San Francisco's new Zuckerberg General Hospital effectively combines state-of-the-art seismic engineering and medical technology with features designed to provide compassionate care for patients.

Engineering the HEART of the City

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SAN FRANCISCO GENERAL HOSPITAL came into being not long after the gold rush of 1849.

More than a century-and-a-half later and following several expansions, its latest iteration was helped along by and named for a pioneer of a different sort of gold rush—the social media boom—Facebook founder Mark Zuckerberg. Along with wife Priscilla Chan, Zuckerberg provided $75 million in funding for the new facility, the Zuckerberg San Francisco General Hospital and Trauma Center (ZSFGH).

Located at the foot of Potrero Hill in San Francisco's Mission District, the new 284-bed hospital is a 550,000-gross-sq.-ft steel-framed, base-isolated building with seven stories above grade and two basement levels. The facility replaces the most recent SFGH, which was built in 1974 and did not comply with the seismic safety requirements set out in California Senate Bill 1953 (passed in 1994). The new general acute care facility, which opened this past spring, provides the most up-to-date equipment and technology in full diagnostics and treatment departments, while doubling the capacity of the new emergency department.

The new Zuckerberg San Francisco General Hospital and Trauma Center is a steel-framed, base-isolated seven-story building.

A 35-ft-diameter steel halo sculpture stands at the ground-level entry of the hospital campus.

Base Isolation

ZSFGH is the only Level 1 trauma center in San Francisco County, so its seismic resiliency is paramount. The project team decided early in the design process to integrate base isolation—one of the most advanced earthquake-resistant methods in use today—in the design of the steel-framed building. Steel is an ideal framing material for a base-isolated structure because steel-framed floors are relatively lightweight, greatly reducing the demands—especially uplifts—on the base isolators and foundations. The steel superstructure is supported on 115 triple-pendulum bearings (manufactured by Earthquake Protection Systems), a pioneering isolator type that allows the building to slide 30 in. in any direction. Around the perimeter of the building, a 3-ft-wide moat between the top of the mat foundation and the finished grade accommodates movement of the isolated structure. In the event of a major earthquake, the new hospital is designed to remain fully operational and serve as an emergency response center.

This project challenged the common perceptions that base-isolated buildings are too expensive or take too long to build, proving that with proper planning and close collaboration among team members, base isolation can be a cost-effective system to integrate into a building without increasing the project schedule. For ZSFGH, the City adopted integrated project delivery (IPD), assembling the design team and general contractor to work collaboratively during design, which helped to compress the project schedule to meet the Senate Bill 1953 deadline.

The IPD method facilitated a number of cost- and time-saving strategies. For example, the design team implemented prototype bearing testing in the early design phase of the project, which was made possible by efficiently identifying the best bearing type and isolator sizes for the project. Following the city's successful commissioning of early prototype bearing testing, the team used the prototype testing results to optimize the superstructure design. This strategy led to early procurement of the

➤ The cruciform-shaped steel column base was shop-welded, while the moment connections to the adjoining beams were field-bolted to eliminate self-straining stresses due to weld shrinkage.

➤ The steel-framed superstructure is relatively lightweight and reduces demands on the base isolators and foundations.


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isolators and an early steel bid package, as well as significant cost and material savings when it came to the structural steel.

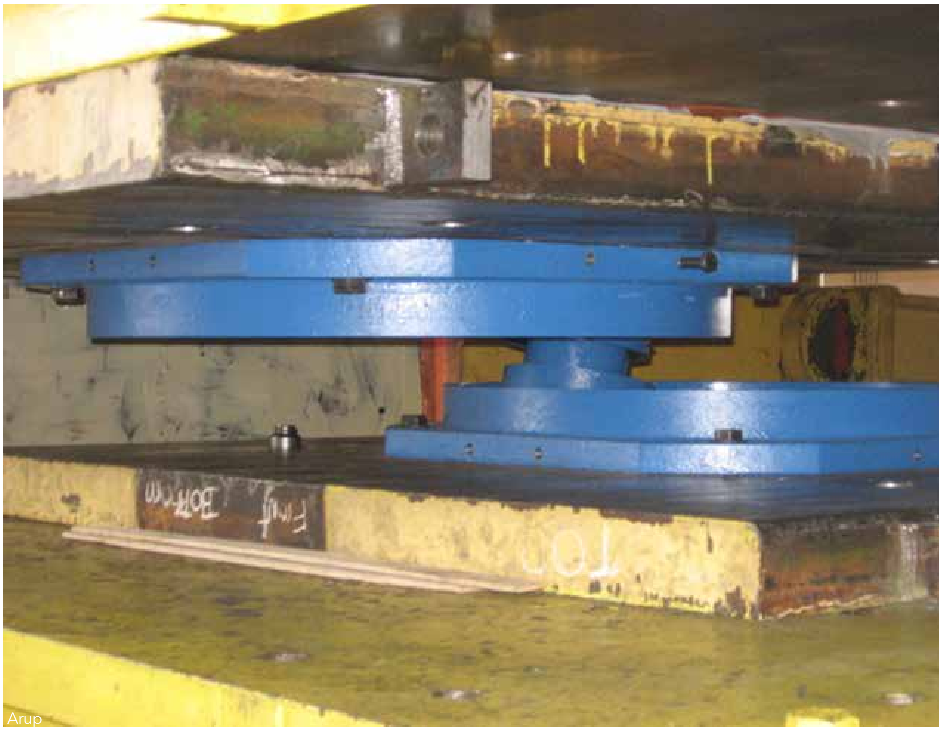
It's also important to note the benefits that the project's base-isolated design has over a conventional fixed-base design, including performing much better in a major earthquake, better protecting the building's contents and allowing the superstructure to withstand maximum-considered-earthquake-level earthquakes and remain elastic. In a fixed-base design, the moment frame connections would yield, and replacing them would be difficult and expensive, resulting in significant downtime. In addition, floor accelerations in the base-isolated hospital are significantly reduced, which results in lower demands on the anchorage and bracing for equipment and nonstructural elements.

