrete]," Lehman said.

Pool Deck Slab at South Wall

Miami Herald

Pool Deck Slab at South Wall



Miami Herald

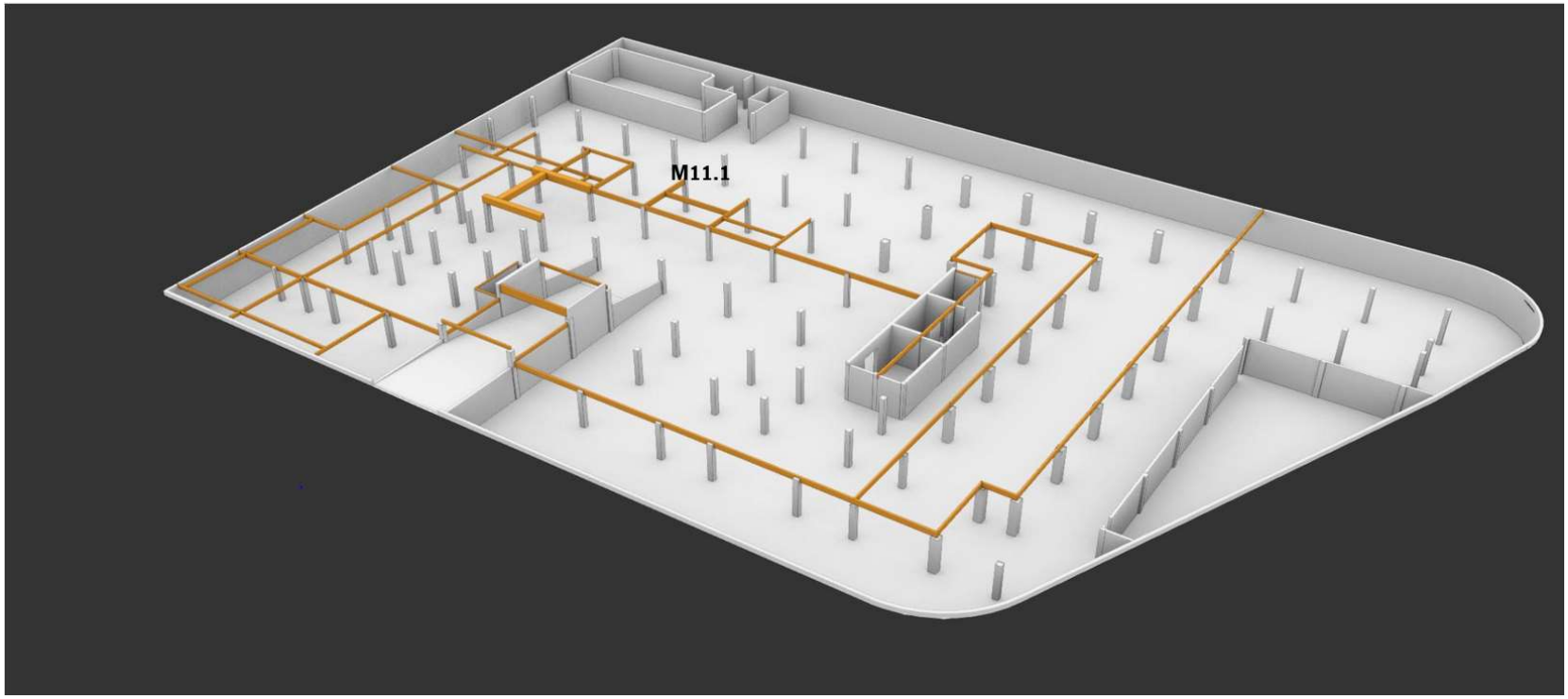
