THE ELEVATED CUBE

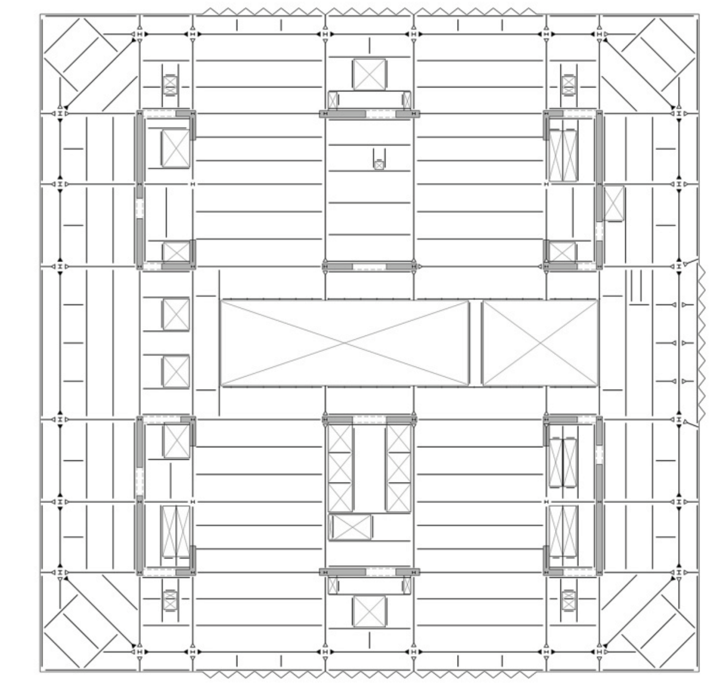
Los Angeles' New United States Courthouse is an 11-story cube of shimmering glass that floats over the streets of downtown. The building is designed to catch and use daylight effectively throughout the interiors, while the façade is self-shading to increase energy efficiency. In response to blast safety and seismicity requirements, the design-build team developed an innovative core and truss structure that allowed the building to float with a 33-ft cantilever in all directions.

Skidmore, Owings & Merrill LLP joined with Clark Construction as a design-build team. During the initial design phases, a collaborative group of consultants and design-assist subcontractors were engaged to help meet the project's design and performance goals established by the client, the General Services Administration (GSA). The Courthouse is designed to achieve LEED® Platinum Certification.

