Micropile Projects in United States

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ABSTRACT

Micropiles have been used for the seismic retrofit of bridge foundations in the United States for the past decade. Particularly, micropile retrofits can be seen along the West Coast corresponding with California's history of earthquake activity. A significant merit of using micropile for bridge seismic retrofit is its limited space requirement for construction. Most existing bridges do not have enough spaces for the retrofit of underground piles. This means that micropile retrofits can fit even in urbanized or high density areas. This report presents the state of two significant micropile retrofits in the US. The content of this report was prepared through interviews with Mr. Rajesh Oberoi of the California Department of Transportation(Caltrans); Mr. Andy Kleiber of Sverdrup Civil, Inc.; and Mr. William J. Perkins of Shannon & Wilson, Inc.

1. INTRODUCTION

Two major earthquakes occurred in California during the past ten years -- 1989 Loma Prieta Earthquake in San Francisco and the 1994 Northridge Earthquake in Los Angeles -- hitting populated areas and causing serious damage to buildings and infrastructure.

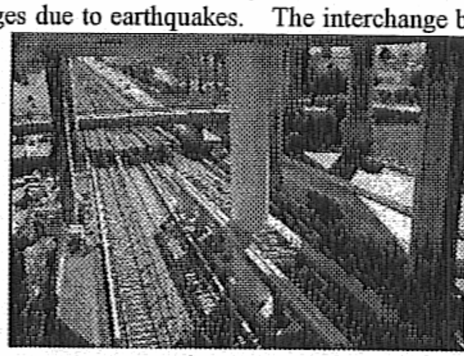
After the Loma Prieta Earthquake, the Department of Transportation of many cities including the Bay Area, Los Angeles and Seattle initiated retrofit programs for its bridges. The 580/980/24 Freeway Interchange retrofit is one of the biggest projects ever initiated by Caltrans.

Seattle Transportation(SEATRAN) initiated a program to retrofit some critical bridges in Seattle. SEATRAN set up factors to be rate the structural capacity of existing bridges such as age, type and material of structures, current bridge condition and soil type. Other issues considered important include emergency routes and traffic volumes. The seismic retrofit of the West Emerson Street Viaduct, the first micropile bridge retrofit in Washington state, was completed in 1996.

2. The 580/980/24 Freeway Interchange retrofit

The 580/980/24 freeway interchange retrofit project in Oakland is the biggest retrofit project in the use of micropile numbers. A significant item to be regarded at the interchange is the Bay Area Rapid Transit (BART) system on the ground, below the four level freeway interchange.

"This interchange experienced minor damage during the Loma Prieta earthquake that indicated that, in the event of a large seismic event, very serious damage would develop at this interchange full of unusual and vulnerable structural systems and details."(*1) Therefore, should be avoided any damage to the BART system by the collapse of the bridges due to earthquakes. The interchange bridge piers are located by a BART railroad track (Fig. 1). The bridge pier located on the left side of the photo has just been installed using micropiles. A distance between the BART track and the bridge pier is about 5m. Fig.2 shows a close-up of the micropile installation by the BART track. As this photo shows, the BART was running during the micropile installation. For this reason, it is critical that the micropile installation be monitored and managed closely to prevent deformation of the retaining earthwall.



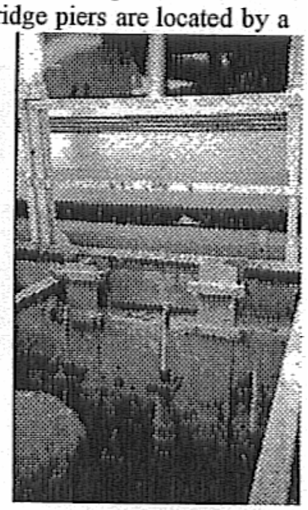


Fig.1 Bird's-eye view of the BART system near the 580/980/24 Interchange (above)
Fig.2 Micropile installed near the BART track (right)

3. The seismic retrofit of the West Emerson Street Viaduct in Seattle

There is a big fault running across the south part of the city of Seattle, known as the Seattle fault. This fault is not active but it caused a big earthquake about 1,000 years ago that resulted in a big uplift and subsidence adjacent to the reverse fault(*2). Though there have not been any big earthquakes recently in Seattle, it is considered to be prepared in the event one were to occur.

