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To: MR. TOM OSTROM, CHIEF
OFFICE OF EARTHQUAKE ENGINEERING

Date: September 12, 2013

File: 07-LA-210, PM R5.91
0000001016 6SSCN
E118-W210 Connector
Bridge No. 53-2102G

From: DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
Materials Engineering and Testing Services and Geotechnical Services
Office of Geotechnical Support – Geotechnical Instrumentation

Subject: Evaluation of Fault Rupture Potential, E118-W210 Connector, LA County, CA (revised)

SUMMARY

NOTE: THIS MEMO IS REVISED FROM THE MEMO DATED JULY 12, 2013, PRIMARILY BECAUSE OF THE OVERLY CONSERVATIVE USE OF "APPROXIMATE" IN DESCRIBING THE MAIN FAULT TRACE LOCATION IN THAT MEMO. THE FAULT TRACE IS ACCURATELY LOCATED; THEREFORE THE OFFSET ZONE IS NARROWER (SEE PAGE 4 AND FIGURE 5).

E118-W210 Connector, Bridge No. 53-2102G, is crossed transversely by the Caltrans-active Tujunga fault, part of the Sierra Madre Thrust Fault Zone, San Fernando section. The total offset expected is 4.9 feet on a plane dipping 35 degrees and trending east-west between bents 8 and 10. This offset corresponds to 2.8 feet of vertical offset (north side up) and 4 feet of horizontal movement to the south. Additionally, 1 foot in a left-lateral direction should be considered. The Connector was apparently retrofitted for 2.8 feet of vertical offset but 4 feet of horizontal movement in a southerly direction may not have been accounted for. No further geologic work is recommended.

INTRODUCTION

This evaluation was prepared as part of the statewide evaluation of fault rupture potential at Caltrans bridges. Caltrans' policies regarding fault rupture at bridges are described in Memo to Designers (MTD) 20-10. Caltrans requires a fault rupture evaluation if a bridge is located within an Alquist-Priolo (AP) Earthquake Fault Zone (EFZ) or within 1,000 feet of an un-zoned fault that is 15,000 years or younger in age. The E118-W210 Connector (Connector) is situated within the

EFZ established for the Tujunga fault in 1979 in the San Fernando 7-1/2' Quadrangle; therefore a fault evaluation was required (Figure 1).

The Connector, built in 1975, is a continuous 10-span CIPI/PS and RC box girder with RC single column bents and open end seated and diaphragm abutments, all supported on spread footings, except for bents 5, 6, 7, and 8 which are supported on 16" CIDH piles. The bridge is 1665 ft long and 38 feet wide.

The Route 118/210 Interchange was in the final stages of design when the Feb 9, 1971, **M**6.6 San Fernando Earthquake occurred. During this earthquake, "geologic upheaval" occurred in the interchange vicinity in the form of faulting, horizontal compression of alluvium and numerous landslides with corresponding soil cracking and displacement (Prysock and Egan, 1981).

FAULT RUPTURE EVALUATION

This bridge was previously evaluated for fault rupture by geologists Jeffrey Knott (1991; amount of displacement) and Joseph Pratt (1994; location of displacement). According to Knott (1991) 2.8 feet of vertical displacement and less than a foot of lateral displacement occurred near the bridge during the 1971 **M**6.6 San Fernando Earthquake. His information was based on mapping performed by Barrows et al (1974) (Figure 2) which shows the measurement location as 400-500 feet from the Connector location and included an assumption of one foot lateral displacement. A thrust fault dipping north at 30-35 ° beneath the Connector was noted by Pratt (Figure 1 in 1994; Figure 3 of this memo). Based on review of several maps of the Tujunga fault and a field visit following the 1994 Northridge earthquake (which did not rupture faults at the surface at this site), the estimated location of the main fault trace is approximately 20 feet south of Bent 9. Pratt observed exposures to the east and noted that the ruptured area at the surface is 5-10 feet wide.

