CHAPTER 1: INTRODUCTION

The objective of this study is to investigate, through laboratory strength tests and centrifuge model tests, the shearing resistance that can be mobilized on slickensided rupture surfaces in clay slopes during earthquakes. The following case illustrates the limitations of our understanding regarding the seismic shear behavior of slopes in clay that contain slickensided rupture surfaces:

A 300-acre residential development at Rancho Solano, near Fairfield, California required significant mass grading. The grading resulted in steepened slopes at numerous locations across the site, and potential stability problems. Two geotechnical firms were engaged to study the potential stability problems, one on behalf of the developer and one on behalf of the property owners association.

Both firms recommended that the slopes should be stabilized using cut-and-fill operations. However, the grading and stabilization plans proposed by the firms differed in cost by a factor of approximately ten – one plan would cost about $2 million, the other about $20 million. This difference in cost was due primarily to the shear strengths chosen by the firms for use in the seismic slope stability analyses.

The uncertainty regarding the seismic shear strength of the Rancho Solano soil is related to the presence of slickensided rupture surfaces in the landslides. Because the landslides at the site had occurred in clayey soils, it was reasonable to expect that a large percentage of the platy clay particles along the rupture surfaces had become aligned in the direction of shear, forming "slickensided" shear surfaces. These slickensided rupture surfaces are inherently weaker than the surrounding soil mass (Skempton, 1964). Figure 1-1 is a sketch that shows a cross section through a slope that contains a slickensided rupture surface.

During an earthquake, ground shaking can cause additional landslide movement. For existing landslides or repaired landslides that contain slickensided rupture surfaces, it is reasonable to expect that the movement will occur along the existing slickensided rupture surfaces, because they are weaker than the surrounding soil. The amount of movement that occurs is controlled by the dynamic resistance that can be mobilized along the existing slickensided rupture surfaces.

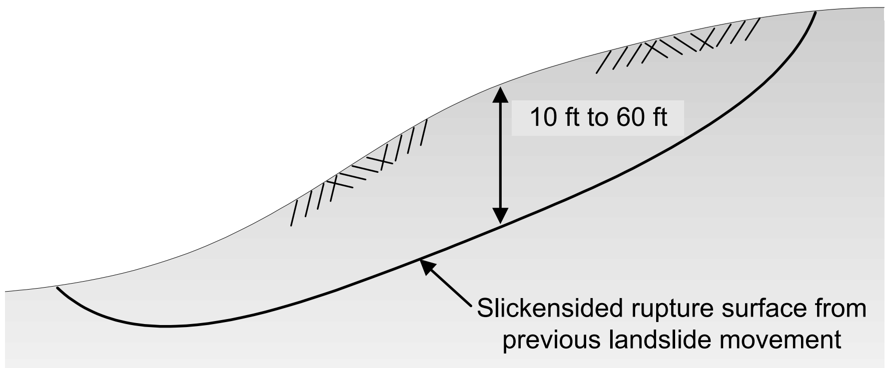

Figure 1-1. Cross section through slope containing slickensided rupture surface.

Little information is currently available concerning the dynamic shearing resistance that can be mobilized along existing slickensided rupture surfaces under seismic loading conditions. Given the present state of knowledge, it is not possible to say whether either of the Rancho Solano stabilization plans represented an optimum balance between safety and economy. Research is needed to provide a logical and supportable basis for evaluating the undrained cyclic shear strength that can be mobilized on pre-existing rupture surfaces in clay, so that projects like the one at Rancho Solano can be designed safely and economically.

Research Studies

The primary goal of the research project outlined in this dissertation is to answer the following question:

> "What is the dynamic undrained shear resistance of a slickensided rupture surface that should be used in analyses of stability and deformation during earthquakes?"

To answer this question, a detailed investigation was undertaken, involving laboratory tests and analyses conducted at Virginia Polytechnic Institute and State University (Virginia Tech) and centrifuge tests at the University of California, Davis (UC Davis). At Virginia Tech, a method was developed for preparing slickensided rupture surfaces in the laboratory, and a series of ring shear tests, direct shear tests, and triaxial tests was conducted to study the static and dynamic shear resistance of slickensided rupture surfaces. At UC Davis, two dynamic centrifuge tests were performed to study the dynamic shear behavior of slopes that contain slickensided rupture surfaces. Newmark's method (Newmark, 1965) was used to perform seismic deformation analyses of the centrifuge model slopes. The results from the Newmark analyses were combined with the laboratory data from Virginia Tech and the centrifuge tests at UC Davis to develop design recommendations for analyzing the seismic stability of slickensided soil slopes.

The research studies described in this dissertation were collaborative in nature, involving numerous contributions from researchers at Virginia Tech and UC Davis. Dr. Binod Tiwari, a post-doctoral researcher at Virginia Tech, performed triaxial tests on test specimens with pre-formed slickensided failure planes. Derek Martowska and Michael Wanger, Master's students at Virginia Tech, provided valuable assistance with the ring shear and direct shear testing programs. Raquel Miller, a Master's student at UC Davis, performed the initial feasibility studies for the centrifuge testing program.