Pool Deck Slab at South Wall

Miami Herald

Pool Deck Slab at South Wall

Miami Herald

Beams Supporting Ground-Level Slab above Basement



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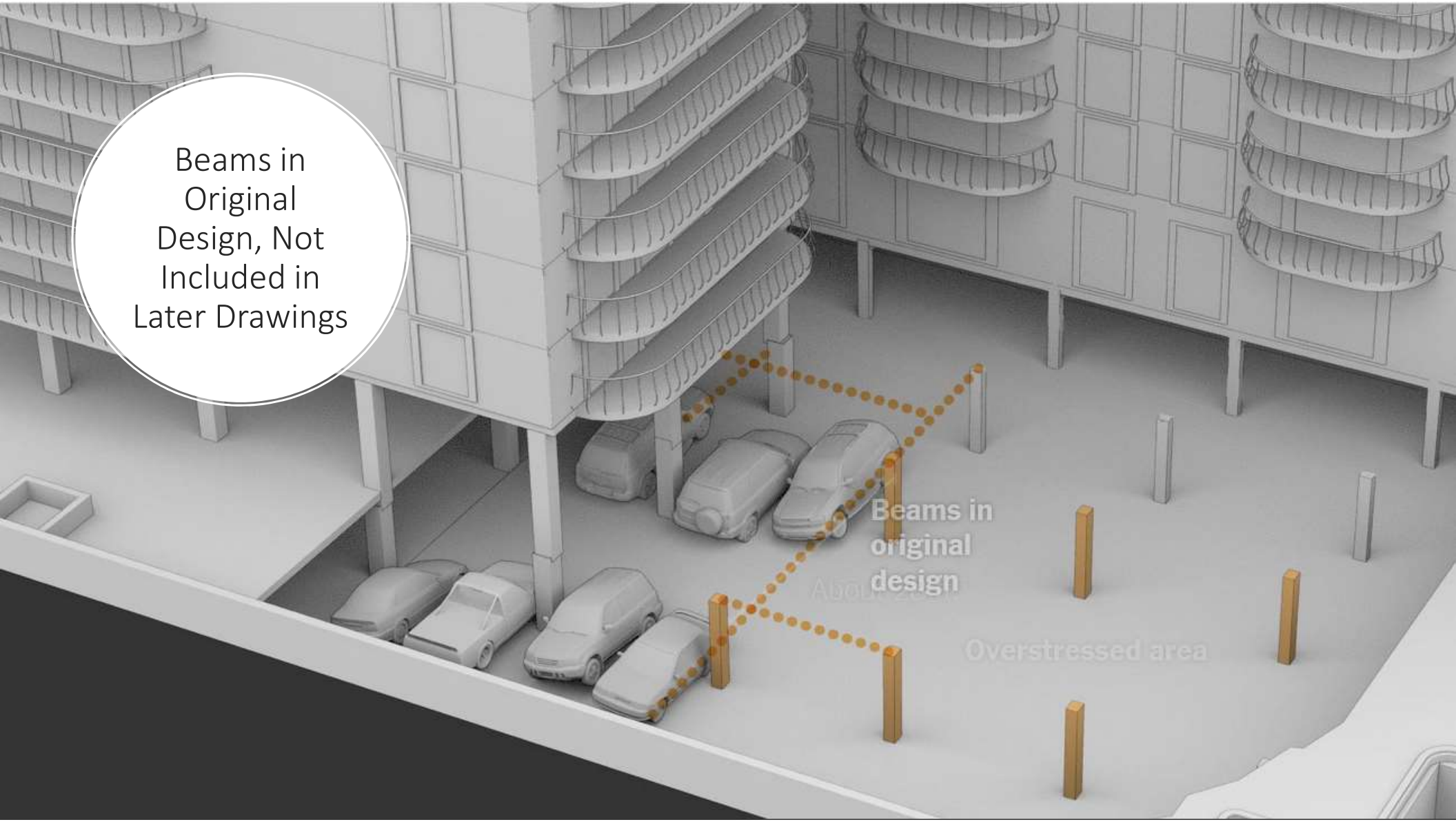
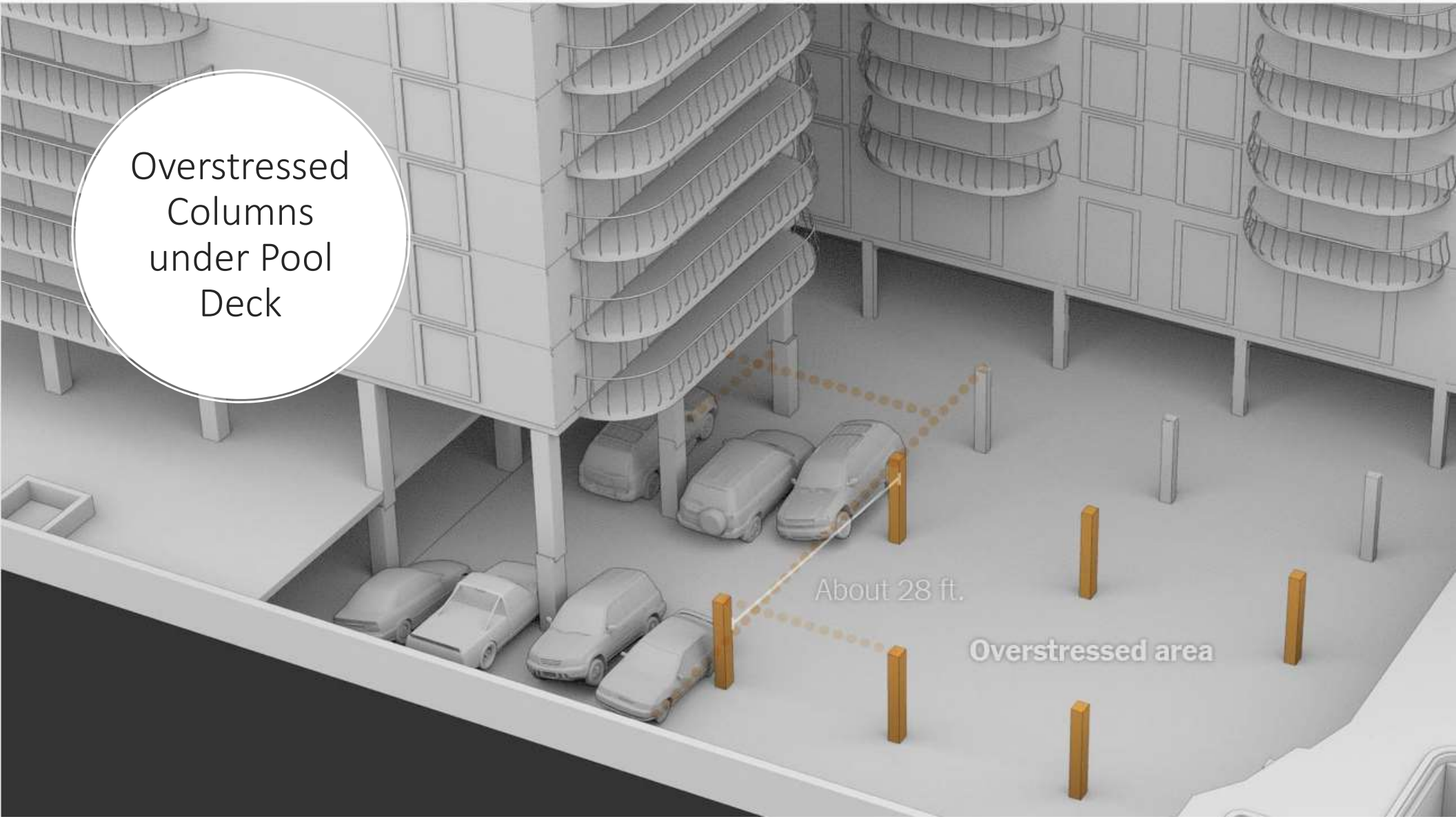
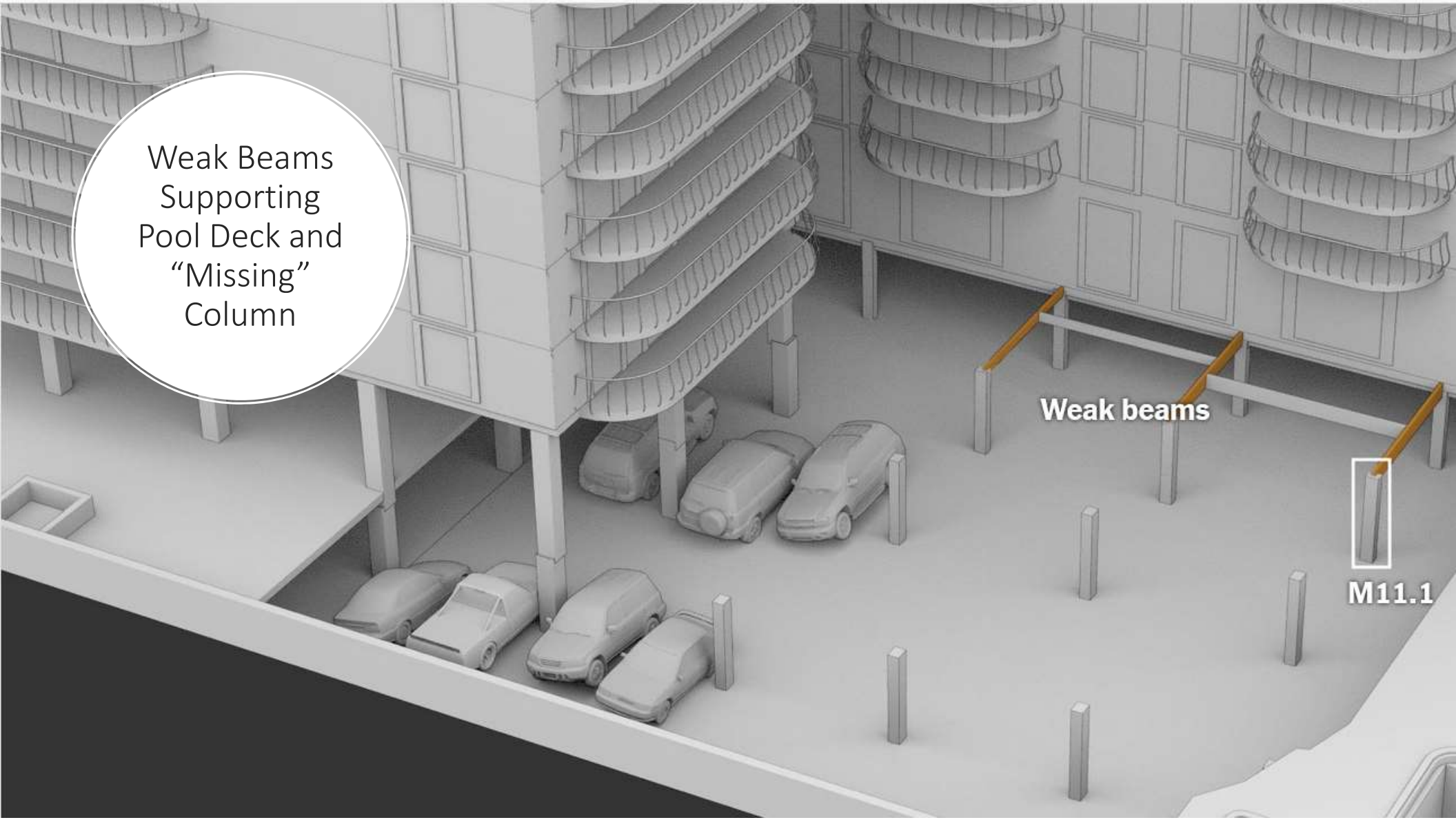