The following note was provided per the November 3, 1994, Retrofit Strategy Memo by Norbert Gee regarding fault rupture hazard at the Connector:

A. General Assumptions

1. *There are no validated and exact analysis procedures for this load case. This is a simplified rational model for the sequential formation of local plastic hinge mechanisms.*
2. *The analytical model is considered a stand-alone frame.*
3. *Since a fault rupture underneath Spans 8 and 10 would cause large displacements and rotations in the adjacent movement joint, the critical scenario is a fault rupture occurring between Bents 9 and 10.*
4. ***Adjacent movement in Span 8 and Abutment 11 joints can accommodate displacements and rotations of fault rupture**.*
5. *Fault rupture occurring directly beneath the Bent 9 footing is not addressed in this analysis because its affects on bent stability are unknown. Currently, there are no analysis or retrofit procedures available to address this condition as a possible collapse mechanism. However, we are proposing that the footing at Bent 9 be retrofitted with piles*

around its perimeter to help maintain vertical load capacity in the event of soil failure near or beneath the existing spread footing. While this footing retrofit may help against lost soil bearing capacity, it is not a retrofit solution to this fault rupture scenario.

B. Results

Vertical displacement:	***Fault Displacement Demand:***	***2.8 feet***
	Frame Displacement Capacity:	***5.6 feet***
Lateral displacement:	***Fault Displacement Demand:***	***<1.0 feet***
	Frame Displacement Capacity:	***1.7 feet***

This assessment fails to consider 4 feet of fault movement in a horizontal plane in a north-south direction.

Field Reconnaissance

A field reconnaissance in the vicinity of the bridge was conducted by Joe Pratt, CEG from the Office of Geotechnical Design South – Branch 1, Douglas Cook, CEG from the office of Geotechnical Design South - Branch 2, and Martha Merriam on 4/9/2013. Joe pointed out where the fault was observed pre-construction (Figure 4). The fault location appears to correspond well with mapped traces located in the San Gabriel Mountains just east of the Connector. We were unable to definitively locate the fault in this area however, because of overgrowth and likely erosion.

POTENTIAL FOR FAULT RUPTURE

Measurements taken 400-500 feet west of the current bridge location after rupture of the Tujunga fault during the 1971 **M**6.6 earthquake (considered a **M**Max size event) were 2.8 feet (0.85 m) vertical and less than 1 foot (.3 m) left lateral (Barrows, 1974 in Knott, 1991). This vertical displacement corresponds to 4 feet of horizontal movement south and 2.8 feet uplift, with the vector sum of 4.9 feet of displacement occurring on a thrust plane dipping 35 degrees north. Note that these values are larger than those obtained using empirical formulas such as those provided in Wells and Coppersmith (1994) or Moss and Ross (2011), but are preferable because they are based on local measurements (Hecker and Abrahamson, 2013). These values should be used for design, tapering off to half the above values 100 feet on either side of the fault as shown in Figure 5.

Fault displacement hazard analysis (FDHA) based on mapping quality is performed given an offset value and is very useful in areas where uncertainties in trace location and base maps exist (Petersen et al, 2011). According to the legend for the 1:18,000 scale map completed for the area (prior to construction of the Connector), the fault trace is, “Positively identified and accurately located” (Barrows, 1975). If we assume an accurate location, vertical displacement will decrease

by half (down to 1.4 feet of displacement) at a distance of 100 feet on either side of the fault trace (Figure 5).

RECOMMENDATIONS FOR ADDITIONAL INVESTIGATION

No additional work is recommended. If you have any questions, please contact Martha Merriam at (916) 227-7135.

