HOLLOW BAR SOIL NAILS
Pullout Test Program

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Commitment to Excellence

ADSC
The International Association of Foundation Drilling

Central Federal Lands Highway Division
12300 West Dakota Avenue
Lakewood, CO 80228

FOREWORD

The purpose of this document is to review the current practice of design of grout-to-ground bond strength and testing protocol for the hollow bar soil nail (HBSN) installations. The study evaluates if there is a correlation between a conventional solid bar soil nail (SBSN) and the installed HBSNs. The study also performs installation according to a protocol to determine the significance of the permeation zone around the unbonded length of an HBSN, and how much effort should be placed into isolating this zone during testing.

This study provides a bond stress comparison between typical SBSNs and HBSNs at four sites. The concurrent injection of grout for the HBSN results in a complete column of grout and some influence on the surrounding soils. It is widely believed that this injection of grout into the soil has a positive impact on the resulting grout-to-ground bond stress.

Current soil nail testing includes a verification test as part of the testing program and enables back calculation of the *in-situ* bond stress of the grout-ground interface. In a traditional SBSN, testing is performed on an isolated length of the anchor bonded to the geotechnical strata of interest. HBSNs are typically used in collapsing ground conditions where the simultaneous injection of grout through the reinforcing bar during drilling keeps the drill hole from collapsing. Due to this installation method, the procedures for typical solid bar installation and testing are not appropriate.

This report provides a summary of the results of this study, which can be used to estimate presumptive design grout-to-ground bond strength values and to develop practical, standard ways to perform pullout tests on HBSNs.

F. David Zanetell, P.E., Director of Project Delivery
Federal Highway Administration
Central Federal Lands Highway Division

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Allen W. Cadden, P.E., Jesús E. Gómez, Ph.D., P.E., Andrew C. Baxter, P.G., Thomas Bird	

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16. Abstract

The use of Hollow Bar Soil Nails (HBSNs) is growing in the excavation support and retaining wall construction. It is anticipated that the use of the HBSN technology could reduce construction schedules, costs, and environmental impacts. The current state of practice for design bond strengths and load testing procedures is based on the current soil nail practice but varies depending on the installation contractor and product recommendations. The objective of this study was two-fold. The first objective was to develop an initial data file from installation and testing at four sites of the available grout-to-ground bond stress of HBSNs, and to determine if correlations exist with traditional solid bar, drill, and grout soil nails (for example, the published nominal values in FHWA-IF-03-017 [GEC No. 7]). The second objective was to establish recommendations for practical, standard ways of performing pullout tests on HBSNs.

Comparisons between the pullout test results showed that the HBSNs generally developed larger bond strength values in granular soils than the SBSNs. Three installation methods for purposes of pullout and proof testing were evaluated. Of which two were found to be to be satisfactory; however, the third one noted to have a significant Doughnut Effect and was not recommended for pullout testing.

Test results of the four sites are included in detail on the attached CD ROM.

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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

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LIST OF ABBREVIATIONS AND SYMBOLS

α	Bond strength = Ultimate shear strength of grout-to-ground interface
A	Cross sectional area of the steel reinforcing bar
AASHTO	American Association of State Highway and Transportation Officials
ADSC	Association of Drilled Shaft Contractors – The International Association of Foundation Drilling
AER	Anchored Earth Retention
AL	Alignment Load
ASTM	American Society for Testing and Materials
D_{nom}	Nominal diameter of the drill hole [in]
DTL	Design Test Load [kip]
E	Young's Modulus of steel, 29,000 ksi
FHWA	Federal Highway Administration
ft	Foot (feet)
Fy	Yield (nominal) strength of hollow bar soil nail
GEC	Geotechnical Engineering Circular
HBSN	Hollow Bar Soil Nail
ID	Inside diameter
in	Inches
kPa	Kilo Pascal
Kip	1000 lb
L_{BV}	Test nail bonded length [ft]
MTL	Maximum Test Load
OD	Outside diameter
PVC	Poly Vinyl Chloride
$Q_{ultimate}$	Pullout load [lb]. If pullout does not occur at the maximum test load, it is noted with (*) in the table
SBSN	Solid Bar Soil Nail
SOP	State of Practice
~	Approximately equal to

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HBSN Study Review Team:
Bernard Froemel – DSI America
Lucian Bogdan – DSI America
Cary Lange – Nicholson Construction Company
Dan Thome – Nicholson Construction Company
Tom Richards – Nicholson Construction Company
Donald Bruce – Geosystems L.P.
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Kathryn Griswell – CALTRANS
Robert Carnevale – DBM Contractors Inc.

FHWA Advisory Panel:
Justin Henwood, Matthew Demarco, Roger Surdahl, Scott Anderson, Barry Siel, and Rich Barrows.