Weak Beams Supporting Pool Deck and "Missing" Column



Pool Deck Slab Punched through Supporting Columns

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Possible Destabilized Columns Where Partial Collapse Started

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Report by Morabito Consultants dated October 8, 2018

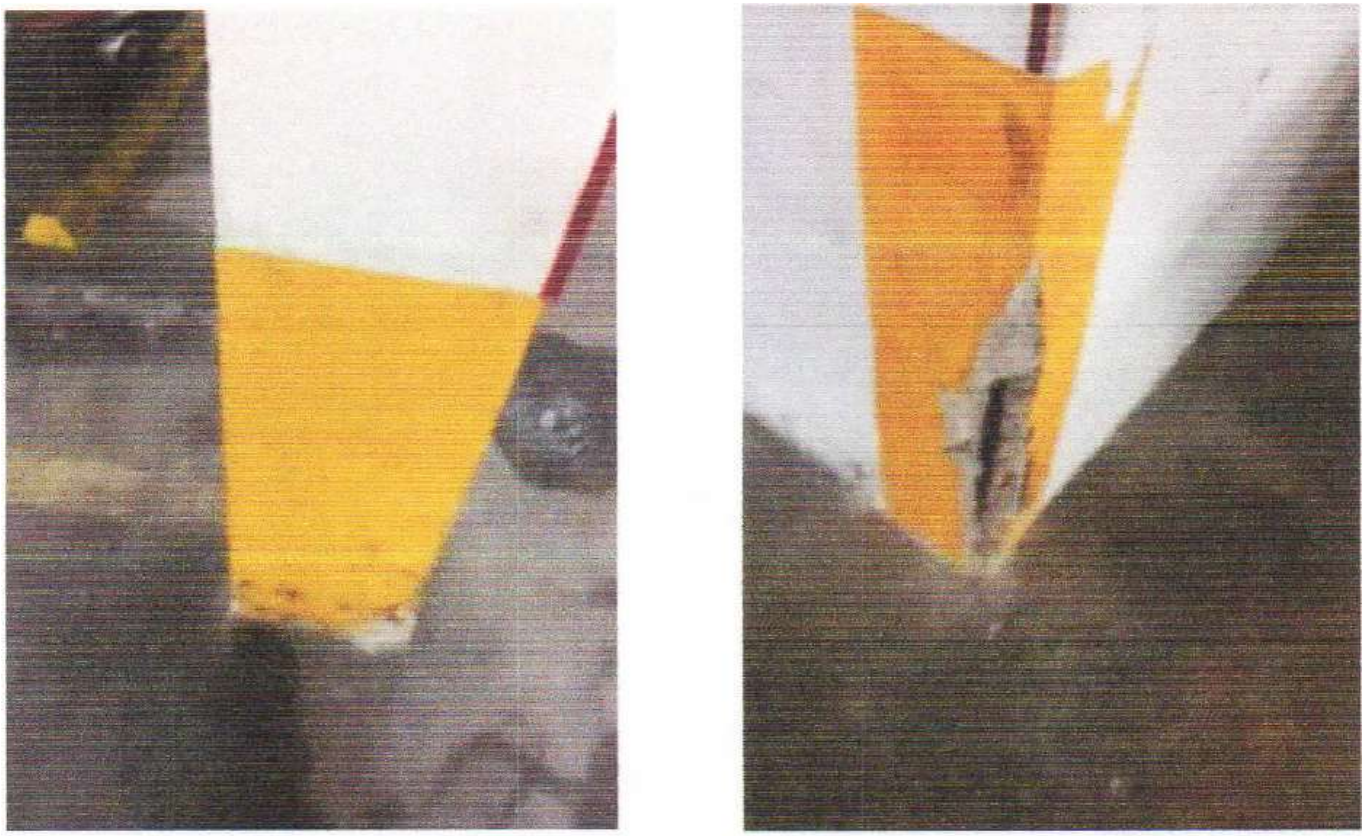

Figure J1: Typical cracking and spalling at parking garage columns

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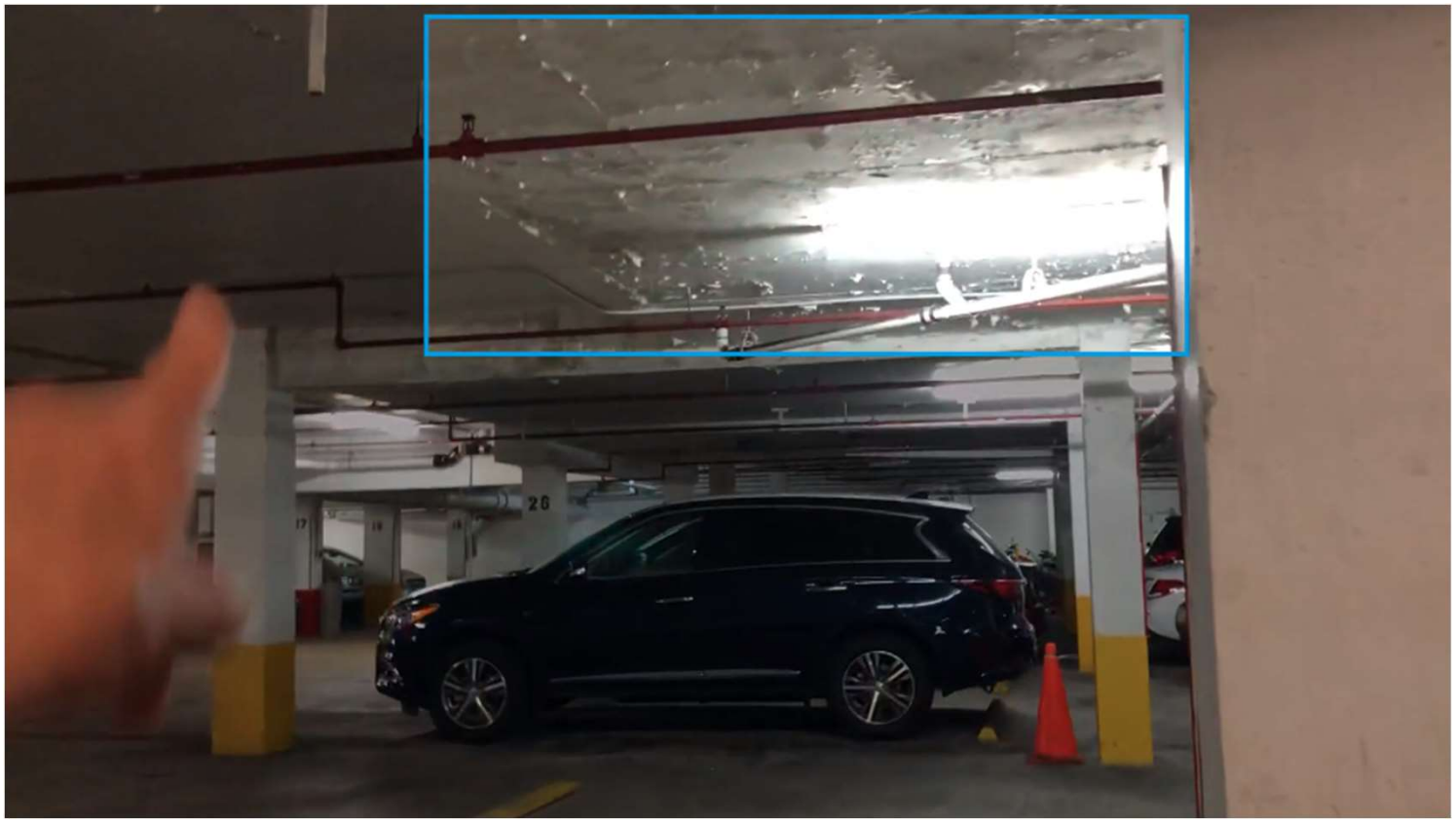
Deterioration of Parking Structure Slab due to Water Seepage



