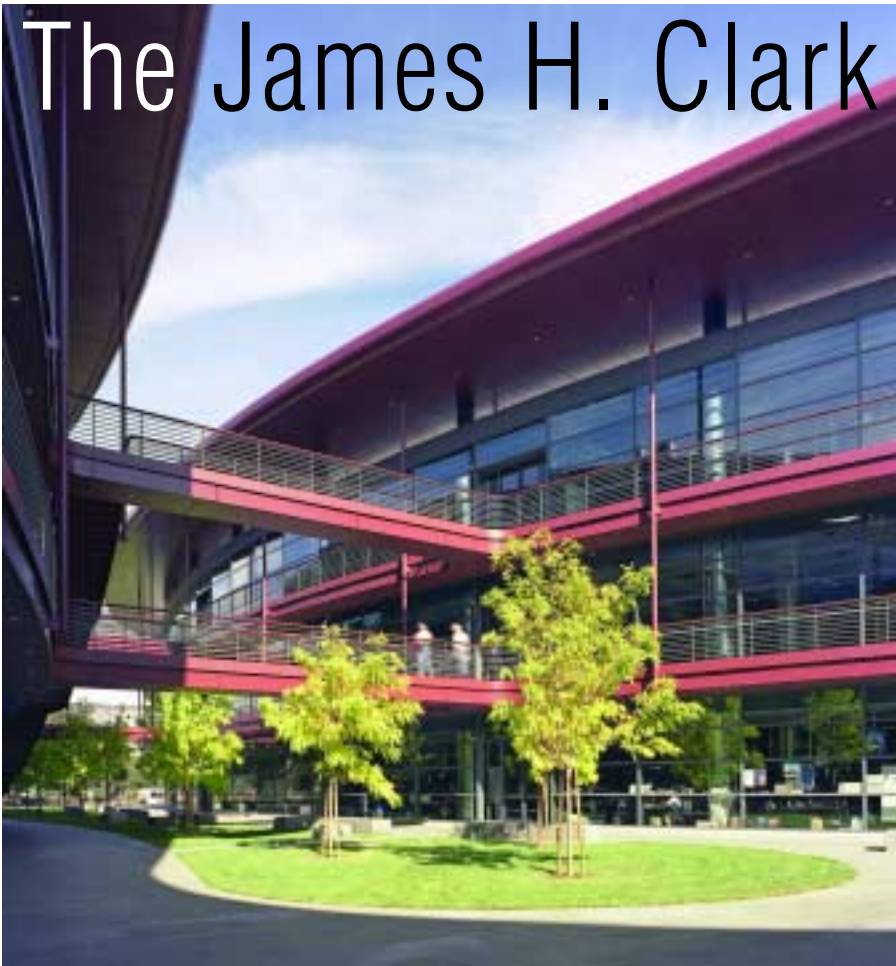


The James H. Clark Center

Stanford, CA

All photographs courtesy Paul Dileanis, Upshots Photography.



Owner

Stanford University, Stanford, CA

Architect

Foster and Partners, London (UK)
MBT Architecture, San Francisco

Structural Engineer

Middlebrook + Louie Structural
Engineers, San Francisco

General Contractor

Hathaway-Dinwiddie, Santa Clara, CA

Fabricator

Gayle Manufacturing Company,
Woodland, CA (AISC member)

Erectors

California Erectors, Bay Area Inc.,
Benicia, CA (NEA members)

Detailer

Naka Drafting, Whittier, CA
(NISD member)

Stanford University's new James H. Clark Center is a high-tech venture for advanced research in the life sciences. The 245,200-sq.-ft facility is home to "Bio-X," an ambitious program designed to dramatically improve the results of scientific research by fostering interdisciplinary collaboration between scientists from the Schools of Medicine, Engineering and Humanities & Sciences.

The Architecture

Clark Center occupies a 214'-by-421' footprint on Stanford's campus. It features a 350'-long, uncovered central courtyard open to the north. Ground-level pedestrian ways to the east and west are located near the courtyard's south end. This geometry naturally divides the complex into three unequal, separate "pods" (East, West and South). The architects designed open labs on the

curved, glazed perimeter adjacent walkways along the courtyard. This environment provides researchers a window to nature. It also allows passers-by to sense what is going on inside—an important programmatic requirement.

The complex is three stories, with a partial sub-level area. Exterior walkways, bridges and stairs provide a variety of circulation routes between the buildings. A continuous band of bull-nosed canopies slightly above roof level protect the walkways, shade the building's glass, and punctuate the vibrant architecture.

User Requirements

The design team was charged with satisfying several challenging requirements relating to vibration environment, large open spaces, lab flexibility and superior resistance to lateral (earthquake) forces.

Vibrations were of particular concern to the researchers. In terms of footfall ex-

citation, the vibration consultant established the minimum goal to be 7,000 kips per in*sec., equating to a vibration amplitude not to exceed 1,800 μ-in/sec.

The design team also had to develop a solution for the desired high ceilings, stiff floors and dense distribution of mechanical, plumbing and other services. In addition, the design required adaptable floor plates, with high flexibility for future rearrangement of space.

Juror Comment

"The elegant architectural response to the clients brief has been equally reflected in the sublime steel design and detailing."