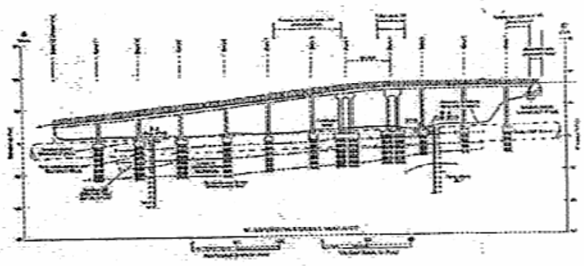


Fig.3 The West Emerson Street Viaduct(*4)

The West Emerson Street Viaduct (Fig.3) is a steel girder and concrete pier type bridge, constructed in 1949. It is located in the Interbay area of Seattle and carries three lanes of traffic over railways. The viaduct length is 213 m. The subsurface soils are consolidated, loose to medium dense, medium dense and very soft fill above the very dense or hard segment. The fill and underlying beach wash are susceptible to liquefaction. Most of the piers are supposed to be timber piling founded in the underlying firm soils. There are obstacles, such as a 3.5 m diameter sewer pipe, a few feet below the ground surface.

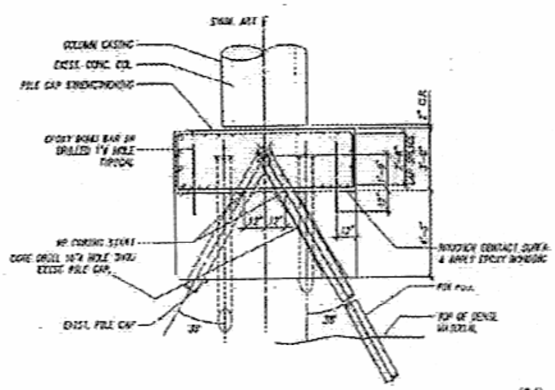


Fig.4 Cross section of the pier seismic retrofit(*4)

The viaduct retrofit will be referred to as characteristic micropile installation due to the little headroom between the under-deck of the bridge and ground surface, as little as 3.5m. Also the configuration of the micropile needed to be designed with the existing sewer pipe. These situations lead to the solution of a 30 degree batterd micropile (Fig.4). A total of 40 micropiles were installed to the five bents between Bent 7 and 11, four micropiles with each pilecap, two pilecaps with each bent.

The micropile diameter is 152 mm (6 inches) and length is 18-19.8 m (59-65 feet). The steel pipe casing is ASTM A53 grade B and the rod is AASHTO M275 ASTM A722 grade 150. The micropiles were designed for both compressive and tensile forces. The micropiles were designed along with a series of calculations. A test was also performed to determine the characteristics of the underground soil near Bent 10. The estimated ultimate friction capacity of each micropile was about 890 kN (200kips) (*3).

4. CONCLUSION

The two micropile seismic retrofit indicated above represent characteristics of installation and design. The 580/980/24 interchange retrofit shows that the micropile seismic retrofit can been used in relatively narrow spaces for construction. Needless to say, it is important to monitor and manage the installation. The viaduct retrofit in Seattle shows the installation pattern caused by limited spaces between the under-deck and the ground-surface. These two solutions will be referred to when a seismic retrofit is taken into consideration for crowded urban area or similar situation.

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REFERENCES

(*1)Scenario for a Magnitude 7.0 Earthquake on the Hayward Fault, pp48, Earthquake Engineering Research Institute, Sept. 1996.

(*2) 94th Annual Meeting of the Seismological Society of America, August 1999.

(*3) Bridge Seismic Retrofit in Seattle, Carole L.B. Michell, William J.Perkins and Thomas M. Gurtowski, pp.147-156, Optimizing Post-Earthquake Lifeline System Reliability, ASCE, August 1999.

(*4) Fig.3-4 by Shannon & Wilson, Inc.,