CHAPTER 1 – INTRODUCTION

Drilled shafts have gained in popularity to support heavy superstructures, including high rises and large bridges. This is attributed to minimal construction noise, high load-bearing capacity, advancement in construction and anomaly detection technologies, etc., (O'Neill and Reese, 1999; Haramy, 2006; Haramy, etc., 2007). Anomalies (or anomalies) as shown in Figure 1 include necking, bulbing, soft-bottom (or gap at the base of drilled shafts), voids or soil intrusions, poor quality concrete, debonding, lack of concrete cover over reinforcement, honey-combing defined as the void or cavity created during the concrete placement, and empty or filled with soft soils or low grade concrete (Jerry A. DiMaggio, 2008). They may occur during shaft drilling, casing, slurrying, rebar cage installing, and concreting. Nondestructive evaluation (NDE) methods, such as cross-hole sonic logging (CSL), gamma-gamma testing, pulse echo testing, and sonic mobility, that can be used to detect anomalies are described in detail in the recent comprehensive works (Wightman, etc., 2004; Haramy, 2006; Haramy, 2006, 2007). Anomalies may significantly reduce the drilled shaft capacity. Therefore, it is critical to evaluate the capacity of a shaft with an anomaly to assure the Factors of Safety of the structure are met. For the purpose of this study, all anomalies are assumed to be voids; and their effects on drilled shaft capacities are evaluated using finite element analyses.

The shape, size, orientation, and radial and longitudinal locations of an anomaly with a drilled shaft can influence drilled shaft capacity in different manners. A comprehensive, finite element analysis program was carried out to evaluate the effects of various anomaly locations, size, shape, and orientation on drilled shaft capacity. A Pile-Soil Interaction (PSI) program was completed in December 2008 as a partial fulfillment of a doctoral study at the Center for Geotechnical Engineering Science (CGES) at the University Colorado, Denver. Based on PSI, another program, PSI-VA, was developed specifically for the evaluation of the effects of anomalies on drilled shaft capacity under axial load.

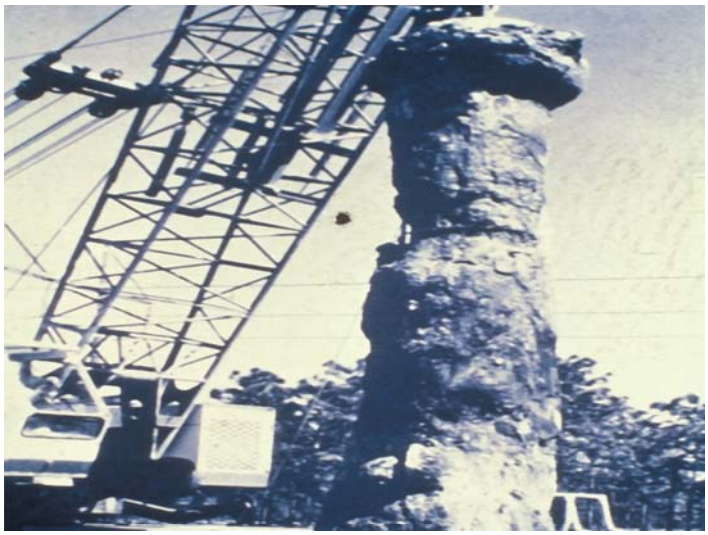

Figure 1. Defective drilled shaft with multiple types of anomalies (DiMaggio, 2008).

Chapter 2 of this report covers the review of previous literatures, contemporary design methods, and the load transfer relationship. In Chapter 3 the methods of computation for the structural capacity of drilled shafts is discussed. Presented in Chapter 4 is the theoretical basis of the PSI-VA computer program (including the integration scheme and the different constitutive material models implemented in the program) and the validation and calibration of the PSI-VA program. Case histories were used to calibrate the computation results and validate the effectiveness s of PSI-VA as an effective computation tool. The many constitutive models of geomaterials provide users the choice of model alternatives and also the tool for studying the model sensitivity on the deep foundation performance prediction and simulation. Finite analysis results of the effects of anomalies are presented and discussed in Chapter 5. Chapter 6 provides the summary and conclusions of this study.

A finite element analysis program, PSI-VA (Pile-Soil Interaction under vertical load with anomalies), was used to assess the effect of different anomalies on the axial load capacities of drilled shafts in soils of various properties ranging from soft to extremely stiff clay and loose to very dense sand. Drilled shaft capacity was determined based on the lesser of structural vs. geotechnical capacity. The results indicated that anomalies affect axial structural capacity, and is highly dependent on the size, concentric location, and depth of the anomaly, and the strength of the surrounding soils. Nonconcentric anomalies decrease the structural capacity of a drilled shaft even under axial load alone.

The future development of PSI-VA will include the capability of importing the results of tomographic imaging and the analysis of effect of anomalies on drilled shaft capacity under combined vertical and lateral loads. Once completed, the PSI-VA program will become a powerful design and research tool for the investigation of effects of anomalies on drilled shaft capacity.