

Seismic Assessment and Retrofit of BART Parking Structures

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BART, the San Francisco Bay Area Rapid Transit system of commuter trains, is one of the San Francisco Bay Area's most vital transportation links, averaging about 360,000 trips every day.

In 2002 BART initiated the Earthquake Safety Program, which will seismically upgrade vulnerable portions of the original BART system. The estimated duration for design and construction of the entire program is approximately 10 years, and the total budget is approximately \$1.3 billion.

Rutherford & Chekene seismically evaluated and designed retrofit measures for three BART parking structures, built between the mid 70-s and early 90-s. All these structures are of cast-in-place reinforced concrete construction. The typical seismic force resisting system consists of moment frames, and in one case of shear walls.

The paper will summarize typical deficiencies found in these parking structures, and will discuss how they compare to findings from recent earthquakes. The paper will include a brief description of how the major deficiencies were retrofitted, and how the design met the challenge to provide solutions that would maintain the number of parking stalls and allow the structure to remain open during construction. Construction of the retrofit is currently under way, and the presentation will show construction of the final retrofit measures.

BART chose to retrofit these structures to the FEMA 356 pre-standard, with some changes made anticipating publication of the ASCE 41 standard. During the design phase, ASCE 41-06 was published as a standard, and Supplement 1 to the standard was developed and published by a special task group. BART subsequently adopted Supplement 1 to Chapter 6 of the ASCE 41 provisions, for concrete structural systems. The paper and presentation will also discuss how the changes to column modeling and acceptance criteria affected design decisions, and will illustrate how early adoption of new developments to codes and standards can provide a more appropriate design, meeting the requested performance objectives.

Columns that were not designated as part of the seismic force resisting system, and are not detailed for deformation compatibility, typically limit the structure's overall deformation capability. This presentation will show the importance of considering accurate stiffness properties of the primary seismic force resisting elements (i.e., walls and moment frames), including foundation flexibility effects, to better predict displacement demands, and confidently assess the acceptability of the behavior of the seismic response.