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REFERENCES

Barrows, A., 1975, Surface effects and related geology of the San Fernando Earthquake in the foothill region between Little Tujunga and Wilson Canyons, in Oakeshott, G., ed., San Fernando, California, Earthquake of 9 February 1971; CGMG Bulletin 196, 462 pp and 5 plates, pages 97-117: ftp://ftp.consrv.ca.gov/pub/dmg/pubs/bull/B_196/

Barrows, A., and others, 1974, Surface effects map of the San Fernando Earthquake area, in Oakeshott, G., ed., San Fernando, California, Earthquake of 9 February 1971; CGMG Bulletin 196, 462 pp and 5 plates, Plate 3: ftp://ftp.consrv.ca.gov/pub/dmg/pubs/bull/B_196/

CGS, 2002, *Guidelines for evaluating hazard of surface fault rupture*, CGS Note 49, 4p: http://www.conservation.ca.gov/cgs/information/publications/cgs_notes/note_49/Documents/note_49.pdf

CGS, 1979, Special Studies Zone, San Fernando Quad, http://gmw.consrv.ca.gov/shmp/download/quad/SAN_FERNANDO/maps/SANFERN.PDF

Caltrans, 2013, MTD 20-10, *Fault Rupture:* http://www.dot.ca.gov/hq/esc/techpubs/manual/bridgemanuals/bridge-memo-to-designer/page/Section%2020/20-10.pdf

Dawson, T., and Weldon, R., 2012, UCERF3, Appendix B: Geologic slip-rate data and geologic deformation model (July 9, 2012 draft), http://wgcep.org/sites/wgcep.org/files/AppendixB_GeologicDeformationModel_20120709.pdf

Gee, N., November 3, 1994, Retrofit Strategy Memo for Rte 118/210 Sep (West) and Rte 118/210 Sep (East): http://svgcgeodog.dot.ca.gov/Data/007/LA/118_13.94_53-2102G_E118_W210_CONNECTOR/00000201.PDF

Hecker, S., and Abrahamson, N., 2013, Variability of displacement at a point: Implications for earthquake-size distribution and rupture hazard on faults: Bull. Seism. Soc. Amer., V.103, pp.651-674.

Knott, J., December, 1991, Preliminary Geologic/Geotechnical Information: http://svgcgeodog.dot.ca.gov/Data/007/LA/118_13.94_53-2102G_E118_W210_CONNECTOR/00000209.PDF

Moss, R., and Ross, Z., 2011, Probabilistic fault displacement hazard analysis for reverse faults: Bull. Seism. Soc. Amer., V.101, pp. 1542-1553.

Petersen, M., and others, 2011, Fault displacement hazard for strike-slip faults: Bull Seism. Soc. Amer., Vol. 101, pp. 805–825.

Pratt, J., July 1, 1994, Supplemental Preliminary Geological/Geotechnical Information for Seismic Retrofit Design: http://svgcgeodog.dot.ca.gov/Data/007/LA/118_13.94_53-2102G_E118_W210_CONNECTOR/00000201.PDF

Prysock, R., and Egan, J., 1981, Roadway damage during the San Fernando, California, Earthquake of February 9, 1971, FHWA/CA/TL-80-17, 190 pp.

Southern California Earthquake Center (SCEC) Earthquake Catalog: http://www.data.scec.org/eq-catalogs/date_mag_loc.php

US Geological Survey, 2010, http://earthquake.usgs.gov/hazards/qfaults/google.php

US Geological Survey, 2008, National Seismic Hazard Maps – Fault Parameters, http://geohazards.usgs.gov/cfusion/hazfaults_search/hf_search_main.cfm

Figure 1. Location map, showing Connector, AP EF Zone boundaries (black), rupture traces from the 1971 San Fernando Earthquake (red), and where 1971 fault offset measurements were taken (red circle) (see Figure 4).

Tujunga Segment of the San Fernando Fault Zone

Surface expression. In the region between Little Tujunga Canyon and Pacoima Wash, the most spectacular and continuous surface effects of the earthquake lie along the Tujunga segment of the San Fernando fault zone. Surface breaks extend from the vicinity of the San Fernando Industrial Park eastward along Foothill Boulevard where, just east of Vaughn Street, the northeast sidewalk and curbing were lifted abruptly 85 cm (2.8 feet) relative to the pavement (90) (photo 1). The breaks continue across the

