

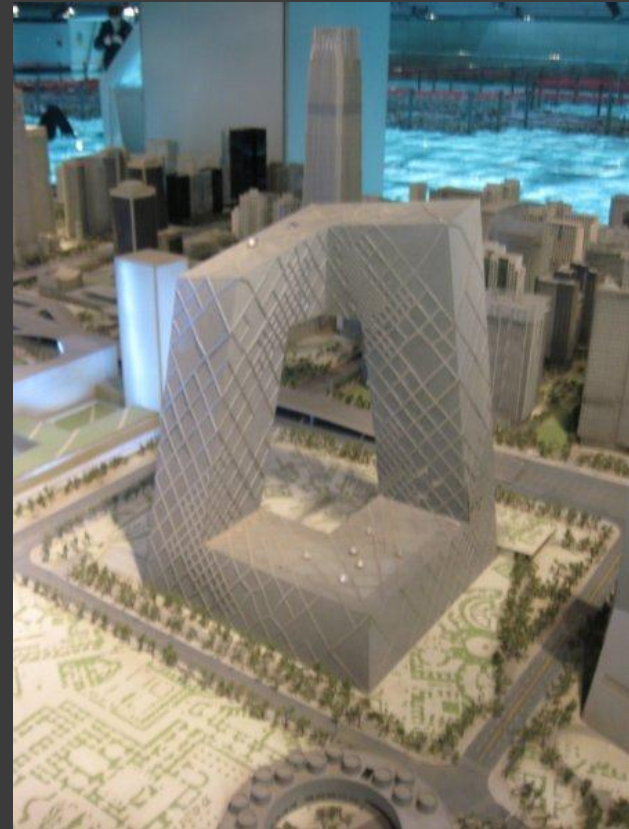
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Arch 631 - Case Study



CHINA CENTRAL TELEVISION (CCTV) HEADQUARTERS

Getting a good footing...

- ⦿ Architects:
 - Rem Koolhaas and OMA
 - East China Architecture and Design Institute of Shanghai (ECADI)
- ⦿ Engineers:
 - Ove Arup and Partners
- ⦿ Financing:
 - Chinese Government (est. Investment: \$1.2 Billion)
- ⦿ New central business district in Beijing, China



Building Footprint: 160m x 160m
Floor Space: 465,000 sq ft

Excavation & Foundation

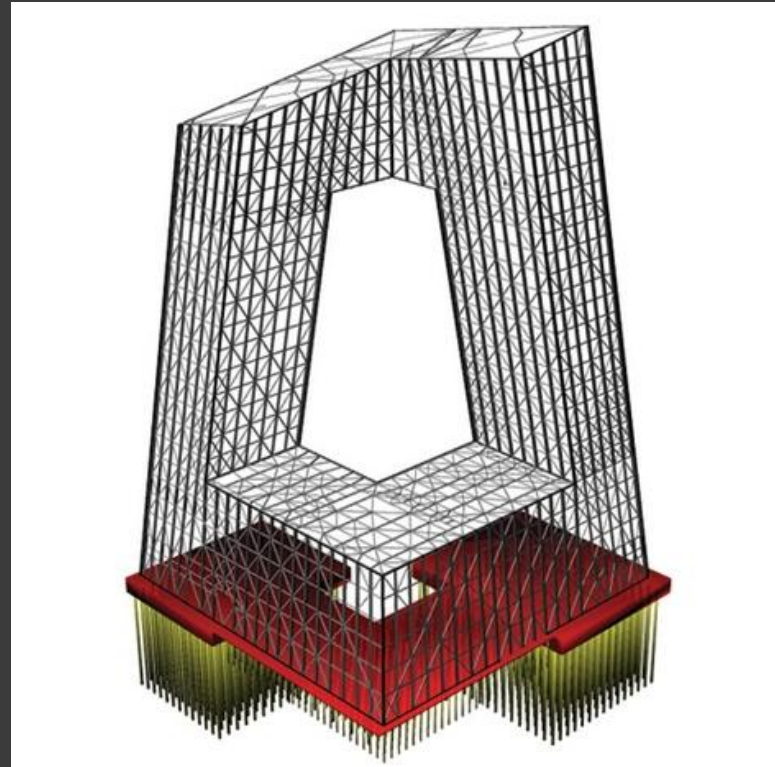
- ◎ Excavation:
 - Took 190 days
 - Had to be done at night due to strict construction regulations; nonetheless, 12,000 cubic meters were removed each night
 - Dewatering wells were installed since the ground water level was above the maximum excavation depth of 24.7m below existing ground level