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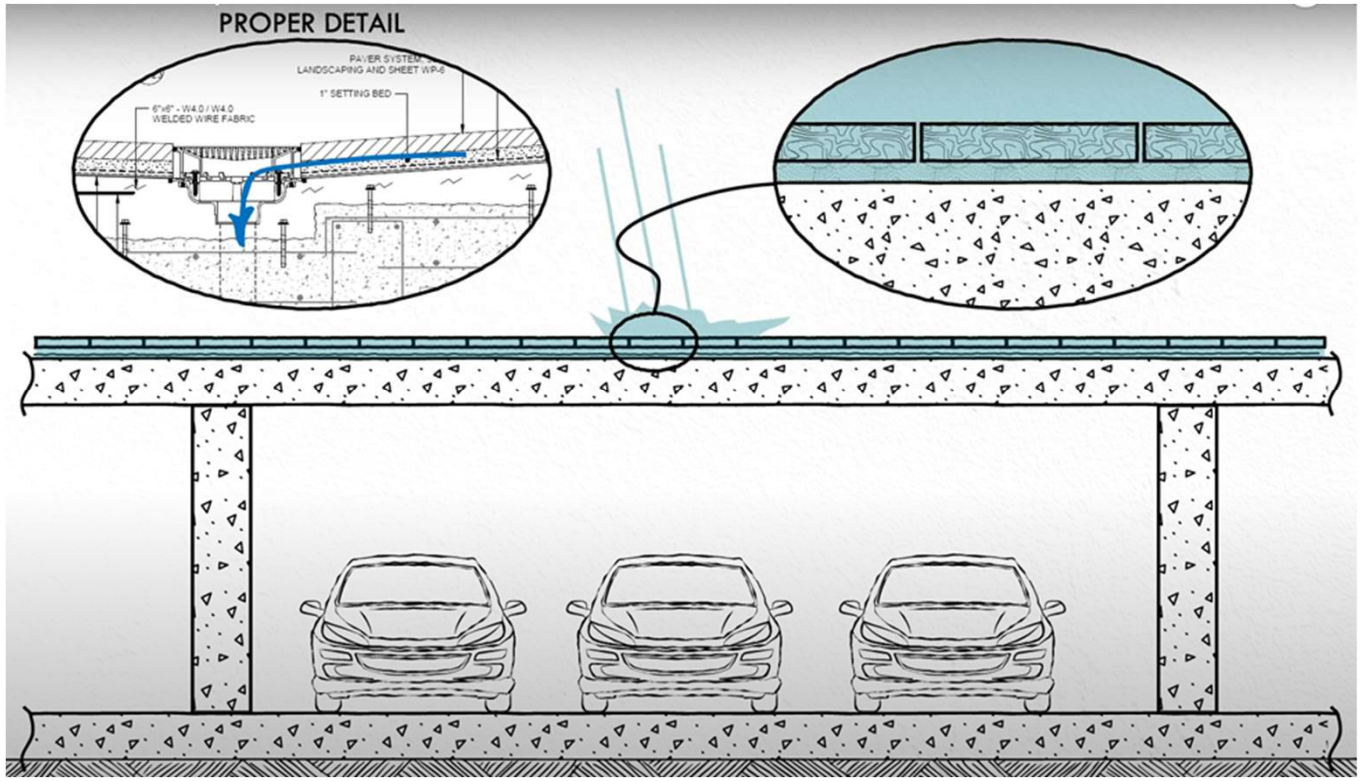
Deterioration of Parking Structure Slab due to Water Seepage (Illustration)



