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## Case Histories of Forensic Engineering "Where Things Went Wrong". Paper No. GR-VIII

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## Session VIII

### CASE HISTORIES OF FORENSIC ENGINEERING "WHERE THINGS WENT WRONG

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Paper No. GR-VIII

#### INTRODUCTION

Historically geotechnical engineering has made significant advances due to the occurrence of failures. These failures have triggered study and research from which new or refined concepts of soil and soil-foundation behavior have emerged. The first and probably the most difficult phase of this work is the determination of what went wrong in the design and/or construction of the project. Because of the size and complexity of even the most routine geotechnical engineering project, the post failure investigation and analysis are often more time consuming and tedious than the design of the original project itself.

#### AN INVESTIGATION INTO THE CAUSES OF BUILDING CRACKS ON THE REAR SCARP OF A MAJOR LANDSLIP

In their paper, "An Investigation into the Causes of Building Cracks on the Rear Scarp of a Major Landslip," Hope and Clayton present the results of a series of six damage assessment surveys on a masonry building. The surveys were carried out over a period of eight years post construction. Because this structure was on the rear scarp of a major landslide, the early assessments concluded that the building damage was due to movement of the landslide scarp. The final two surveys, conducted during the seventh and eighth years after construction of the building included much more intensive measurements. These surveys included visual mappings of the cracks and detailed measurements of diurnal changes and seasonal movements over periods of several months. The investigations included monitoring of variation of crack widths versus temperature, precise leveling and distortion surveys. The results of these investigations lead to the conclusion that the principal causes of crack damage were drying and shrinkage and later, thermal cycling and crack creep associated with the structural design. The survey suggested that the damage was not due to foundation or soil problems as originally postulated. This paper points out the significant fact that often, the best course of action in evaluating foundation failures is simply thorough and well designed long-term monitoring. This is particularly true for those

cases where the structural damage is not threatening the safety of the structure.

#### IT'S NOT WHAT YOU PAY; IT'S WHAT IT COST YOU; A GEOTECHNICAL ENGINEERING CASE STUDY

J. Richard Cheeks outlines a litany of procedural and contractual errors that lead to major slope instabilities at a school construction project. In his paper, "It's Not What You Pay; It's What It Cost You; A Geotechnical Engineering Case Study," Cheeks discusses how the design architect relied on a geotechnical report prepared by a general civil engineering firm whose engineers clearly did not have geotechnical training or experience. The civil engineer had been hired at the urging of the owner with the implicit understanding that, if the architect did not hire the civil engineer, the owner would look elsewhere for architectural services. The geotechnical report submitted to the owner and given to the architect for review was clearly deficient. However, the architect did not insist upon the employment of a qualified geotechnical engineer to conduct the subsurface investigation and approved the submitted report.

During construction, the presence of displaced faults and consequent blockage of water bearing layers, and inadequate compaction and fill control resulted in recurring landslides. Inadequate subsurface data hindered repair activities and continuing sliding occurred. Finally, an experienced geotechnical engineer was employed to identify the causes of the instability and to design a retrofit. Total estimated damages were between \$800,000 and \$1,000,000. Lessons learned include the repeated admonition that engineers should only work in their areas of expertise. The value of geotechnical engineering was not recognized until massive liabilities had been incurred by the parties.

As an aside, the author points out that alternative dispute resolution (ADR) processes should be contained within contractual documents. The invocation of these processes will often lead to settlement before trial or arbitration.

## CASE HISTORIES OF DAMAGING EARTHQUAKES

Walter W. Hays presents a concise description of 16 damaging earthquakes and the “forensic lessons” learned from multidisciplinary postearthquake investigations. He lists nine “mistakes” that either singly or collectively, has increased the vulnerability to earthquake damages made repeatedly in every country prone to earthquakes. From these, and other studies, seven “avoidance strategies” that should be used in the planning, siting, design, construction and land-use practices for earthquake-vulnerable sites are listed.

## SINKHOLE DROPOUTS DUE TO UNDERGROUND UTILITY INSTALLATION ON CONSTRUCTION SITES

Matthew A. Dettman discusses the process by which sinkhole collapse is caused by the accumulation and flow of water through the gravel bedding material placed beneath underground utility pipes. He points out that leaking water pipes have often been identified as the source of water that leads to sinkhole collapse. However, highly permeable bedding material serves as a high volume collector and pathway for surface and shallow groundwater to intrude and be directed to vulnerable areas. Two case histories are described that have been attributable to this phenomenon. He suggests that the use of “a flowable fill” may be a viable alternative to gravel as pipe bedding.

## IS IT A SINKHOLE?

This paper discusses three case studies of presumed subsidence damage to residential structures in central Florida. Ericson and Smith point out the complexity of the subsurface stratigraphy and the presence of swelling and compressible soils that cause subsidence-like damage to structures. Because of the documented presence of massive sinkhole activity in the region, it has become common for home owners to assume that all settlement damages to their homes derive from sinkhole collapse. Insurance claims filed by the homeowners and Florida law requires the investigation of the claim by qualified professionals. The authors discuss the conduct of three such investigations and three different conclusions regarding the causes of the damage.