Compared with a conventional fixed-base design, the base-isolated design also used significantly less steel—as in 3,000 tons (the project used 8,500 tons of steel in all). A fixed-base design would have also required deeper columns and beams, thus limiting the space available for utilities and make coordination more difficult. Base isolation allowed steel intermediate moment frames to be used for the superstructure, and a fixed-base building would have had to meet requirements for steel special moment frames, leading to additional building costs.

Superstructure

The hospital has two distinct floor plans: a four-story rectangular podium and a five-story bed tower comprising two interlocking circular cylinders bisected by a parallelogram core. The glazed cylindrical tower houses the patient rooms and support spaces, while the brick podium houses the diagnostic and treatment departments. The framing system uses composite flooring supported by steel beams and girders, which in turn are supported on steel wide-flange and built-up cruciform columns.

➤ A triple-pendulum bearing was subjected to lateral displacement during the prototype testing.



▲ Prototype bearing testing early in the design phase.

➤ The building is supported on 115 of these bearings, allowing it to slide 30 in. in any direction.

As the building transitions from the rectangular podium to the cylindrical tower, transfer beams of W36 sections are used at levels 2 and 3 to receive the W10 columns supporting the inpatient beds and rooftop garden in the cylindrical tower above.

To accommodate ZSFGH's ambitious program and the significant amount of overhead utilities typically required in a hospital, steel moment frames were selected in lieu of braced frames or shear walls, as the lateral resistance system to create more space for an efficient health-care floor layout. The moment frame beams are W27 and W36 sections, and the moment frame columns consist of W27 and W36 wide-flange columns and flanged cruciform columns for orthogonal moment frames. High-strength steel plate (65-ksi) is used for built-up wide-flange columns at selected locations for increased capacity.

Constructability was a central focus when designing the steel details of the new hospital, exemplified by the steel column base detail. Cruciform-shaped steel column bases are placed above the isolators to resist the offset between the superstructure and the isolators that occurs when the isolators undergo large displacement. The cruciform column bases are shop-welded and delivered to the site as modular assemblies, which enhanced installation and saved time in the construction schedule. In addition, splices of the beams adjoining to the cruciform assemblies are field-bolted moment connections—not welded—in order to eliminate the self-straining stresses due to weld shrinkage that would impose on the structure.

In the X-ray, radiology, resuscitation and operating rooms—where the overhead ceiling spaces are the busiest—a steel overhead-equipment-support modular grid supports all of the overhead medical equipment such as lights and booms. The modular grid is composed of horizontal HSS4×3 and HSS3×3 sections forming an orthogonal grid, which is hung from the

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Steel canopies at the top of the sunshade fins are visible from the rooftop terrace garden.

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Overhead medical equipment is supported by a steel modular grid hung from the floor beams above.

floor beams above through unistrut drops. Unistrut bracing provides lateral stiffness for the support grid, and this modular grid facilitated the coordination and installation of utility runs, ductwork and equipment supports in these vital rooms.

Exposed Steel

A number of exposed structural steel components are featured on the hospital campus. A vertical fin sunshade structure, built from HSS8×8 steel sections, was placed on the south- and west-facing facades of the podium structure. The sunshade elements are oriented according to the path of the sun and are painted in bright white. Expressive steel canopies at the top of the curved facade's sunshade fins are also visible from the rooftop terrace garden, which is open to the public.

A steel halo sculpture—a 35-ft-diameter ring cantilevered off of two 16-ft-tall columns—stands prominently at the ground-level entry of the hospital campus. The halo is built from 14-in.-diameter stainless steel pipe sections, with the ring and elbows fabricated to fit the architect's curved geometry design. On the opposite side of the campus, a trussed pedestrian bridge with exposed HSS6×6 provides the important pathway between the new hospital building and the original medical facility at the second floor.

Heart of Gold

The material-saving base isolation system is one of the sustainable design features expected to earn the hospital a LEED Gold certification. Other green features include the use of building materials containing at least 30% recycled content, including steel, ceiling tiles, porcelain tiles, terrazzo flooring and Forest Stewardship Council-certified wood. The hospital also features full-height curtain walls that use low-emissivity glass and insulation to protect against heat gain, as well as window shades and room lighting fixtures that are automatically adjusted based on sunlight levels as detected by photovoltaic sensors.

Financed by an $887.4 million voter-approved bond, as well as a record number of significant donations, ZSFGH is a city lifeline that, according to Mayor Ed Lee, "represents San Francisco's values at their best, and demonstrates that our city is a leader in innovation and compassion… for creating a world-class, seismically safe, technologically advanced and sustainably built hospital for all San Franciscans"—truly the beating heart of a vibrant city. ■

Owner
San Francisco Department of Public Health

General Contractor
Webcor Builders, San Francisco

Architect
Fong and Chan Architects, San Francisco

Structural Engineers
Arup in collaboration with Bello and Associates Structural Engineers, a Local Business Enterprise participant, San Francisco

Steel Team

Fabricator and Erector
The Herrick Corporation, Stockton, Calif. (AISC Certified Fabricator and Erector)

Detailer
Candraft Detailing, Inc., New Westminster, B.C. (AISC Detailer)

A trussed pedestrian bridge links the new hospital building to the original medical facility.

Perretti and Park

The new base-isolated building on the left serves as a replacement of the original main hospital on the right.

Perretti and Park