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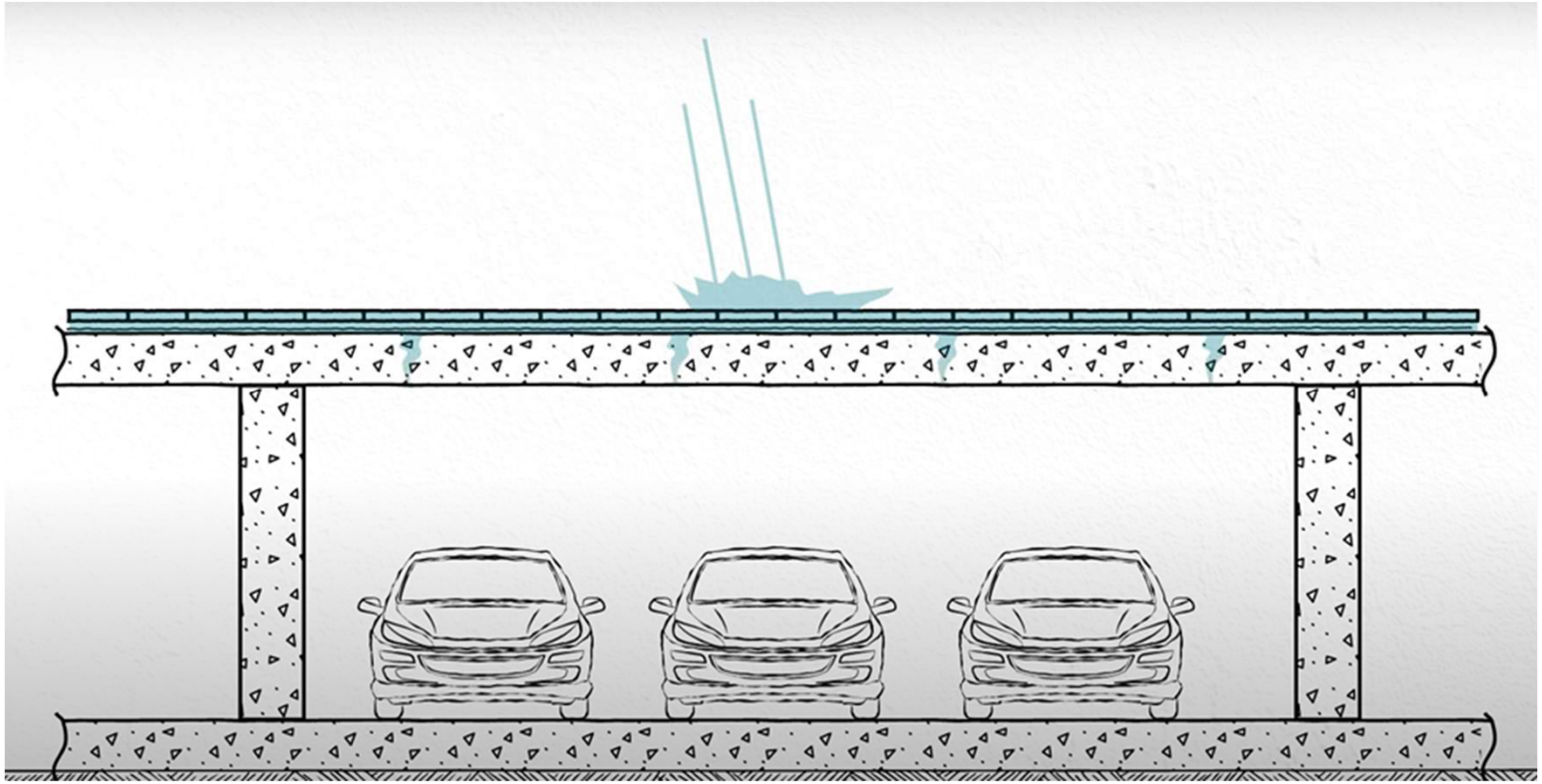
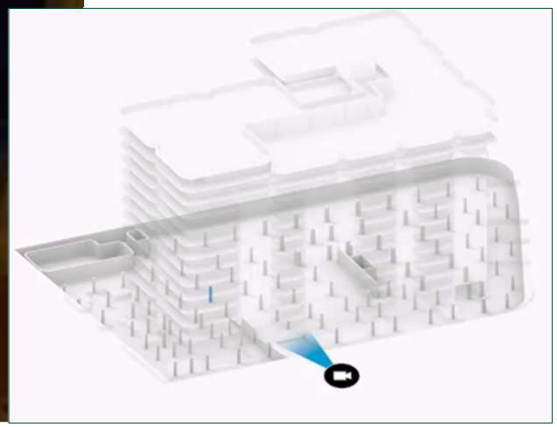
Deterioration of Parking Structure Slab due to Water Seepage (Illustration)