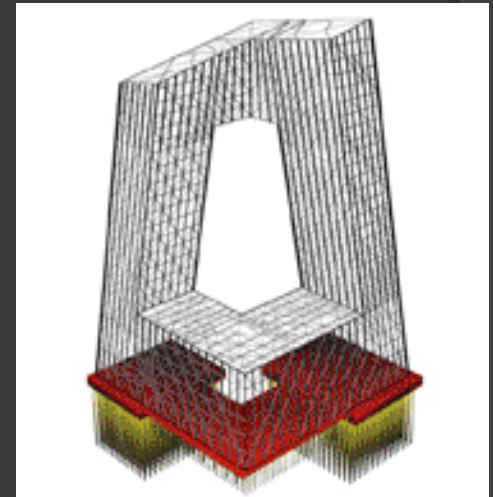
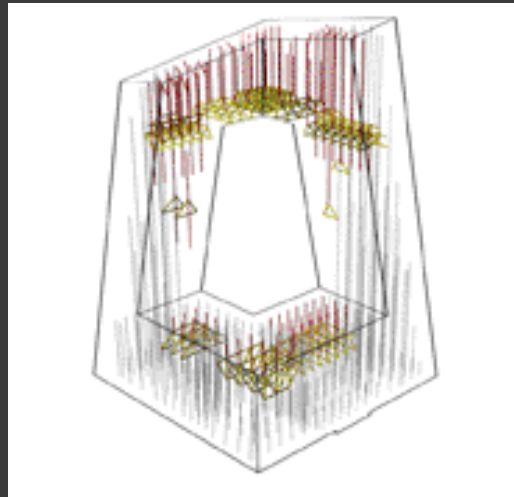
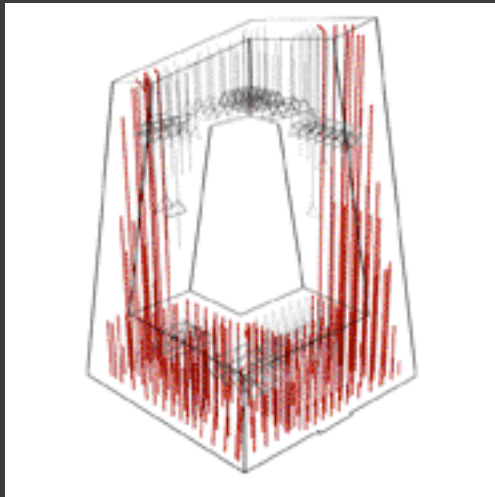
Excavation & Foundation

◎ Foundation:

- Two separate piled raft foundations support the two connected towers
- 370 reinforced concrete bored piles beneath each (133,343 cubic meters of concrete in total)
- Each Pile contains 39,000 cubic meters of concrete and 5,000 tons of reinforcement



Substructure and Foundations



Substructure and Foundations

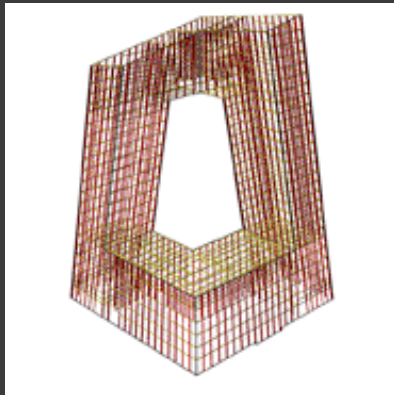
- ◎ Towers: stand on piled raft foundations
 - The piles are typically 1.2m in diameter, and about 52m long
 - Towers to act as a toe, distributing forces more favorably into the ground
 - The foundation system is arranged so that the center of the raft is close to the center of load at the bottom of each Tower, and no permanent tension is allowed in the piles. Limited tensions in some piles are only permitted in major seismic events.



