

Cost-effective Implementation of Nitinol to Improve the Seismic Performance of an Unreinforced Masonry Building

Terrence F. Paret*

* Wiss, Janney, Elstner Associates, Inc. (WJE)

2000 Powell Street, Suite 1650, Emeryville, California, USA 94608
e-mail: tparet@wje.com, web page: <http://www.wje.com>

ABSTRACT

Congregation Sherith Israel, one of San Francisco's lesser known gems, is an historic unreinforced masonry building with a naturally lighted dome that rises over 100 feet above its centrepiece --- an ornate mural painted vaulted sanctuary that occupies nearly 90 percent of the plan area of the building. Though damaged only modestly by the 1906 earthquake that destroyed many of its unreinforced masonry neighbors, it was subject to a local seismic upgrade ordinance. Various innovative strengthening techniques --- including the first known use in North America of super-elastic nitinol for seismic resistance --- were implemented to supplement the structure's inherent strengths. The design was developed to permit all historically significant features to remain virtually undisturbed by the work and construction was completed in 2017.

Constructed in 1904 and now on the National Register of Historic Places, Congregation Sherith Israel was designed by famed architect/engineer Albert Pissis who designed a disproportionate number of extant San Francisco structures that survived the 1906 earthquake --- evidence that earthquake - resistance could be achieved reasonably well prior to the development of finite element analysis techniques. Nonetheless, the building was required by the municipality to be strengthened to meet seismic safety standards for assembly occupancy.

Following years of study, a strengthening plan that was feasible and cost-effective, yet would not harm the historic interiors and exterior was developed and installed. Construction involved an initial phase of more traditional strengthening in 2010 to maintain occupancy on an interim basis, followed by a second phase of innovative technologies to achieve full compliance.

The strengthening philosophy relied heavily on supplementing, rather than supplanting the existing buildings strengths and leveraging its natural dynamic characteristics. The nitinol was designed to provide structural "fuses" within an octagonally-configured tension tie system to promote re-centering and control out-of-phase, out-of-plane behaviour of the vulnerable gable end walls, parapet and arches that define the main facades. Though the nitinol interconnects all four gable end walls, the octagonal configuration of the system causes no disruption to the domed sanctuary by circumventing the interior dome, and the sanctuary today is in the same condition as before the project. The supplemental seismic work included a fiber reinforced polymer catenary to prevent outfall of wall segments with high height-to-thickness, and rocking compression-only pilasters to control northward (outward) displacement of a thin planar exterior wall without incrementing the demand on its floor-to-wall ties when the building sways toward the south.