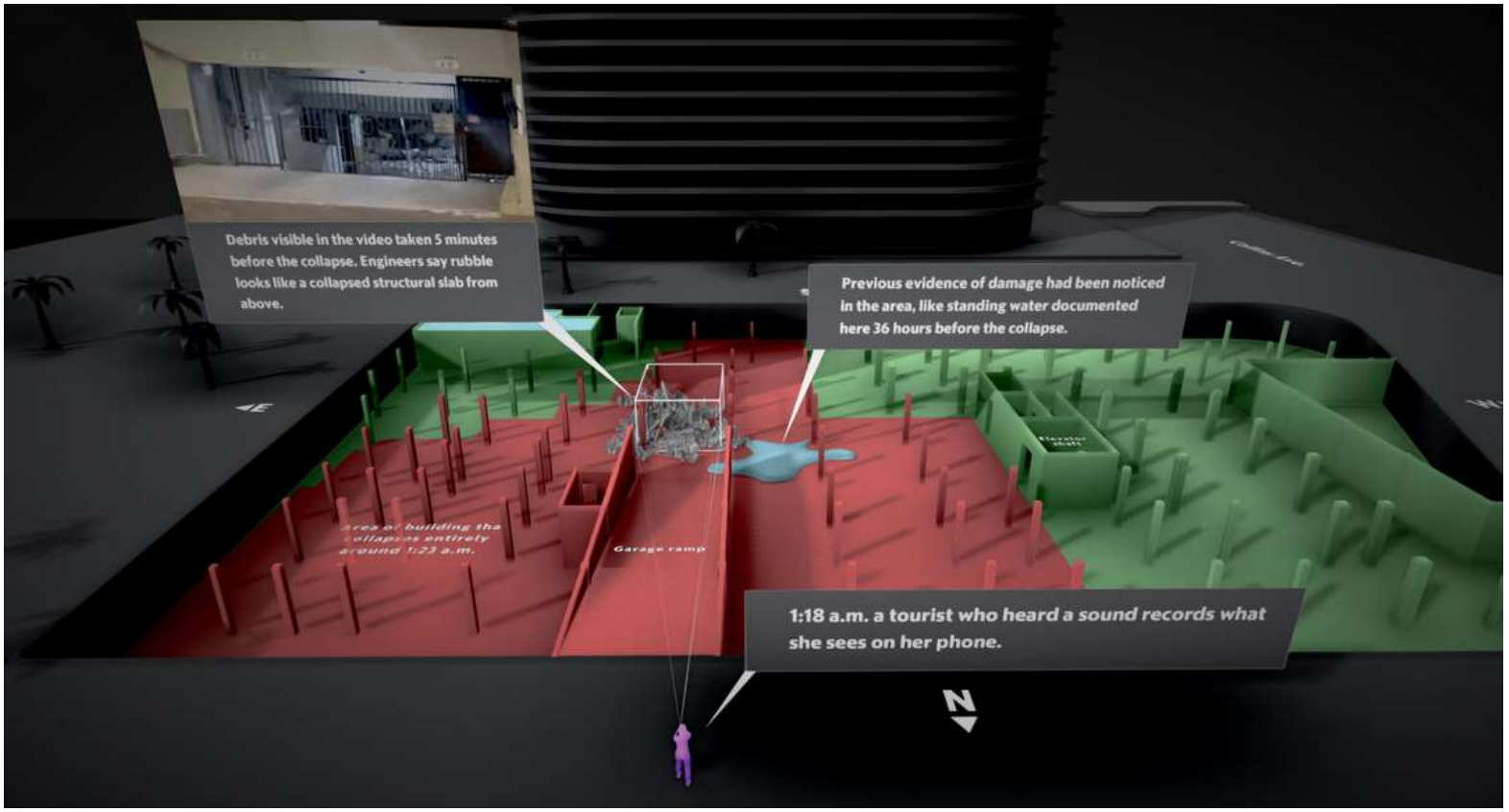
Water Leakage From Ceiling of Garage

This water leakage was recorded right before the collapse. The water and fallen debris appear to have been roughly below the planter beds on the pool deck's northern edge.



LEFT: Adriana Sarmiento via Storyful, Right: The Washington Post

Five Minutes Before Collapse



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Possible Causes of Partial Collapse

- Code violations
- Improper design
- Improper construction
- Inadequate maintenance
- Failure to heed calls for repair from competent professionals
- Combinations of some or all of the above

Possible Causes of Partial Collapse

(Prof. Atorod Azizinamini, Florida Atlantic University)

1.Detail in column strip for bottom reinforcement probably met the code requirement (1971) but does not meet current code requirement for structural integrity

2.Foundation did not include grade beams and allowed uneven settlement. Shear walls in east west direction was very minimal. In North South direction, poor judgment was exercised in proportioning the shear wall.

3.Slab at pool level was tied to building and expansion joint was not provided.

4.It is not clear how slab at garage level was connected to column. Is it at foundation level? Is it about two ft above foundation?

5.The reinforcement ratio for columns are crazy (more than 6 percent). This means at splice location you would have 12 percent steel.

Critical Improvements in ACI 318 since Building Was Designed

The building was likely designed under the early or mid-1970s Florida Building Code and ACI 318-71 or ACI 318-77. Concrete durability, flat plate punching shear, and structural integrity provisions of ACI 318 are critical areas of improvements that engineers, architects, and building officials must be familiar with for safe performance of concrete buildings.

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