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Initial Structural Assessment of Sierra Boulevard Unitarian Church Sacramento, California

Note:

This structural assessment provided is based on the current edition of the California Building Code to identify the general state of the structure in question as it pertains to current requirements. It should be noted that structural retrofit is *required* if the existing structure is modified or altered by more than 5% to the gravity system and 10% to the lateral system, but some comments identify potential structural deficiencies that could not be ascertained without further investigation.

Basic Description of Structural System:

Vertical (gravity) – Plywood sheathing over light timber rafters, joists, and girders comprise the roof structure of the auxiliary wing. In the open "sanctuary" portion, large laminated wood arches provide support for what appears to be a tongue and groove roof sheathing system. The wood elements are supported by reinforced concrete bearing walls and cast-in-place concrete columns.

Lateral (seismic/wind) – Perforated reinforced concrete shearwalls throughout; plywood diaphragm sheathing in the auxiliary portion, with tongue and groove sheathing in the sanctuary to provide the diaphragm. No major openings in the diaphragms, or discontinuities.

System and geometry relationship:

Due to the structure's hexagonal shape, the lateral analysis for a seismic event would require an increase of 30% in the forces derived by the ground acceleration and applied in the longitudinal direction of the building (i.e. along the North-South axis of the building). In the transverse direction, there are significant resisting wall lines in the direction of the applied ground motion and therefore would not require any loading increase, because the relative contribution of the skewed walls would be negligible. The Code also requires that the structure be reviewed for horizontal irregularities to determine whether or not additional design considerations would be required; the plan shape does not qualify for these irregularities, and therefore does not require any additional design consideration. One area of concern is the concrete walls being supported by the much weaker wood elements, which will be addressed later.

Code changes:

The Building Code in California has changed significantly since construction, especially in regards to lateral forces, with the introduction of an Importance Factor and revisions to the energy dissipation of lateral systems. The intention of the Importance Factor is to recognize the significance of how occupancy groups vary in their ability to would be able to find safety should an event occur, as a flight response to danger. Since the Importance Factor is related to the occupancy of the building, in this case it would require an additional 25% increase to the derived earthquake forces. Simply put, due to the number of people that could be present in a major event, the structure would be required to be 25% stronger as a prescribed effort to allow people time to escape. The difference between the energy dissipation values provided since construction to present remains to be researched.

Lateral load types: wind and seismic

Seismic likely controls due to height and mass of structure, given the concrete walls and plan dimensions. Wind is not likely to be the governing design force, except at overhangs, due to the building profile and proximity of other structures, trees, etc.

Items of Concern/Final Thoughts:

The as built condition is different than design plans. This is the most significant area of concern, as no details are provided to address a substitution of laminated wood arches in lieu of structural steel as detailed in the plans. From the set of drawings available for review, it appears that the structural steel beams required additional truss elements, based on elevations and details provided. The current construction is large laminated wood arches with no truss action, and is suspect without calculation and detailing, as the original design would be considerably more stout than the current system Due to arch geometry, the ends of arches "thrust"- which is a lateral displacement of the end. The thrust consideration was not applicable in the original design due to the truss action of the structural steel; given the substitution it is questionable how those forces were resolved. Further consideration should be given to the extent of the substitution from an out of plane wall support perspective. If the steel shown in detail A on S5, given the current code minimum force and because the supporting diaphragm is susceptible to deflections at high forces, the adequacy of the anchorage of the concrete walls is questionable.

The lateral load resisting system cannot be evaluated by a visual 'walk thru' as loads are not present until there is an event. Because the concrete shearwalls are perforated, there is the potential for a brittle failure of those walls in a seismic event. A brittle failure of the walls could potentially result in a collapse of the structure. Based on the information provided, it appears that the concrete walls are reinforced by 2- #4 @16" on center, each way. Given the weight of the structure, this may be adequate for the demand, but further analysis would be required to determine the certainty. The quantity of steel meets the Code required minimum steel ratio, but the strength of the walls (both when loaded in-plane and perpendicular to the face) will require a more complete analysis.

There is the potential, based on review of the drawings available, that there exists a deficiency in the lateral load path of the resisting system in an event. Due to the geometry of the building, it does not appear that there are any straps or ties for diaphragm continuity and load transfer across openings. Given the detailing available, it does not appear that there are any "collector" members, and the elements in place that may serve as such are likely to not work based on current code requirements. Since the design and construction of this structure, the building code has introduced an "overstrength factor", which essentially guarantees that critical elements of a structure will not fail. Other area of concern, based on detail review, is that the in plane shear transfer from the diaphragm to the shearwalls does not appear to be present, with no clips from blocking to the wall plates (or toe nails) are shown to get the load transfer at the concrete walls.

Gravity loads are fairly regular and predictable, so surprises are not likely unless there is decay, damage or modifications. Visual observation reveals no significant gravity load failures over service life to date. However, it appears that there was a previous mechanical unit upgrade/revision. This could be problematic depending whether the structure was checked for the new sizes and/or weights, which would affect any further changes but would require consideration as cumulative effects of changes.

Based on the information available and on-site observation, it is critical to express the importance of assembly occupancies and the resulting concern for the safety of those occupants based on number of people that may be present during an event when evaluating the adequacy of the existing structure and potentially modifying or adding to the building.

Recommendation:

Due to the items from the initial findings indicated in this report, it is recommended that a comprehensive structural analysis be performed prior to any building modifications to determine if there are deficiencies in the building, and to what extent they jeopardize the safety of patrons in a lateral event. Should inadequacies be discovered, it is highly recommended, though not required by Building Code if the building remains unaltered, that those deficiencies be addressed through retrofit or replacement.