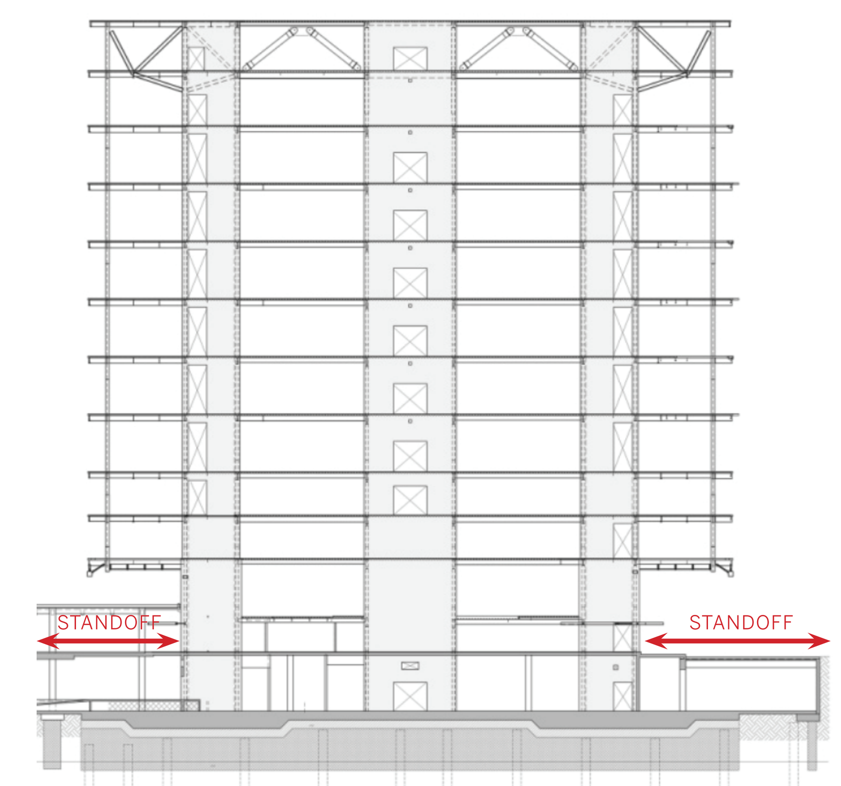
THE CONCEPT: FLOATING THE STRUCTURE FOR INNOVATIVE BLAST PROTECTION

Responding to blast mitigation and security considerations, the design concept for the 633,000-sq-ft facility is based on a novel idea of elevating the building above a large civic plaza by removing all vulnerable ground-level perimeter columns and supporting the entire structure on hardened-concrete shear wall cores.

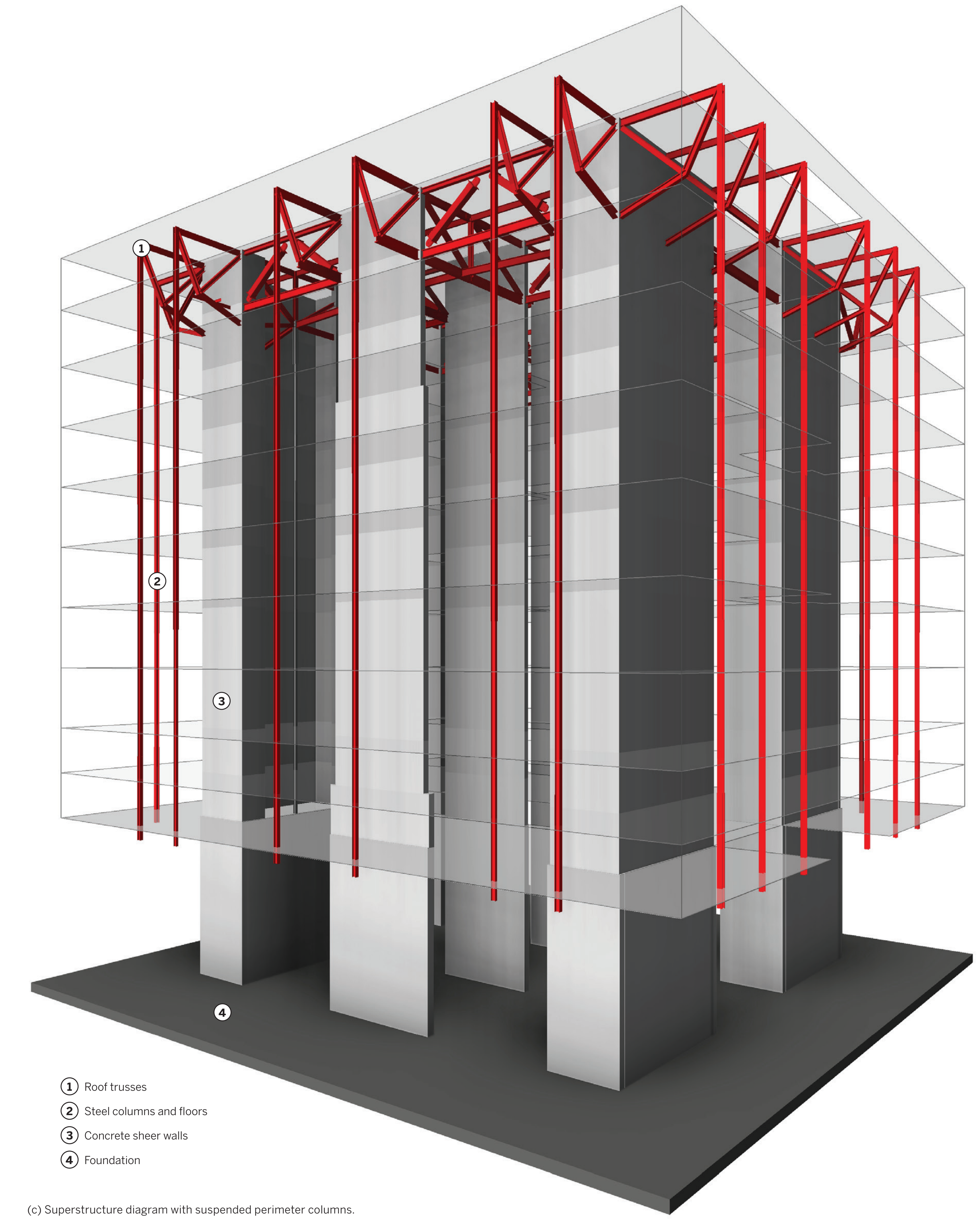
The open plaza area provides greater standoff distance from the neighboring streets; mitigating the potential impact of blast threats, and allowing the cubic massing to appear as a singular, hovering form. Four robust primary building cores support a three-dimensional steel roof truss system which cantilevers symmetrically to the building perimeter, supporting the vertical loads of the building's outer 33-ft. All perimeter columns are hung from this truss system. A high performance unitized curtainwall façade was also designed to meet the building's blast requirements.



