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Application of Ground Anchors and Soil Nails in Roadway Construction

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15. Supplementary Notes

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16. Abstract

Application of Ground Anchors and Soil Nails in Roadway Construction includes five multimedia presentations that describe and explain the principles of science and engineering related to the construction of ground anchors and soil nail wall systems. The objective for the first module, *Introduction to the Inspection of Soil Nails and Ground Anchors,* is to offer an introduction to drilled soil nails and ground anchor technologies, especially relating to installation, testing, and inspection. Recognizing the extensive knowledge base for these topics, this module forms the prerequisite to the advanced topics offered in the second and third modules. The two advanced modules are in alignment with existing FHWA reports and permit more digital features to be introduced to enhance learning.

The *Inspection of Soil Nail Walls* module includes metric conversion screens and very extensive features for viewers with disabilities. Interactive animation, video, practice exercises, and checklists are provided throughout the module, summarizing key items discussed in the text. Printable blank forms and checklists are included via web browser access in the contract documentation section. These forms are used by the inspector during the construction inspection process to record important data concerning the installation and testing of either the ground anchors or soil nails. Of special significance and digital complexity are the comprehensive corrosion protection schematic sequences detailing current design and construction practice for Bar and Multi-Strand tendons, under both Class 1 and Class 2 protection.

17. Key Words	18. Distribution Statement
GEOTECHNICAL ENGINEERING, SOIL NAIL WALL, GROUND ANCHORS, CONSTRUCTION, INSPECTION, ROAD DESIGN, ROAD CONSTRUCTION	No restriction. This document is available to the public from the sponsoring agency at the website http://www.wfl.fhwa.dot.gov/td/.

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Application of Ground Anchors and Soil Nails in Roadway Construction

Technology Deployment Program
Western Federal Lands Highway Division
Federal Highway Administration
610 East 5th St.
Vancouver, WA 98661

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)

Foreword

The state of construction technology in geotechnical engineering in the United States of America is not at par with international standards, as identified in *Geotechnical Practice in Canada and Europe* (FHWA-PL-99-013). The scanning report highlighted practices in other countries that have advanced their technology by focusing on strong research programs, innovative designs, and contractor partnerships. These contractor partnerships strongly supported advances in geotechnology testing, design, analysis, and construction. The Federal Highway Administration (FHWA) report concluded that, in part, the leading U.S. obstacles for new knowledge implementation are:

- Poor communication between structural and geotechnical disciplines,
- Lack of Reliability Based Design (RBD) competency, and
- Inadequate site investigations.

If problems develop in the field, then the lack of comprehensive technical in-house reviews and poor field inspections can also compound the problems, contributing to project delays and leading to cost overruns and claims.

For highway design and construction, federal agencies have been assigned a special leadership role to demonstrate best construction practices including knowledge dissemination. Highway engineering field staffs are the most 'information handicapped' members of the design and construction team. Their daily challenges include:

- Large physical distances and diverse geo-environmental conditions,
- Restricted availability of information in remote locations,
- Possible extremes of climate and weather concerns, and
- Cumbersome, bulky, and heavy paper formatted documents including plans, specifications, and permits.

To deliver a quality geotechnical component in constructed projects, many varied products and services must be integrated, often in difficult and unpredictable conditions. To efficiently accomplish this task, knowledge accessibility is probably the key component. It is imperative to begin integrating advanced teaching technologies with the highway infrastructure knowledge base.

Ground anchor and soil nail wall systems are required to undergo a higher proportion of testing compared to other foundation engineering technologies because of the high degree of uncertainty, as well as the consequences of unsatisfactory performance. The unique and critical role played by field inspectors in ensuring quality in the constructed project for this technology requires extensive knowledge and training.

Digital Educational Tools and Training Modules

The need for training FHWA field engineering staff provided the impetus to begin a multi-media pedagogy exercise. Two high priority training topics, ground anchors and soil nails, were selected and then divided into three modules. A module is an independent, self-contained educational unit. To date, no comprehensive effort has been made in any area of geotechnology to fully embrace multiple kinds of media for knowledge access, learning comprehension, and self assessment. The use of multi-media enhanced research implementation in rockfall catchment slope design has only recently been reported. Customized learning tools, advanced video and audio features, and other innovations, such as off-line CD training, can help close the previously described technology knowledge gap.

