DRILLED SHAFT AXIAL CAPACITY
Effects Due to Anomalies

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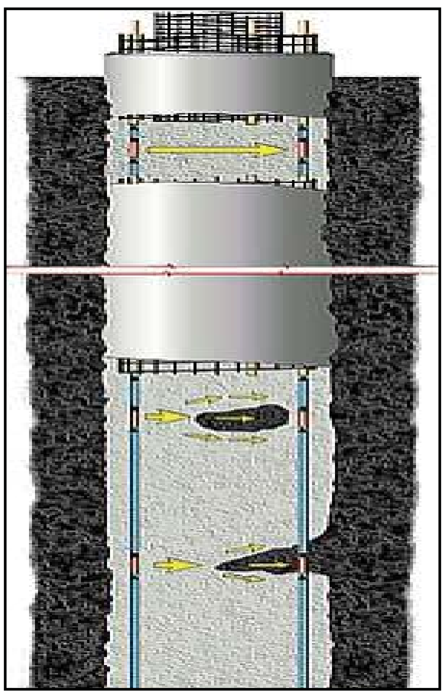

U.S. Department of Transportation
Federal Highway Administration

Federal Lands Highway
Commitment to Excellence

Central Federal Lands Highway Division
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Lakewood, CO 80228

FOREWORD

The Federal Lands Highway (FLH) of the Federal Highway Administration (FHWA) promotes development and deployment of applied research and technology applicable to solving transportation related issues on Federal Lands. The FLH provides technology delivery, innovative solutions, recommended best practices, and related information and knowledge sharing to Federal agencies, Tribal governments, and other offices within the FHWA.

The objective of this study was to produce guidelines for assessing the importance of defects on the drilled shaft capacity in different soils and also priority for remediation effort. The study included a literature search on earlier research, enhancement of a finite element code, PSI for use in this study, results of a comprehensive finite element analysis program with varying factors including defect location and sizes, soil types, and concrete strength. The following are the recommendations for the remediation guidelines:

- A proper construction quality monitoring program including sonic wave survey, tomographic imaging, and temperature, moisture, and density measurements are recommended for all critical drilled shafts,
- Once defects are located remediation measures must be implemented to fill the defect voids with concrete,
- If prioritization is necessary in fixing the defects, the shallow, non-concentric defects must receive first attention because of its experience of a higher pile loads than a deeper defects,
- The effects of soil types and strengths must be properly assessed from the pile load transfer and structural capacity curves to assess the critical nature of a defect(s).

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Notice

Quality Assurance Statement

Technical Report Documentation Page

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15. Supplementary Notes

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16. Abstract

Drilled shafts are increasingly being used in supporting critical structures, mainly because of their high-load supporting capacities, relatively low construction noise, and technological advancement in detecting drilled shaft anomalies created during construction. The critical importance of drilled shafts as foundations makes it mandatory to detect the size and location of anomalies and assess their potential effect on drilled shaft capacity.

Numerical analysis was conducted using Pile-Soil Interaction (PSI), a finite element analysis program to assess the effect of different anomalies on the axial load capacities of drilled shafts in soils ranging from soft to extremely stiff clay and loose to very dense sand. The investigation included the affect of anomalies of various sizes and lengths on both structural and geotechnical capacities. The analysis results indicate that the drilled shaft capacity is affected by the size and location of the anomaly and the strength of the surrounding soil. Also, nonconcentric anomalies significantly decrease the structural capacity of a drilled shaft under axial load. The resulting drilled shaft capacity then equals the smaller one of the two capacities: structural or geotechnical.

17. Key Words	18. Distribution Statement
DRILLED SHAFTS, GEOTECHNICAL, STRUCTURAL, DRILLED SHAFT CAPACITIES, ANOMALIES, FINITE ELEMENT ANALYSIS, PSI	No restriction. This document is available to the public from the sponsoring agency at their website http://www.cflhd.gov.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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