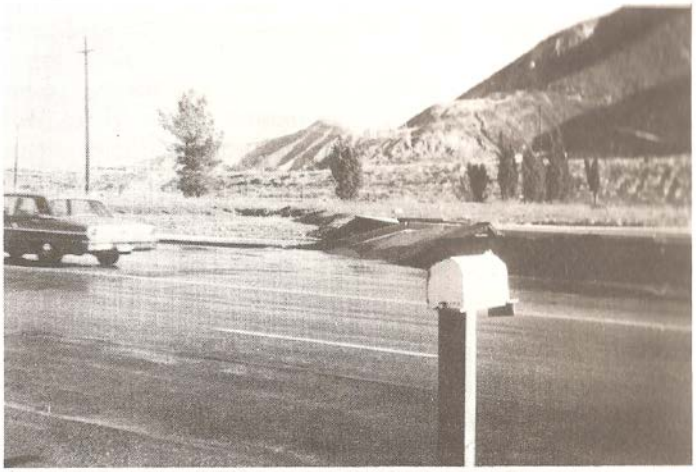

Photo 1. Frontal fault scarp of the Tujunga fault segment on Foothill Boulevard just west of the Foothill Nursing Home, which has since been razed (locality 90, plate 3). Note water in street from ruptured water mains. ***Photo taken by F. Harold Weber, Jr., at 9:00 a.m., February 9, 1971.***

Figure 2. Location where 2.8 feet of vertical offset was measured after 1971 San Fernando Earthquake (looking northeast). See Figure 1 for location with respect to Connector. (Barrows, 1975).

