USE OF MICROPILES FOR SEISMIC RETROFIT

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-ABSTRACT-
Seismic Design Using Micropiles
Route 24/580/980 Retrofit Project

Presented to: International Workshop on Micropiles
September 26-28, 1997

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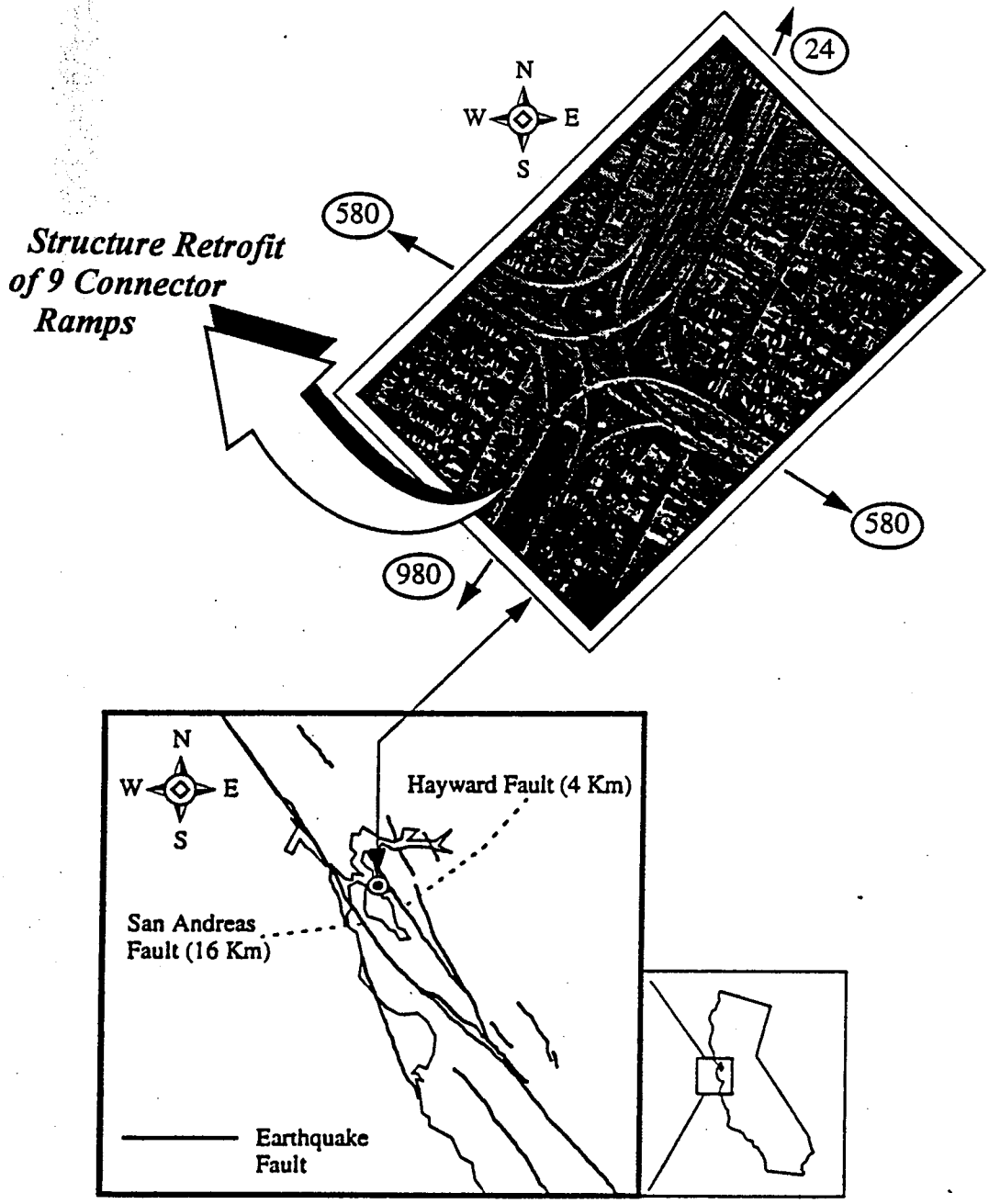
Description of Presentation:

An example of the use of micropiles in an ongoing public transportation project can be found in Oakland, California. With completed plans currently going to print in preparation for bid this winter, the route 24/580/980 interchange in Alameda County will soon be undergoing major retrofit. The project incorporates extensive use of micropiles due to extremely confined construction areas. Highlights of the $2^1/_2$ year analysis and design effort will be presented from the Project Engineer's perspective.

The presentation will consist of a project overview via a 10 minute video followed by a number of general design examples. Typical hand calculations and PC design tools will be compared. Topics will include:

- Site Seismicity
- Project Constraints
- Footing design
- Pile performance
- Soil/pile interaction
- Micropile considerations

9/19/97 rjb



Location of the 24/580/980 interchange.