(a) Typical floor framing plan.



(b) Typical building section, showing how the standoff distance was increased by incorporating a 33-ft cantilever in all directions for blast protection.



(c) Superstructure diagram with suspended perimeter columns.

NEW UNITED STATES COURTHOUSE – LOS ANGELES

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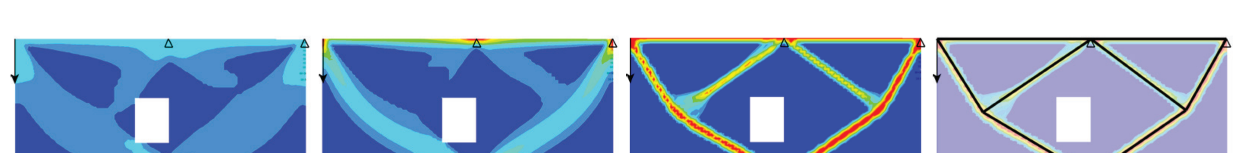
OPTIMIZING THE CORE AND TRUSS SYSTEMS

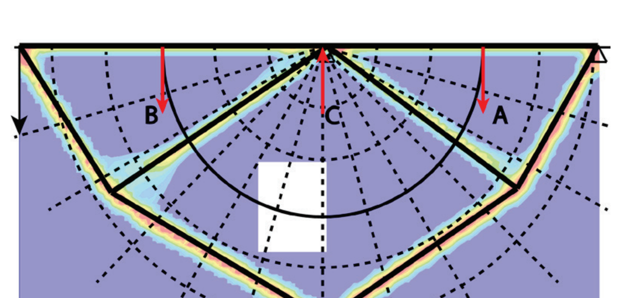
The lateral system consists of four primary reinforced concrete shear wall cores that correspond directly to the program organization and are designed to act as organizing elements for stairs and mechanical rooms, providing lateral stiffness from the foundations through the entire height.

One of the project's most significant design challenges was that the gravity loads from the perimeter columns needed to be carried back to the reinforced concrete core elements. The layout of the roof truss system was inspired by a series of in-house studies on optimal truss geometries based on Michell's early 20th century work on frames of least weight, also known as Michell trusses. These truss systems represent the stiffest layouts for the least amount of material in a continuum, and were chosen for the Courthouse due to the high floor-to-floor elevations, and favorable coordination with the MEP layout.

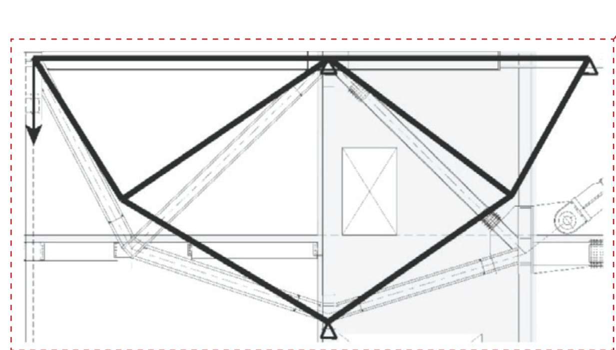
The final optimized geometric form is similar to a bicycle wheel, and resulted in material savings of approximately 15% when compared to the most efficient conventional trusses. Each cantilevered corner of the building is completely column-free, accomplished using a "layered" cantilevered beam framing approach to control displacements while minimizing the steel needed.



