USGS, CGS, PEER Surface Displacement Fault Hazard Workshop (SDFH)
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Thoughts on SDFH relating to Water Systems

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Introduction

East Bay Municipal Utility District (EBMUD) is a water/wastewater utility located on the east side of San Francisco Bay, California. It provides water service to a population of about 1.3 million people located in portions of Alameda and Contra Costa Counties. The District has approximately 4,200 miles of transmission and distribution piping. The District contains three active faults: the Hayward, the Calaveras and the Concord Faults which constitute the Surface Displacement Fault Hazard (SDFH) in the EBMUD Service Area.

Background

Approximately 200 transmission or distribution lines cross one of the three faults cited. Major crossings of the Hayward Fault include the Claremont Tunnel (a 9' horseshoe shaped tunnel), the San Pablo Tunnel (a 5'-6" oval shaped tunnel), the South 54 (a 54" transmission pipeline), the South 30 (a 30" transmission pipeline). Numerous other smaller diameter lines cross the faults.

EBMUD undertook a 10-year Seismic Improvement Program (SIP) from 1995-2005 to retrofit facilities and mitigate pipeline damage. Methods of mitigation included: installing pipelines in casings to allow them to move, installing shutoff valves and hydrants on each side of the fault to allow short-term bridging of pipe ruptures with above ground flexible hoses and installation of automatic shutoff valves to stop flow on detection of excess flow or seismic accelerations.

The Claremont Tunnel was designed with a special vault section designed to maintain its structural integrity while undergoing displacements due to fault offset and creep of up to 8.5 feet (7.5 feet of fault offset at 16% exceedance value and 1 foot of creep offset). The design performance goal was to be able to provide water service immediately following a Magnitude 7 event on the Hayward Fault. As a redundancy feature, a 72" inside diameter, free-standing, steel "Carrier Pipe" was placed in the vault section should any failure of the tunnel liner occur.

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SFDH Areas of Interest

With the above back drop, EBMUD is interested in the following related to defining the surface fault displacement hazard for design purposes:

1. The location of the active fault trace(s).
2. The width of the fault zone and its displacement characteristics and models of how it will move (i.e., how much of the movement occurs where). For the design of the Claremont Tunnel Seismic Upgrade, a 16% exceedance value of fault displacement (7.5 feet horizontal, representing 5 feet mean offset and 2.5 feet std. deviation) plus an allowance of 12 inches representing about 50 years of creep based on survey measurements of the rate from 1928 through 2002 were used in the design. The full amount was considered as possible in an 80 foot zone centered on the existing fault trace and up to 30% (horizontal) of the full displacement was considered as possible in zones about 450 feet wide centered on the active zone. In both cases, vertical offset of 10% of the horizontal amount was considered possible.
3. The speed with which the fault moves and the overall time period within which this movement occurs (i.e., does it move all at once or does it move a portion of the total displacement with the rest occurring over minutes to days to months to years). Although we had estimates of this movement of about 1 m/sec, the uncertainty stated at the time of the design (2002-2004) was at least an order of magnitude on each side of this estimate. We used the rupture speed in design of the "Carrier Pipe" to ensure that the pipe would remain serviceable after impact of the rock mass on either side of the fault.
4. The creep rate at the fault zone and its spatial distribution (i.e., does it all occur at the same point or is it distributed over some width. Our survey measurements in the Claremont Tunnel indicate that about 80% of the displacement due to creep since 1929 occurred over about a 10 foot width with an additional width occurring over a total width of about 400 feet centered on the active trace.
5. The probability of occurrence of various amounts of surface fault displacement offset and the approximate recurrence intervals of this movement. Also, does it move in similar discrete amounts due to seismic events of a similar size (as the Hayward Fault seems to) or are the events more randomly distributed in size and frequency.
6. Estimates of fault movement that conform deterministic estimates based fault parameters with the probabilistic estimates. For an engineer to establish appropriate design criteria, the results of models based on either deterministic or probabilistic methods should converge.
7. How do fault displacements vary with depth within the near surface (up to 1,500 feet of depth) zone. This is important in the design of tunnels crossing faults if there is a significant variation.
8. Estimates of fault movements for major known active faults that can be used in preliminary design evaluations to determine project feasibility prior the site specific geologic/seismologic studies done as part of the project.

The Way Forward

I would concur with the general consensus at the Workshop that a group and process similar to the NGA process for ground shaking be established. The group should contain a mixture of researchers and lifeline industry representatives to ensure research efforts are directed toward real problems encountered in design of engineering projects.

However, it is important to recognize that restricting research simply to practical problems is short-sighted. There also needs to be an ongoing component directed towards the gaining a complete understanding of fault behavior and in developing models of how faults behave without the limitation of solving current practical problems. With a mixture of interest in both practical and theoretical approaches, we will come to a more rapid and complete understanding of surface fault displacements and the hazard it produces.