UCSF CLINICAL SCIENCES BUILDING

Seismic Rehabilitation

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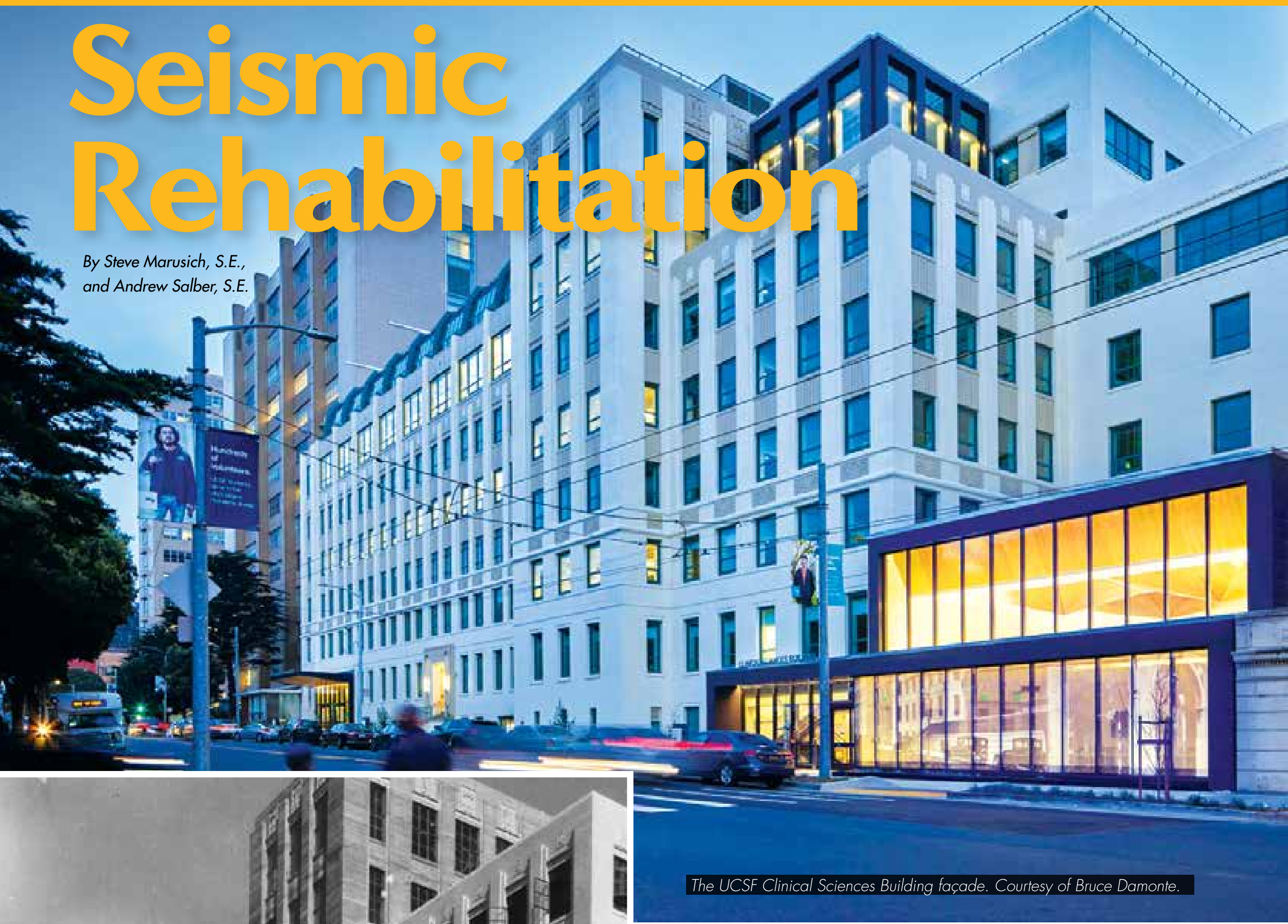


The UCSF Clinical Sciences Building façade. Courtesy of Bruce Damonte.

CSB exterior view circa 1930s.