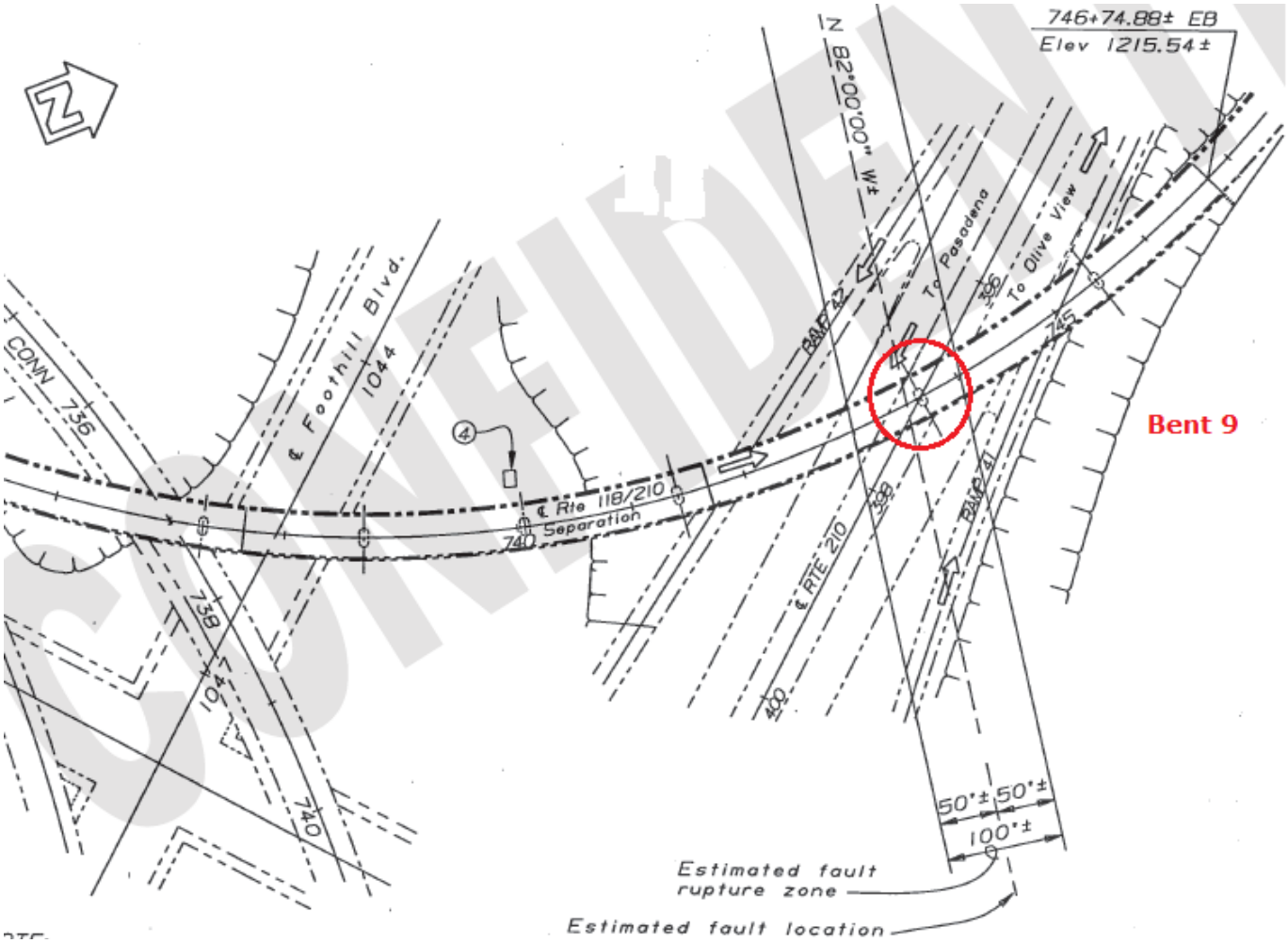

Figure 3. Location of 100-foot wide fault crossing previously designated beneath the E118-W210 Connector in relation to Bent 9. (9-25-1995 General Plan [confidential]). See Figure 5 for extent of fault rupture. Per this memo, displacement is estimated at 2.8 ft vertical, 4 ft horizontal (net displacement of 4.9 ft). At a distance of about 100 feet on either side of the main trace, estimated displacement is half these values.

Figure 4. Looking west along the Connector. Bent 9, in the center median, is located in the fault zone shown in Figure 1. Photo taken 4/9/2013.

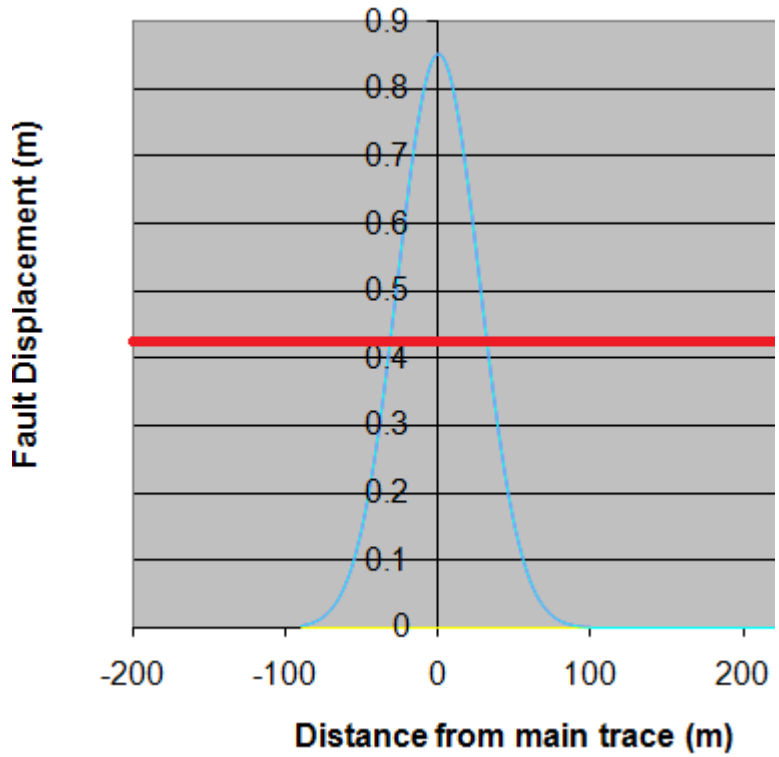

Figure 5. Vertical fault displacement away from main trace. Displacement is estimated at half the value at the main trace at a distance of about 100 feet on either side of the main trace.