Systems

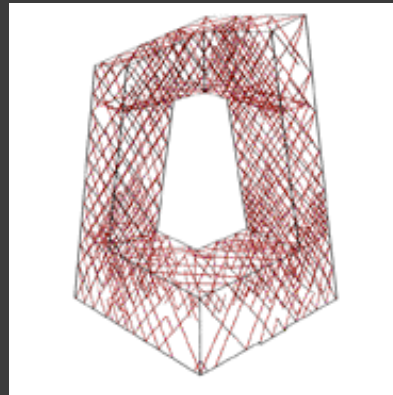
Continuous Braced Steel Tube Structure

- Diagrid system exoskeleton: Superstructure - the 'continuous tube'
 - Adopting this approach gave proportions that could resist the huge forces generated by the cranked and leaning form, as well as extreme seismic and wind events



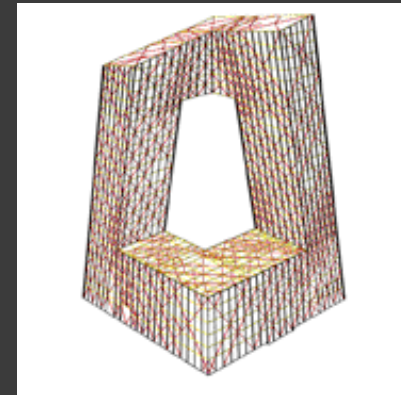
Regular grid of columns
and edge beams

+



Patterned diagonal
bracing

=



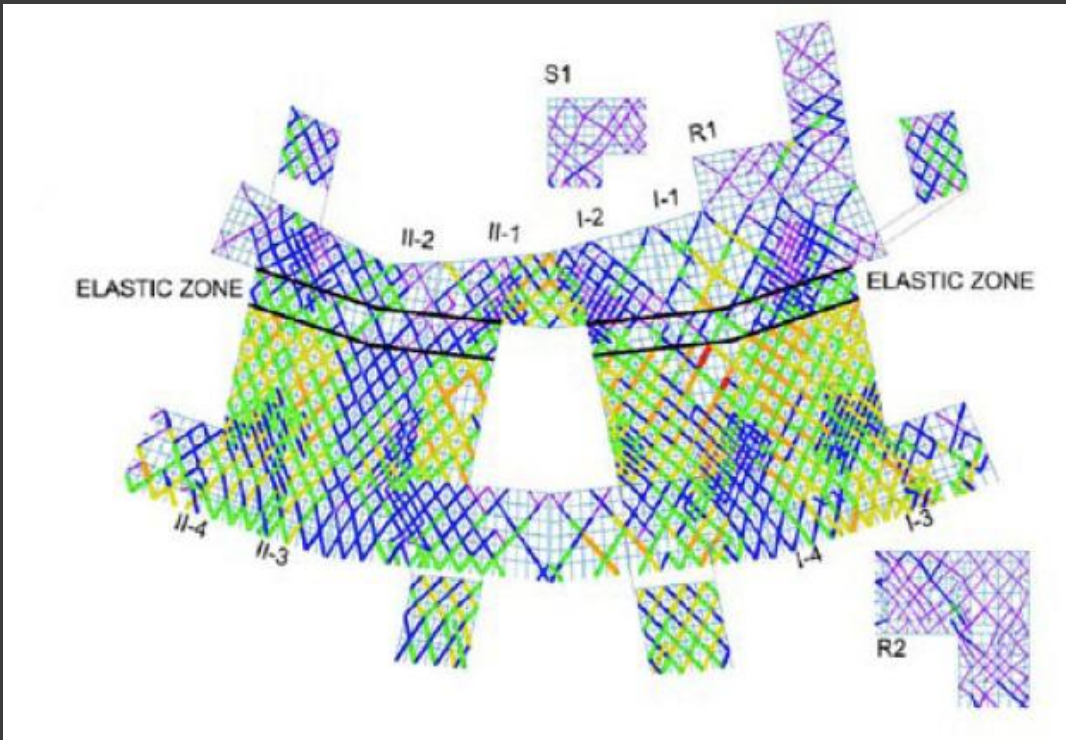
Braced tube system

Systems

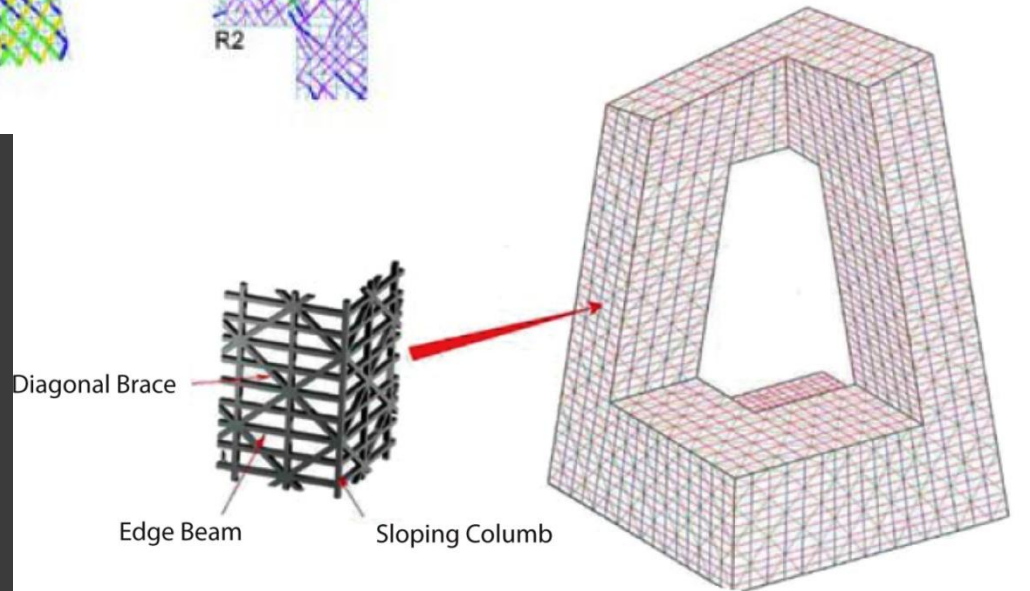
⦿ Tubes and Columns

- This 'tube' is formed by fully bracing all sides of the façade
