IMPLICATIONS FROM A GEOTECHNICAL INVESTIGATION OF LIQUEFACTION PHENOMENA ASSOCIATED WITH SEISMIC EVENTS IN THE CHARLESTON, SC AREA

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ABSTRACT

First-hand accounts of sand boils and other liquefaction-related phenomena associated with the Charleston, SC earthquake of 1886 provide clear evidence that liquefaction was common in this event. Recent geologic investigations in the Charleston area have found relic liquefaction features indicating the repeated liquefaction of sandy soils in the Charleston area due to recurring large seismic events. Liquefaction features could be found because of recent soil exposures afforded by long drainage ditches and pits excavated for the mining of sand. Although these findings have led to an improved understanding of seismicity in the Charleston region, little hard data exists on the geotechnical setting of the areas involved in past liquefaction or levels of seismic loading. A two-year field investigation was undertaken by Virginia Tech to study the liquefaction findings associated with seismic events in the

Charleston area from the perspective of geotechnical engineering, especially those findings associated with the 1886 earthquake. The investigation involved defining the engineering parameters of the Charleston soils on the basis of in-situ and laboratory tests, and estimating the levels of seismic loading required to produce the observed liquefaction phenomena.

In the course of the field investigation, 57 cone penetration tests (CPT's), 6 Standard Penetration Tests (SPT's) and 35 auger holes were performed. Seven sites within the 1886 meizoseismal zone and nine sites outside of this region were studied. Laboratory tests including cyclic triaxial and sieve tests were performed to supplement the field work. Of the sites where field tests were performed, the surficial soils were largely formed from ancient beach ridge deposits. The insitu and laboratory tests showed soil conditions within these deposits to be appropriate for liquefaction. Soil profiles within the beach deposits were relatively uniform, with the older deposits consisting primarily of medium to dense, fine to silty sands, with some areas which contained interbedded clays. The younger beach deposits were generally more liquefiable than the older units, consisting almost entirely of loose to medium, fine to silty sands to a depth of 20 ft. or more. The water

table was located close to the ground surface at all test sites.

Previous geological studies had shown that beach ridge soils as old as 230,000 years have liquefied multiple times in the past 10,000 years. That soils of this age remain highly susceptible to liquefaction is surprising, and unique to the Charleston environment. This finding is attributed to the relatively low rate of seismic activity in the Charleston region (little opportunity for densification of loose sands).

Evidence for progressive densification of the older beach ridges due to repeated shaking was found in the presence of medium to dense layers in the soil profile. Such layers were largely absent from the younger beach ridge deposits.

The soil information obtained from the testing was used to infer levels of seismic loading required to produce the observed liquefaction at each site. The seismic loading levels were estimated based on a combined approach using two established liquefaction analysis techniques. The findings suggest that the magnitude and peak acceleration of the 1886 earthquake were likely less than values derived from seismological evidence (M = 7.7 and 0.5 - 0.6g peak acceleration). Based on the findings of this study it was estimated that for an M = 7.5 event, peak accelerations in

the meizoseismal zone of 0.3 to 0.4g would serve to explain the observed 1886 liquefaction phenomena. If it is assumed that the magnitude of the 1886 earthquake was less than 7.5, then the estimated peak accelerations would be larger than the 0.3 to 0.4g estimate. Reasons for differences between the estimated levels of seismic shaking are not entirely clear and should be the subject of future research.