The Art Deco-inspired Clinical Sciences Building (CSB), located on the University of California, San Francisco (UCSF) Parnassus Heights Campus, originally served as the school of dentistry when it opened in 1932. In the 80 years since, CSB has been in continuous service, providing much-needed clinical, office, academic, and research space for the campus. Unfortunately, being approximately 5 miles from the San Andreas Fault, the building is expected to experience significant earthquake ground shaking, which it was not originally designed to withstand. To reduce this risk, UCSF recently completed a seismic rehabilitation of CSB to extend the life of this vital building for at least another 80 years.

Existing Structural System

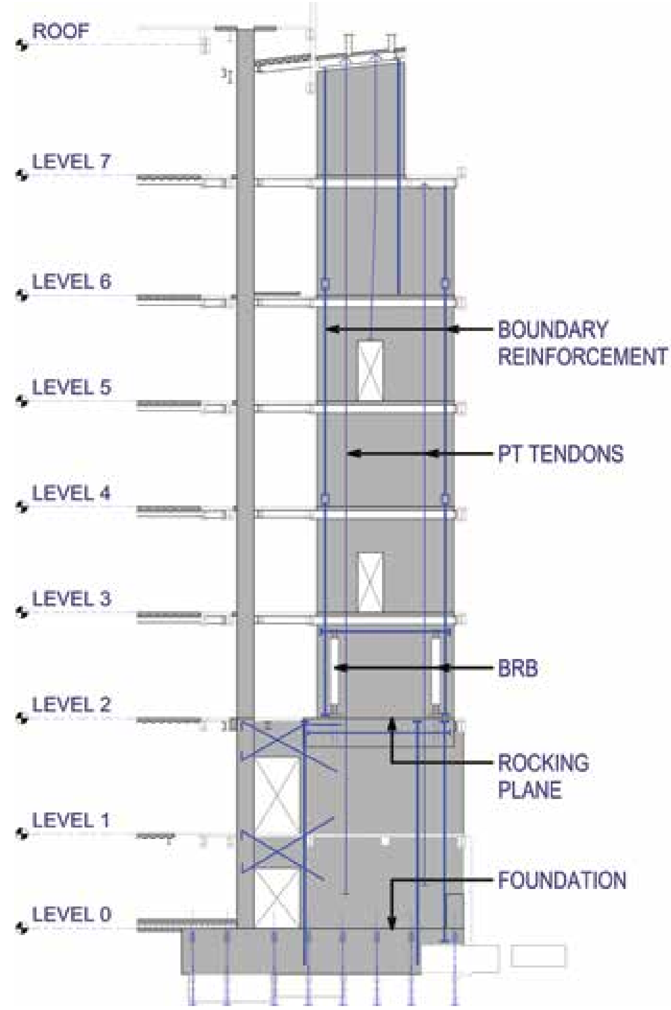
The seven-story, 108,000 gross square-foot building consists of 4-inch-thick, one-way concrete slabs supported by a complete steel frame founded on concrete spread footings. The façades are 7-inch-thick, board-formed punched concrete walls. Lateral loads are resisted primarily by the nonductile concrete façade and additional 6-inch-thick concrete walls around interior stair and elevator cores.

Performance Objectives

Previous seismic studies indicated that CSB posed a severe risk to occupant safety in a major seismic event. Given its historical significance and the limited land available on campus, the University opted to seismically rehabilitate the building. The project had to meet the University's minimum seismic standards, similar to the Basic Performance Objective for Existing Buildings per ASCE 41-13, *Seismic Evaluation and Retrofit of Existing Buildings*. However, UCSF also sought to improve functional recovery time in a moderate earthquake and repairability in a major earthquake to align the building's performance with its intended use supporting faculty at the adjacent mission-critical hospital. After coordination with UCSF's Seismic Review Committee, the Damage Control Structural Performance Objective (S-2) in a moment magnitude 7.5 deterministic earthquake on the San Andreas Fault was added to the overall criteria to achieve UCSF's goals. Since functional recovery is highly dependent on the performance of the nonstructural systems, the criteria also targeted the Operational Nonstructural Performance Objective (N-A) for systems critical to re-occupancy.

Vertically Post-Tensioned Rocking Shear Walls

The project utilized vertically post-tensioned rocking shear walls to improve the seismic performance of the building. Unlike conventional shear walls, rocking walls tend to remain essentially elastic, with the walls rotating in a rigid body manner around the base. This allows the rocking walls to distribute lateral deformations more uniformly over the height of the building. For CSB, the use of rocking walls resulted in distributed cracking throughout the façade rather than concentrated areas of damage, which was beneficial for re-occupancy after a major earthquake.