- The planes of bracing are continuous through the building volume in order to reinforce and stiffen the corners





Final bracing pattern



Original bracing pattern

Systems



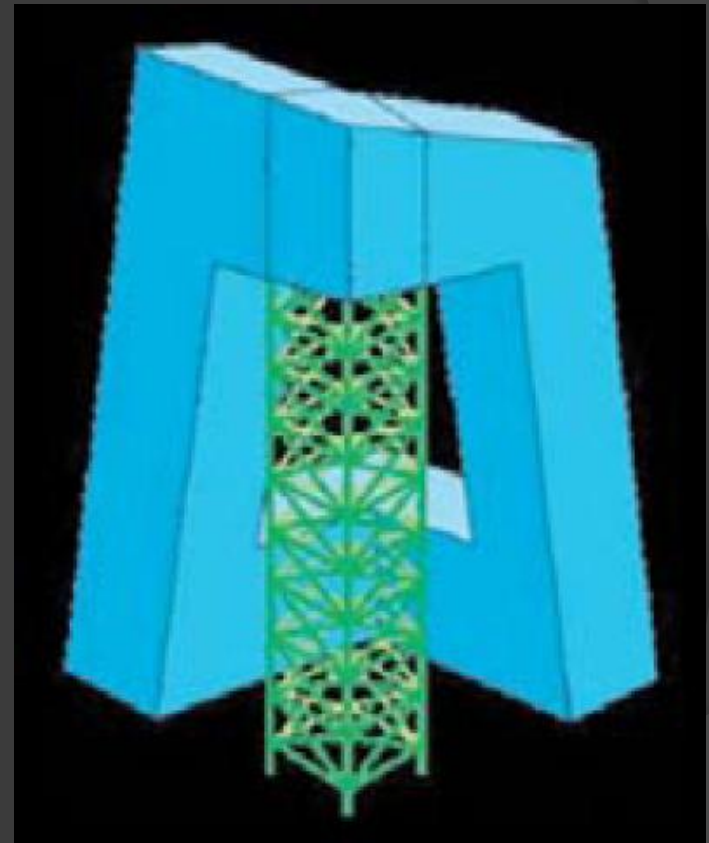
- Triangles are dense in regions that bear heavy loads and sparse where loads are light

Construction Issues

- ⦿ Construction sequencing and its effect on the final stress in the structural elements
- ⦿ Ensuring the building and elements were constructed to the designed setting out and positions, within allowed construction tolerance
- ⦿ Construction and linking of the overhang

