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EVALUATION OF INTEGRATED SEISMIC HAZARDS AND GROUND FAILURE IN PULL-APART BASINS DURING THE 1999 KOCAELI EARTHQUAKE, TURKEY: COLLABORATIVE RESEARCH BETWEEN THE UNIVERSITY OF TEXAS AND WILLIAM LETTIS & ASSOCIATES

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TECHNICAL ABSTRACT

Earthquake-induced ground failure and subsidence can cause considerable damage to coastal infrastructure. During the 1999 Kocaeli earthquake in Turkey, significant ground failure and damage were observed in coastal areas, and were particularly concentrated in the pull-part basins created by stepovers in the fault rupture.

Preliminary observations indicate that liquefaction-induced slope failures and tectonic subsidence were the two main failure mechanisms that affected the pull-apart basins during the Kocaeli earthquake. The presence of steep slopes at the nose of delta fans and loose deposits within the active delta fan deposits resulted in liquefaction-induced slope failures. Outside these delta fans, where older geologic deposits are located or the sediments are predominantly finegrained marine deposits, normal faulting caused tectonic subsidence. In addition, an interaction between tectonic subsidence and liquefaction-induced ground failure was observed in some areas. In these regions, earthquake-induced ground failure enhanced the inundation by the sea compared with areas that only experienced tectonic subsidence.

The results of this study show that there is a strong correlation between geologic setting and ground failure susceptibility. Pull-apart basins at stepovers in strike-slip faults can cause large areas of tectonic subsidence and inundation. This subsidence causes significant damage for facilities located close to the shore. Geologic mapping is necessary to identify areas susceptible to tectonic coastal subsidence so that facilities can be sited appropriately. Delta fans are highly concentrated within pull-apart basins because of the nature of the pull-apart mechanism. Downdropping caused by this fault-induced extension transforms the basin into a depocenter for sediments. The depositional process within delta fans results in loose sediments, which make them very susceptible to liquefaction. The steep slopes (about 20 degrees) that exist at the nose of a delta fan because of the soil deposition process are less stable than adjacent areas with flat slopes. As a result, more intense

ground failure (ground cracking and slope failures) is observed in these steep areas. Thus, development on delta fans may result in dramatic losses within seismically active regions unless precautions are taken.

NON-TECHNICAL ABSTRACT

Earthquake-induced ground failure and subsidence can cause considerable damage to coastal infrastructure. During the 1999 Kocaeli earthquake in Turkey, significant ground failure and damage were observed in coastal areas, and were particularly concentrated in stepovers of the fault rupture. Investigations indicate that ground failure and subsidence occurred due to (1) liquefaction of loose, sandy soils and (2) faulting along the coastline. Liquefaction was concentrated along delta fans at the mouth of creeks, while subsidence occurred within stopovers of the fault rupture. In some places, liquefaction and tectonic subsidence were both present, causing even more intense damage. The results from this study can be applied to many sites in California, where critical facilities have been constructed in coastal areas near fault stepovers.