The Structure

Due to cost and construction-schedule considerations, structural steel was the best choice for the building's framing. Each pod has its own independent lateral force-resisting system. A system of walkways completely encircles the second and third levels, with pedestrian links designed with seismic/expansion joints to prevent the transfer of horizontal forces between pods.

The entire structure is developed on a 10'-6" lab-plan module. Column spacing is dictated by the module, either 21'-0" or 31'-6". Columns, beams and girders are ordinary wide-flange sections. Nearly all floor and roof beams are 38" deep to produce stiff floor framing that satisfies vibration requirements.

Lateral force resistance is provided by a dual system of Eccentrically Braced Frames (EBF) and Special Moment-Resisting Frames (SMRF).

Unique Structural Design Challenges

The building uses normal weight concrete (4½") over 3", 18-gauge composite steel deck, on W40x149 beams and girders. Beams and girders feature closely spaced 24"-diameter holes cut through their webs. These pierced spans allow passage of utilities/services, producing considerable savings in building height.

Calculated structural-system vibration characteristics are 7,770 kips per in*sec, with an amplitude of 1,550 μ-in per second. This performance was confirmed with finite-element analysis and validated by testing of an existing, similar structure.

The SMRF beam-to-column connection (welded flange plate) was subjected to two full-scale tests. One failed at 5% rotation, the other was stopped at 4.5% rotation with capacity remaining, exceeding the 4% FEMA-350 test criteria.

Since walkways encompass the entire perimeter of the pods, live loads posed concerns for vibrations migrating into lab spaces. Cantilevered walkway beams were designed for required strength. After dead loads were in place, steel pipes were hung from roof outriggers and connected to the free ends of the cantilevers. The floor slabs of the walkways were separated at building lines. The vibration consultant confirmed the success of this "belt and suspenders" solution.

Outriggers support the roof canopy, as well as live loads from walkways and all loads from courtyard stairs. The 16'- and

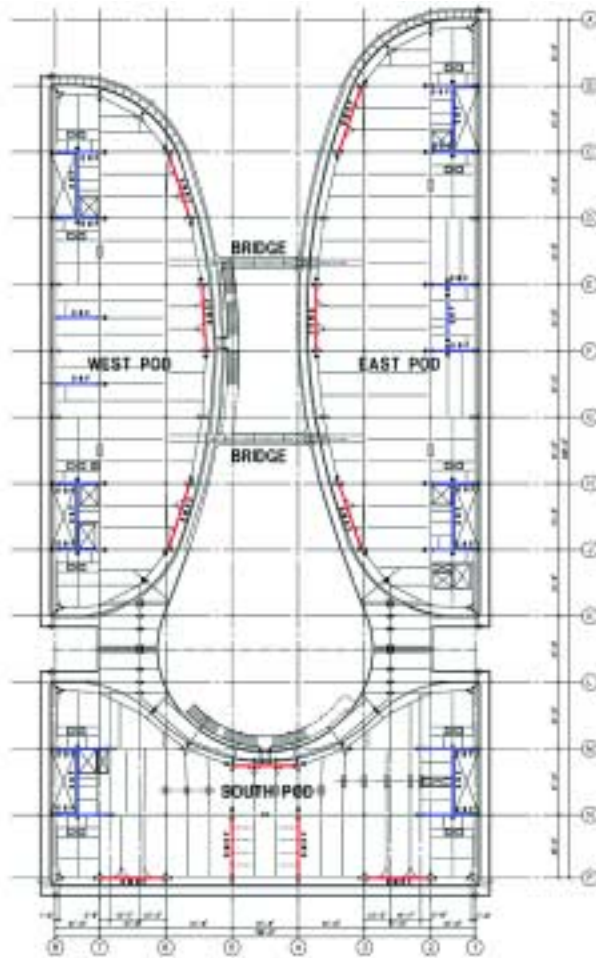


20'-long cantilevers are stiff in spite of their 4'-8" back spans.

Links between walkways include two narrow bridges over the courtyard, and two wide bridges from the south pod to east and west pods. Maximum spans exceed 60' (with 18' cantilevers), while depths are limited to the depth of walkway structure (18'-½" for steel). The narrow courtyard bridges are on "conventional" slide bearings at one end. The wider bridges between pods feature innovative, mid-span seismic separations: the second- and third-floor structures are separated entirely at mid-span and are hung from "telescopic-seismic" beams at canopy level, supporting the entire three-story-wide bridge system. They are provided with a mid-span sliding joint, where a half-beam is allowed to

move in and out (up to 15") within a welded steel box fixed to another half-beam. Top and bottom "snug" slip bearings provide a couple to transfer bending moment (5,300' kips) across the joint. Seismic separations are 10" at the 2nd and 3rd floors, 15" at the roof.

There are two types of exposed steel stairs: "exit stairs," along the exterior East and West elevations, and internal "courtyard stairs." The exit stairs are isolated from the building structure. The courtyard stairs run from ground level to the 3rd floor in continuous, curved ribbons along building lines. These stairs are hung from paired roof pipe hangers spaced 31'-6". Inter-story stair drift concerns were solved by slip bearings at two floor levels, with fixed anchorage at a third. ★



SECOND AND THIRD FLOOR STRUCTURAL FRAMING PLAN