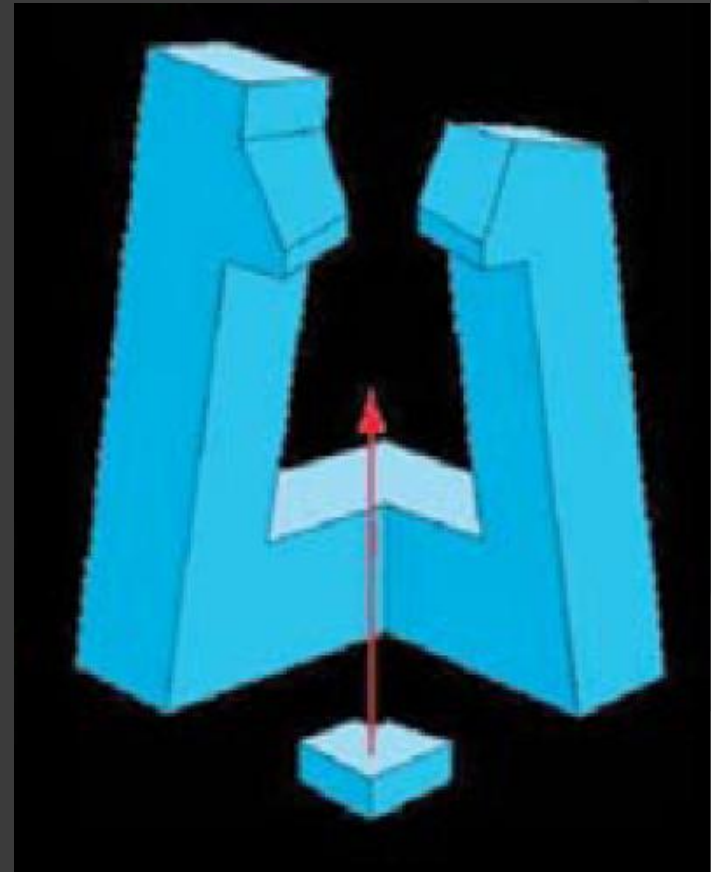
Construction of the Overhang

- ◎ **Proposed method 1:**
Constructing a temporary tower at the full height of the overhang to use as a platform for construction of the overhang in-place



Construction of the Overhang

- ◎ **Proposed method 2:**
Constructing the base of the overhang on the ground, then lifting it into place between the two towers



Construction of the Overhang

- **Chosen method:** Constructing the overhang as a series of cantilevers from each tower until they meet in the middle

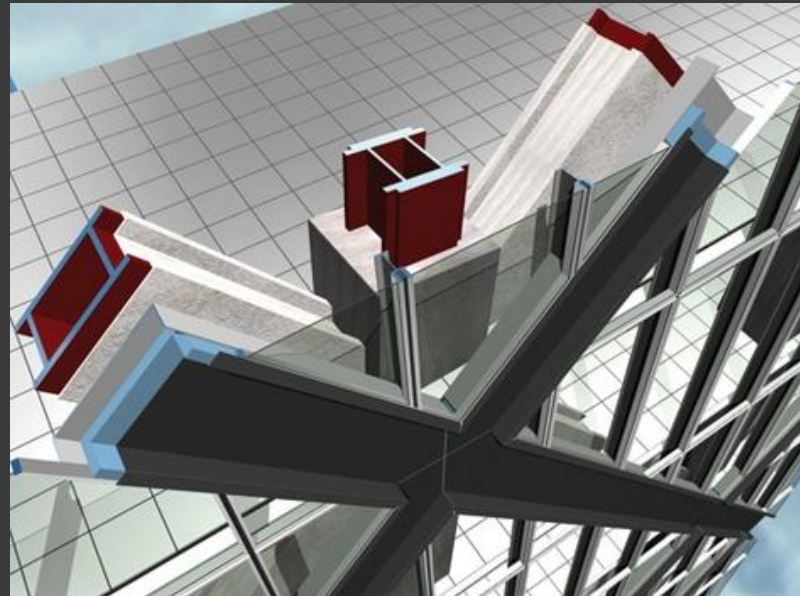


In The Wake of the Shake

- ◎ Performance based design
 - Level 1- No structural damage
 - Level 2- Minor repairable damage, columns remaining elastic and unaffected
 - Level 3- Severe damage is allowed as long as the structure does not collapse