(a) Truss optimization iterations.



(b) Overlay of optimal Michell Truss.

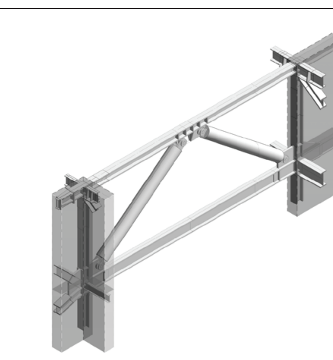


(c) Final truss design with overlay of optimal solution.

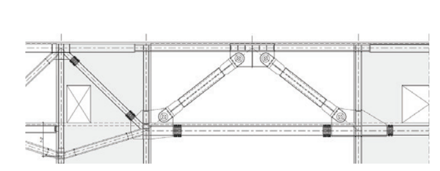
BUCKLING RESTRAINED BRACES

Another challenge was that the shear wall cores were best suited as rectangles, leading to a "weak" direction (north-south) that exceeded the allowable story drift given the high seismicity of California. Rather than a conventional optimization process of increasing wall thicknesses, an idea was developed to use the roof truss as a "mega" coupling beam at the top story.

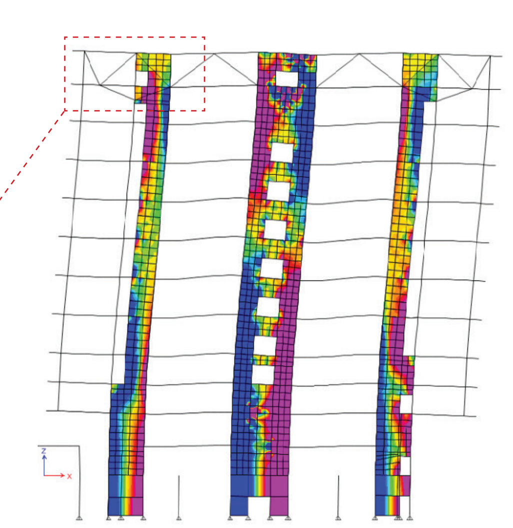
16 ductile buckling restrained braces (BRBs) were used as linking diagonals between the shear walls to control seismic drifts in the weak direction, and the structure became strength-controlled rather than stiffness controlled. Fabricator Herrick Steel assisted SOM in the final detailing of the truss connections and node joint configuration, providing iterative comments in working sessions to determine the most economical and efficient joints.



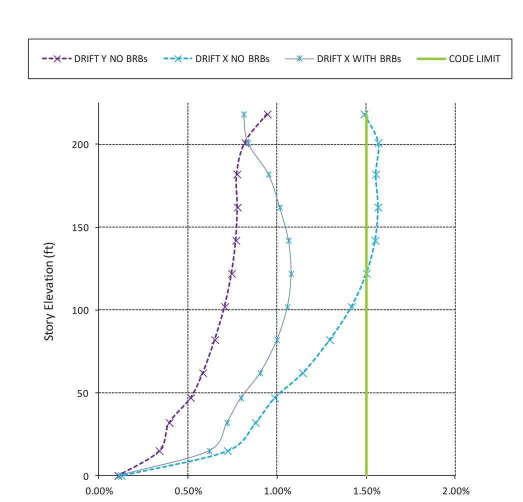
(a) The linking truss: isometric view of BRBs.



(b) The linking truss: elevation of BRBs.



(c) Axial stress due to lateral loading (induced double curvature deformation).



