SEISMIC RETROFIT ANALYSIS APPROACH OF BART A-LINE NORTH AERIAL STRUCTURES

Kuang Yak Lim, PhD
Vice President
HDR Engineering, Inc.
Walnut Creek, California
USA
Kuang.Lim@@HDRInc.com

Kuang Yak Lim**,** born 1960, received his Bachelor of Science and Master of Science degrees in Civil Engineering from Texas Tech University and Doctoral degree in Civil Engineering from Washington State University.

Phoebe Cheng
Senior Bridge
HDR Engineering, Inc.
Walnut Creek, California
USA
Phoebe.Chang@HDRInc.com

Phoebe Cheng, born 1971, received her Bachelor of Science degree in Civil Engineering from University of California at Berkeley and Master of Science degree in Civil Engineering from Massachusetts Institute of Technology.

Adrian Gunderson
Vice President
HDR Engineering, Inc.
Walnut Creek, California
USA
Adrian.Gunderson@HDRInc.com

Adrian Gunderson, born 1960, received his Bachelor of Sceince degree in Civil Engineering degree from the University of New York at Buffalo.

ABSTRACT

The A-Line North aerial structures of the San Francisco Bay Area Rapid Transit (BART) system start at 19th Avenue in the City of Oakland, USA and extend to the Bay Fair Station in the City of San Leandro, USA. The line segment is 9-1/2 mile long and is evaluated as part of the BART Earthquake Safety Program. About 90% of the structures consist of twin precast-prestressed concrete girders simply supported on single-column hammerhead piers. Along the alignment, there are some special structures with inverted U-bents, double-column bents, C-bents, pier-walls and aerial stations. The span lengths range from 55 to 145 feet, with average span at 75 feet; the column heights range from 16 to 40 feet, with average height at 30 feet. The structures are analyzed with fault normal and fault parallel ground motions based on the maximum of probabilistic and deterministic approaches. Varying soil properties, foundation flexibilities, spatial variation of the structures, interactions between expansion joints, rail-structure interactions, load redistribution due to element hinging, and foundation rocking are considered through combinations of single- and multiple-degree-of-freedom linear static and dynamic analyses, push-over analyses, stand-alone rocking analysis and K-secant rocking analyses. The collection of analyses is meant to capture the structural responses at various stages throughout an earthquake event, including foundation rocking. The paper presents the seismic performance criteria and evaluation procedures, and a summary of the seismic vulnerabilities of the as-built structures. Proposed retrofit measures are also included.

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