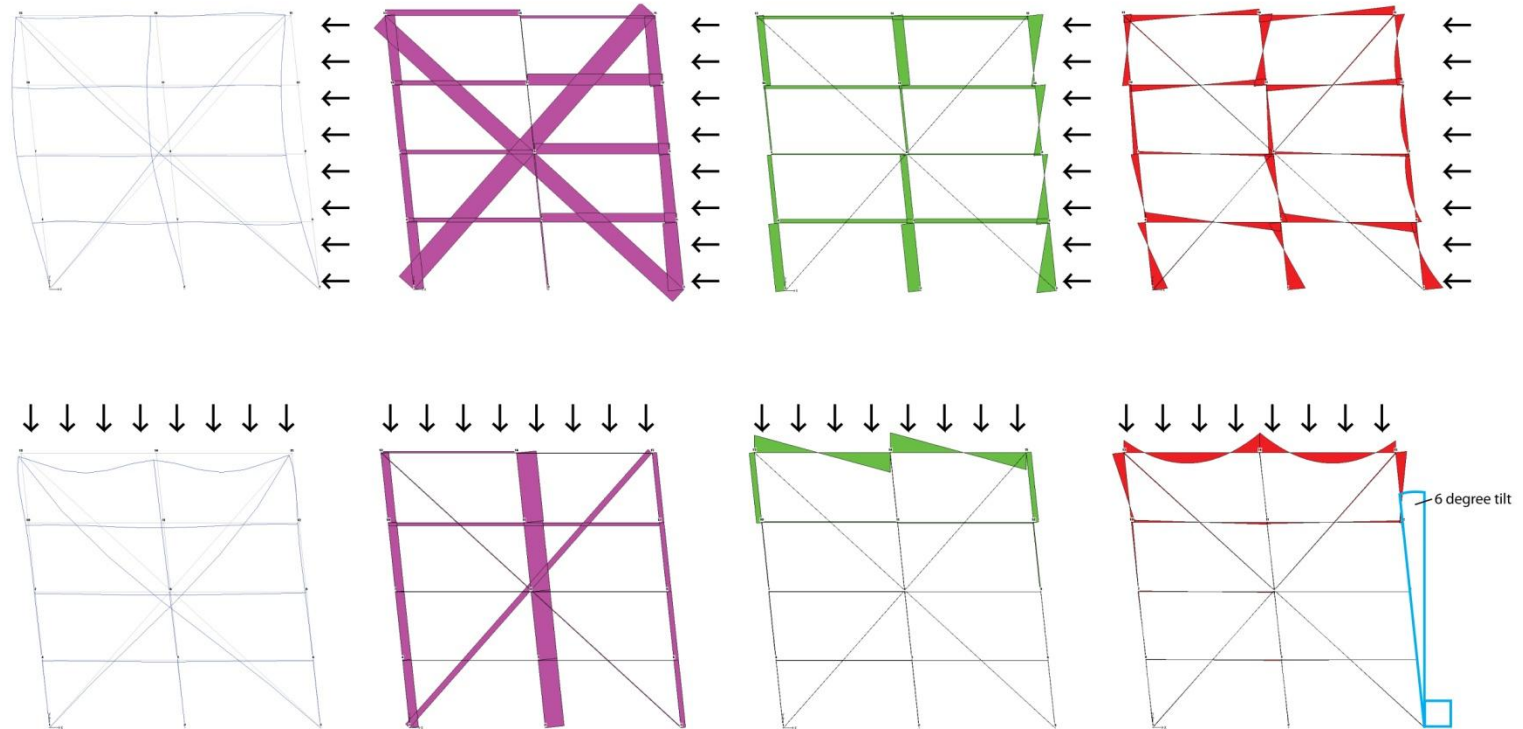
- ⦿ Programmatic features dictated much of the design: two-storied studios led to diaphragms only being added every other floor
- ⦿ Exterior diagrid resists lateral and vertical loads
- ⦿ Built with a high degree of redundancy



- ⦿ Computer testing with Limit State Design Criteria- had to prove that the buckled tubing could still support gravity loads after a quake
- ⦿ 1:20 scale model produced and observed on a shake-table



Multiframe Analysis



Architectural Renderings



Bibliography

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