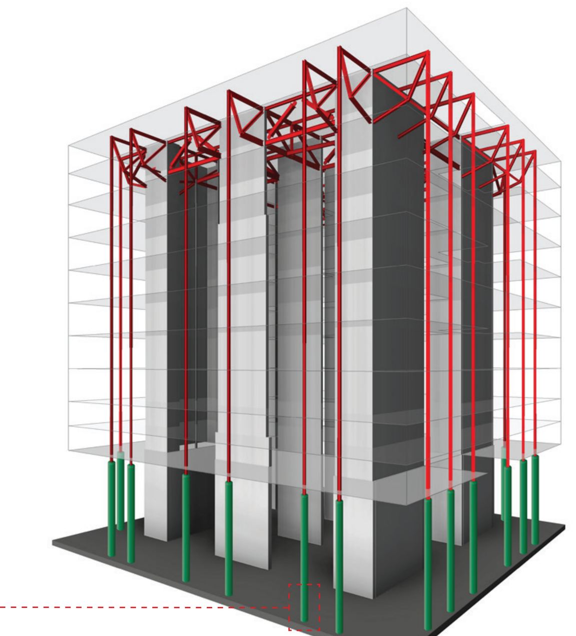
(d) The linking truss: influence in weak axis (x) drift.

CONSTRUCTION SEQUENCE AND TEMPORARY SHORING

A conventional construction sequence would have more than doubled the schedule for the superstructure, and increased the cost of construction beyond feasibility. Instead, a bottom-up procedure was followed by erecting perimeter columns on top of 48-ft-tall steel temporary shoring columns until the roof trusses were completed and perimeter columns could be suspended. Design criteria accommodated the downward vertical movement that occurred when columns were transferred from compression to tension via jacking devices in the basement.

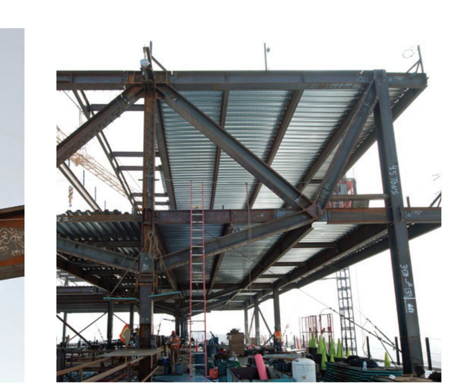
Early collaboration across the design-build team was critical to success. Nonlinear staged construction analyses were performed using ETABS 2013, and deflections at critical stages were tabulated. Relative elastic deflection between the perimeter columns and the core walls was studied at each level in combination with creep and shrinkage analyses. Corrections in floor elevations at the perimeter locations were determined for construction. More than 400 chevron braces were installed and removed as concrete floors were poured. Clark Construction closely managed the critical path construction sequencing.

(a) Jacking devices in the basement.



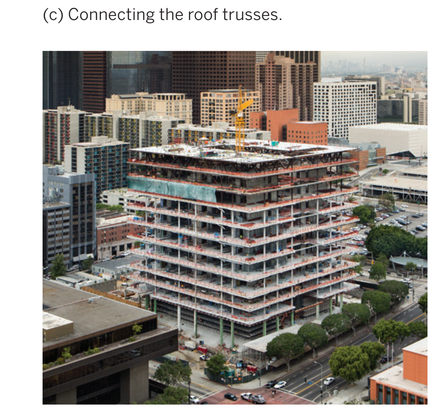
(b) Superstructure diagram with temporary shoring columns in green.

(c) Connecting the roof trusses.

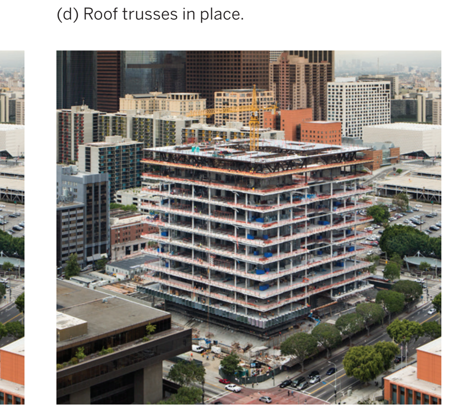


(d) Roof trusses in place.

(e) Column-free cantilevered corner framing.



(f) Temporary shoring columns in place.



(g) Curtainwall installation commences.

(h) Curtainwall installation begins as final shoring is removed, to meet critical path sequencing.

PROJECT CREDITS

Architect and Structural Engineer:
Skidmore, Owings & Merrill LLP with Clark Construction (design-build team)

General Contractor: Clark Construction

Client: U.S. General Services Administration (GSA)