State of California
DEPARTMENT OF TRANSPORTATION

Business, Transportation and Housing Agency

Memorandum

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To: MR. TOM OSTROM
Supervising Bridge Engineer
Office of Earthquake Engineering

Date: October 11, 2013

Attention: Mark Yashinsky

File: 04-ALA-13 PM 7.76
59-93034-N
EFIS# 0000001016-N
La Salle Ave OC 33-0160

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Subject: Evaluation of Fault Rupture Potential for La Salle Avenue Overcrossing - Bridge 33-0160 on State Route 13, MP 7.76, Alameda County

SUMMARY

Caltrans Bridge 33-0160, the La Salle Avenue Overcrossing, lies in Oakland, Alameda County (ALA-13-7.76; Figure 1). The bridge is located within the active Hayward fault zone (north section). The bridge could experience up to 1 meter (3.3 feet; Table 1) of lateral offset during the M_{Max} 7.3 event, perpendicular to and anywhere within the bridge footprint. Up to 0.1 meters (0.3 feet) of vertical offset can be expected to occur with the horizontal offset. No further geologic work is recommended.

INTRODUCTION

This evaluation was prepared as part of a statewide evaluation of fault rupture potential at Caltrans bridges. Caltrans policies regarding fault rupture at bridges are described in Memo to Designers 20-10 (2013). Caltrans requires a fault rupture evaluation if a bridge is located within an Alquist-Priolo Earthquake Fault Zone or within 305 meters (1,000 feet) of an un-zoned fault 15,000 years or younger in age. The Alquist-Priolo Earthquake Fault Zone Map is shown on Figure 2.

The La Salle Avenue Overcrossing was built in 1956. It is a continuous reinforced concrete haunched slab on a reinforced concrete 3-column bent and closed rigid frame abutments with straight wingwalls. All are founded on reinforced concrete piles.

This fault displacement hazard evaluation consisted of reviewing selected literature, air photos, and LiDAR images, a site visit, and deterministic and probabilistic calculations of anticipated offset.

LITERATURE, AIR PHOTO, LiDAR, AND FIELD REVIEW

Logs of Test Borings

A test boring drilled in 1954 show that the bridge is founded on fractured and deeply weathered sandstone, possibly Franciscan mélange. Groundwater lay between 15 and 30 feet below the ground surface.

Bridge Inspection Reports

Bridge inspection reports detail no bridge damage consistent with observable damage or distress from fault creep.

Creep

The Hayward fault is creeping at 4±0.06 mm/year at the La Salle observation site 60 meters away from the La Salle Avenue Overcrossing (Weldon et al., 2012). Creep sites along the northern Hayward fault have been monitored for 20-35 years.

LiDAR Images

Figure 3 shows Lienkaemper's (2008) map of the Hayward fault at the La Salle Avenue Overcrossing superimposed on the LiDAR image base. Lienkaemper (2008) locates the Hayward fault (heavy red line) approximately 60 meters (200 feet) east of the bridge, at an offset curb on La Salle Avenue. A second offset curb at Medau Place and a nearby trench (Kaldveer, 1981) site also constrain the location of the active fault.

Site Visit

I visited the site on August 26, 2013. I found no evidence of faulting immediately around the bridge or within the bridge footprint.

Literature Review and Site Visits - Conclusions

The Hayward fault lies 60 meters (200 feet) from the bridge footprint, oriented approximately perpendicular to the bridge. Lienkaemper (2008) mapped the fault at this location with a ≤20

meter (66 foot) uncertainty. There is evidence of creep in offset curbs at La Salle Avenue and nearby Medau Place that constrains the location of the active fault.

CALCULATIONS OF EXPECTED OFFSET

To quantify potential fault offset, I used a spreadsheet developed by the Division of Research and Innovation in collaboration with Geotechnical Services, based upon methods presented in Petersen, et al. (2011), and Abrahamson (2008). Both a deterministic fault displacement analysis and a probabilistic fault displacement analysis were performed. The input parameters included maximum magnitude, slip rate, mapping and base map errors, and average block model moment reduction (aseismicity factor).

Mmax

The $\mathbf{M}_{max}$ of 7.3 is cited in the Caltrans fault database[1], which references the USGS (2008).

Slip Rate

This report uses the slip rate from Dawson and Weldon (2012) of 9 mm/year.

Average Block Model Moment Reduction (Aseismicity Factor)

Average slip on the fault as a whole should be reduced by the ratio of creep to slip rate for calculations of potential offset. We apply an average block model moment reduction (aseismicity factor) of 0.15 presented in the UCERF 3 (Weldon, et al., 2012). This has the effect of reducing the predicted offset to account for the reduction in moment created by creep on the fault plane.

Empirical Slip Measurements

Although numerous trenches have been excavated near the bridge and on the northern Hayward fault, there is a lack of published empirical slip measurements and none were incorporated into the spreadsheet. Alquist-Priolo trenches are usually excavated with the sole purpose of locating the fault and defining a setback, and rarely are used to investigate earthquake histories or coseismic slip. Aagaard, Lienkaemper, and Schwartz (2012) show that slip on the creeping Hayward fault occurs through creep, coseismic slip, and post-seismic deformation. They write "...for the Hayward fault the models suggest that the long-term geologic slip will be dominated by contributions from interseismic creep and afterslip with a minimal contribution from coseismic slip." The three sources of slip cannot be differentiated in trench exposures.

[1] CT fault database: http://dap3.dot.ca.gov/shake_stable/v2/technical.php

Site-to-Source Distance

Lienkaemper (2008) shows the Hayward fault approximately 60 meters (200 feet) east of the bridge, at the La Salle Avenue creep site, where the curb is offset, shown on Figure 3. Bridge inspection reports and field observations yield no evidence of the fault lying within the bridge footprint or close to it. For offset calculations, the distance of 60 meters from the bridge to the mapped trace of Lienkaemper (2008) was weighted 95%, while the USGS fault database (USGS, 2010) location 20 meters (66 feet) east of the bridge was weighted 5%. The low weight given to the USGS map reflects the large uncertainty of the fault location mapped by the USGS.

Type of Slip

The Hayward fault is a right-lateral strike-slip fault. Potential horizontal offsets could occur perpendicular to and anywhere within the bridge footprint.

Calculated Potential Offset at the Bridge

The deterministic offset calculation results are shown in Figure 4. The probabilistic calculation results are shown in Figure 5. The probabilistic calculation yielded a larger offset and will be used per MTD 20-8.

Fault Offset within the Bridge Footprint

Up to 1 meter (3.3 feet) of right-lateral offset could occur within the bridge footprint during an earthquake on the Hayward fault (Figure 5).

Vertical Displacement

Vertical displacements of up to 10% of the horizontal displacements, or 0.1 meters (0.3 feet) should be expected to occur with the horizontal displacements.

Table 1 - Results of Offset Calculations

Scenario	M_{max}[2]	Slip Rate[3]	Site-to-source distance	Deterministic offset	Probabilistic offset, 975 yr return
Hayward fault, Lienkaemper 95% Hayward fault, USGS, 5%	7.3	9 mm/year	60 m Lienkaemper 20 m USGS	0.6 m	1 m

[2] USGS (2008)
[3] Dawson and Weldon (2012)

RECOMMENDATIONS

No further geologic work is recommended at this time. If you have any questions, please contact Anna Sojourner at (510) 622-8839.

c: TPokrywka, CRisden, Daily File
ASojourner/mm
Attachments: Figures 1 – 5

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