Rocking shear wall elevations.

Post-tensioning anchorage and ducts.

The walls only have a limited amount of reinforcement and vertical post-tensioning connecting the walls to the foundation to allow the rocking motion. The reinforcement provides hysteretic damping, while the vertical post-tensioning provides additional stiffness and an elastic re-centering force.

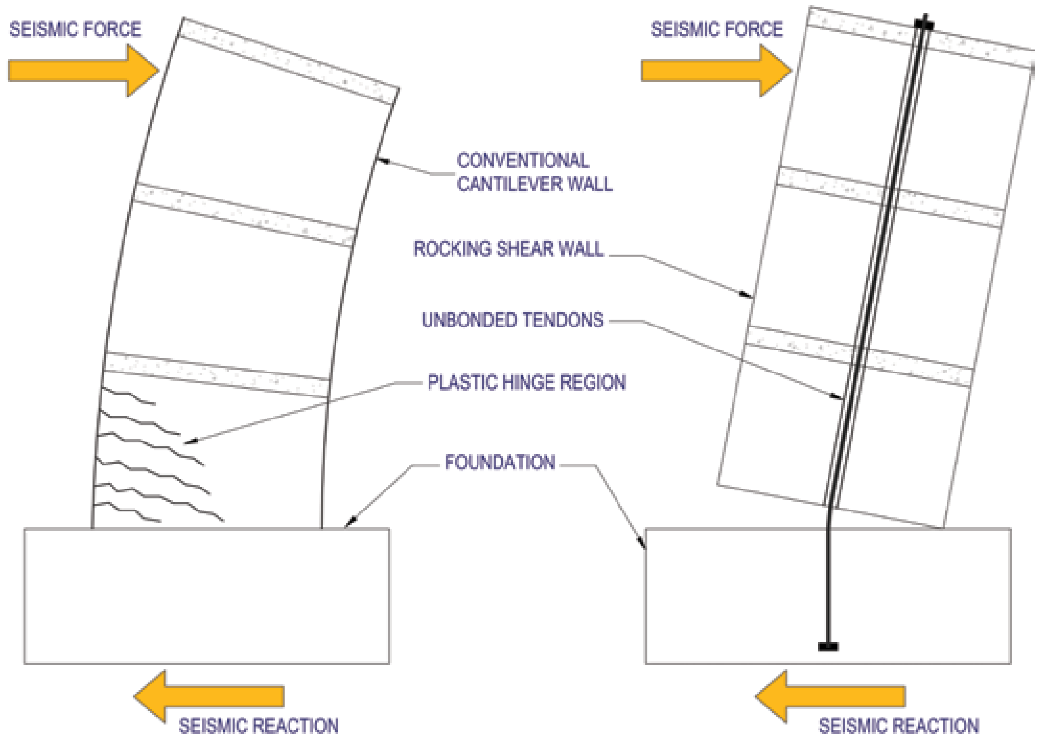
In traditional rocking walls, the reinforcement is typically internal rebar that is unbonded for a few feet above the rocking plane to limit strain demands on the bars. However, for CSB, external damping devices were used to allow easier access for post-earthquake inspections. In addition, because of the modest vertical velocities, hysteretic devices were preferable to viscous dampers.

Consequently, vertically oriented buckling-restrained braces (BRBs) were provided near the ends of the walls. The BRBs were sized to fit within the available floor-to-floor height and limit the ultimate strains to less than 3.0%. The BRBs were attached to the walls with base plates using fully-tensioned threadbars to reduce the possibility of slip at the wall interface.

An unbonded multi-strand post-tensioning system was used for the walls to maximize the available vertical post-tensioning force. For similar bar strain reasons, the vertical post-tensioning was unbonded and ran in ducts the entire height of the walls. The tendons were anchored just above the foundation and at the top of the wall in locations that could be easily accessed in the future. Because the tendons are unbonded, a fully encapsulated system was used for corrosion protection. The vertical post-tensioning was proportioned so that the restoring force would overcome the BRBs compressive strength, ensuring re-centering of the wall.