24/580/980 Interchange Retrofit
SRP #569
EA 04-133161
ESC Design

Project Overview/Design Highlights Short-list

Prepared By: Ron Bromenschenkel
Project Engineer

Structure Inadequacies

- Poor column confinement; #4 @ 12, typical
- Insufficient hinge seat length at high elevation hinges
- Out-of-phase motion damage expected at double deck bents (8 total)
- Single mat footing reinforcement
- Inadequate pile performance (Raymond step-taper)
- Insufficient pile-to-footing connections
- Poor footing-to-column connections (lap splices)
- Weak single column pedestals
- Low capacity bent caps
- Outrigger torsion problems
- Top of column shearing at specific connections to superstructure

Design Constraints

- Active seismic area; Hayward fault 2.7 mi. and San Andreas 16.2 mi. away
- Bay Area Rapid Transit (BART) system running north-south through the interchange
- No pile driving allowed to prevent BART track settlement and preserve area historic structures
- Unknown utilities; pot holing funds limited at time of design
- Space for retrofitting very limited due to BART, freeways, local streets, residences, & businesses
- High ADT with minimal impact allowed; ES ramp is only truck route and cannot be closed
- 18 C-bents, most with inaccessible footings.
- Lead contaminated fill material (structure excavation, bridge) to be disposed of
- Several locations with low overhead clearance
- Many foundations located under BART tracks and adjacent structures

Seismic Design Criteria

- Regular Bridge, Non-collapse criteria
- Caltrans site specific ARS; peak demand 1.2 g
- BART specific ARS (Viaduct only); peak demand 2 g
- Caltrans Memos to Designers, October, 1995
- P-Delta considerations
- Ductility, shear, and joint shear references from ATC-32
- Caltrans Seismic Bridge analysis package, April, 1993
- Bridge Design Specification (1983 AASHTO with Interims and revisions by Caltrans)

Note: *Value Engineered project*

Analysis-Key points

- Caltrans Strudl model
- Imbsen & Associates nonlinear NEABS model
- Lawrence Livermore National Labs nonlinear NIKE3D model (South Connectors)
- Caltrans local analysis and design models

Caltrans Seismic Bridge Performance/Servicibility Criteria

GROUND MOTION	MINIMUM PERFORMANCE CRITERIA	IMPORTANT BRIDGE PERFORMANCE CRITERIA
FUNCTIONAL EVALUATION	(3) Immediate Service Repairable Damage	(4) Immediate Service Minimal Damage
SAFETY EVALUATION	(1) Limited Service Significant Damage	(2) Immediate Service Repairable Damage

Micropile General Advantages

- Workable in limited headroom situations
- Suitable for difficult subsurface conditions
- High capacity with small diameter
- Minimal noise and vibration
- Bonded length determined by contractor
- Performance testing (CT) ensures quality
- Economics maximized by competing w/State Design (CT)

Micropile General Disadvantages

- Limited lateral pile stiffness
- Not suitable for liquefaction prone sites
- Not suitable for highly corrosive sites
- Generally more expensive than standard piles
- Time for working drawing review required
- 'State Design' required for 'Alternate Pile' use

Summary

This State of California retrofit project is one of the last to be addressed in Caltrans' Phase II retrofit program. The site is located between two active faults and has shown minor damage during the Loma Prieta event. After nearly a two year analysis period, a 'no-collapse' criteria with peak spectral acceleration of 1.2g was determined for the project.

Several design constraints existed, the most complicated of which was finding a solution for light rail and utility passage. A separate viaduct supported on soil nail piles was designed to provide wire raceways for the four sets of rails and related utilities without interrupting service. Special shoring was also required to facilitate retrofitting footings currently under rail tracks. Other project constraints include congested local traffic, freeway traffic, inaccessible substructures, lead contaminated surface material, and low overhead clearance.

Global analysis structure displacement demands were met via designs based on local modeling. Computer modeling accounted for soil PY and tz, structural element properties, boundary conditions, and grouped pile affects. Various pile types were incorporated into these designs. Existing piles were evaluated for possible resistance contribution. Driving of new piling has not been permitted due to concern for track settlement and possible damage to local historic buildings. This led to use of cast-in-drilled-hole piles as well as use of micropiles to satisfy such constraints. Where possible, pile types were combined to produce the most economical solution. Hybrid designs utilized in-house computer programs to estimate individual pile lateral and vertical demands.

For this project, Caltrans has included a 'State Design' micropile with approved alternates allowed. The project used Caltrans standard micropile specification (see PUB on Caltrans internet site, *www.dot.ca.gov*) with project specific modifications. Standard practice is to include a pile test program including testing for both test and production piles. Data from these future tests will add to the current micropile data base and hopefully contribute insight on full scale micropile performance/testing.

Note: Complete design details will be available for review after bid opening near 1/98.