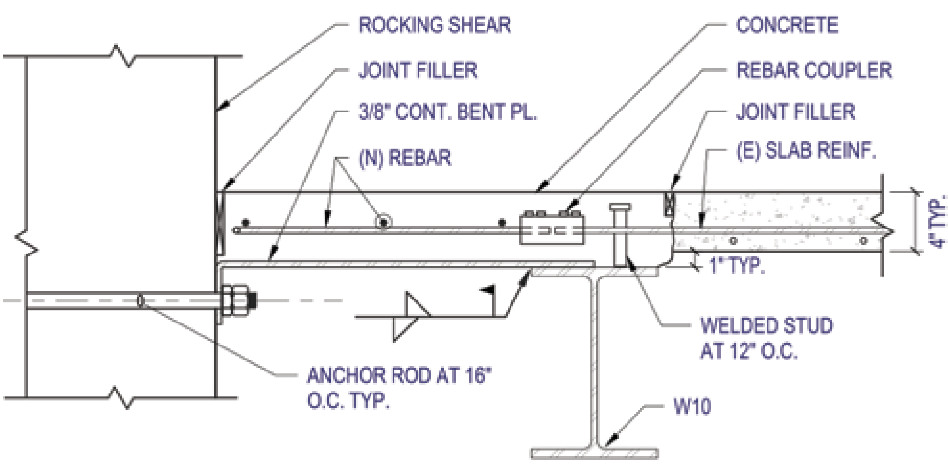
Wall-to-Slab Connections

Interaction between the rocking walls and the existing structure was an essential consideration in the design. The ends of the walls were anticipated to uplift as much as 2 inches. Where the rocking walls were adjacent to interior framing, the existing steel connections were determined to have sufficient capacity to accommodate the anticipated rotational and axial demands without compromising gravity support. However, this approach was not possible where the rocking walls abutted the existing historic façade. In these locations, the façade would resist the rocking motion resulting in undesirable damage to the façade and adjacent framing connections.

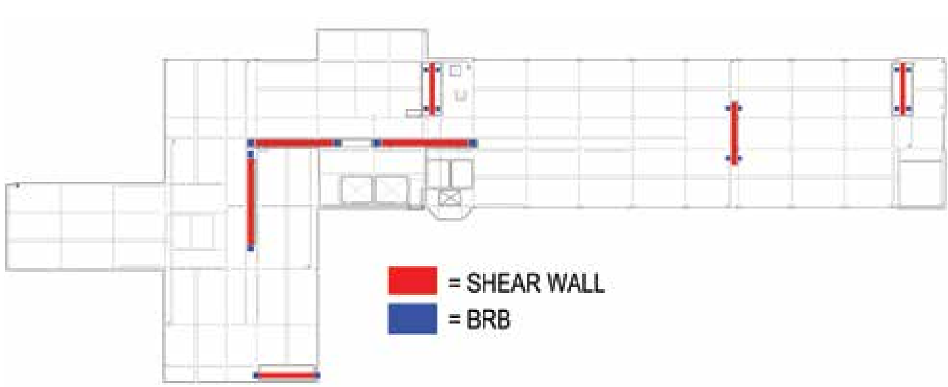


Comparative response of conventional and rocking walls.

Laterally stiff but vertically flexible connections were developed to connect the walls to the adjacent structure to resolve this issue. A bent plate was used based on its reliability and predictability. It was designed to allow the wall and surrounding floor to move independently in the vertical direction while enforcing deformation compatibility in the horizontal directions. The bent plate was welded to the adjacent collector beams and bolted to the rocking walls to transfer lateral forces. The bent plate was covered with nonstructural concrete to create appropriate acoustic and fire separations.



Flexible wall-to-slab connection detail.



UCSF CSB shear wall layout.

Conclusion

With the rehabilitation project now complete, the Clinical Sciences Building provides UCSF with a modern, inviting, and seismically safe facility to continue its mission of "*Caring, Healing, Teaching, and Discovering*." The innovations implemented into the design were only possible through the openness and collaboration of UCSF, the design team, and the contractor. As UCSF works to revitalize its Parnassus Heights campus, CSB will feature prominently as a vital reminder of the University's past as they look to the future.▪

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