The ground anchor and soil nailing modules on the accompanying CDs include the following multi-media features:

- *Linked Navigation* allows the user to rapidly move around the module. Alphabetically organized Index pages are also included for using the CD as a reference product.
- *Videography* filmed on-site and edited, highlights construction techniques, real world processes, and testing procedures.
- *Expert Speaks* sections of studio quality recorded sessions convey the voices of a group of technical experts offering their own knowledge and experience.
- *Flash Animation* illustrates key terms, best practices, and site procedures via annotated, custom built animations.
- *Roll-Overs* for mouse activated overlay screens of nail and anchor sections and figure expansion with audio explanation, complete with artist renditions and/or schematics.
- *Stills and Text* linked via the navigation structure to other areas of the CD.
- *Disability Features* are included for some user disabilities in the audio or visually impaired categories through alternative navigation and computer narration.
- *Other Resources* give access via the pc web browser to standard forms and checklists and provide updates from a FHWA server of advances in the technology.
- *User Survey* from online links to assess the user learning experience.

A mix of these technologies is illustrated throughout the three accompanying modules on five disks.

The objective for the first module, *Introduction to the Inspection of Soil Nails and Ground Anchors,* is to offer an introduction to drilled soil nails and ground anchor technologies, especially relating to installation, testing, and inspection. Recognizing the extensive knowledge base for these topics, this module forms the prerequisite to the advanced topics offered in the second and third modules. The two advanced modules are in alignment with existing FHWA reports and permit more digital features to be introduced to enhance learning.

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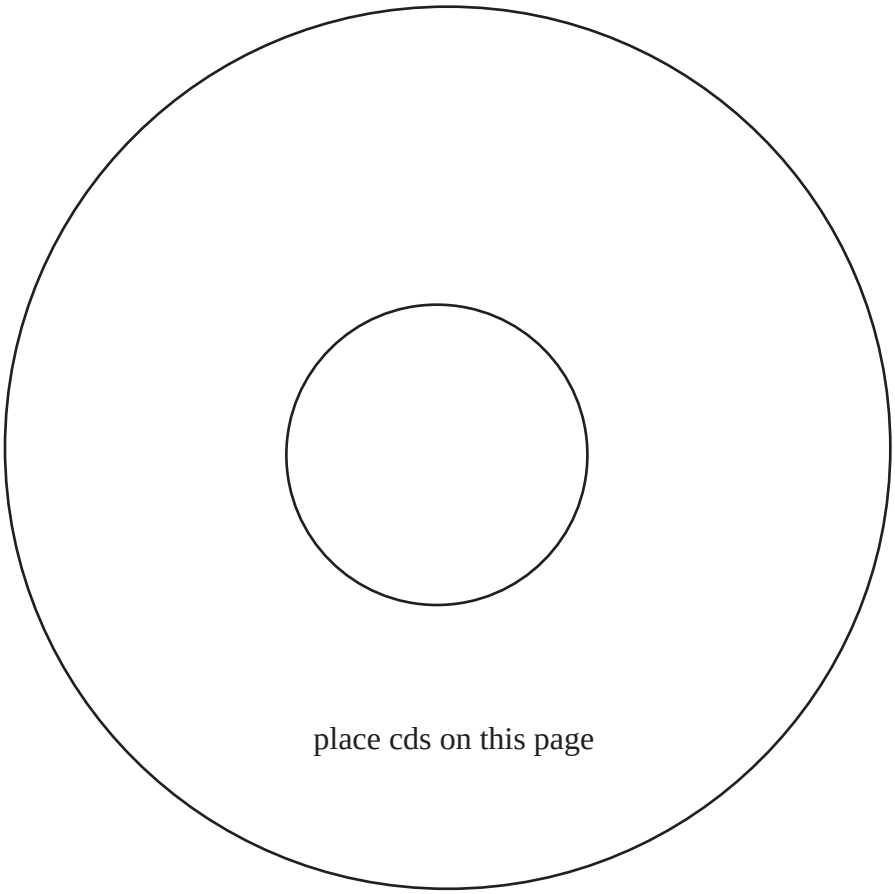
Among other specialist topics, users listen to experts stress the importance of soil identification and record keeping with an introductory piece on soil sampling. All inspectors are encouraged to obtain copies of: *Soil Nail Field Inspectors Manual* (FHWA-SA-93-068), *Ground Anchors and Anchored Systems* (Geotechnical Engineering Circular No. 4, FHWA-IF-99-015), and *Recommendations for Prestressed Rock and Soil Anchors* (Post-Tensioning Institute). These publications are referenced in various sections of this manual to provide the inspector with additional details on specific operations.



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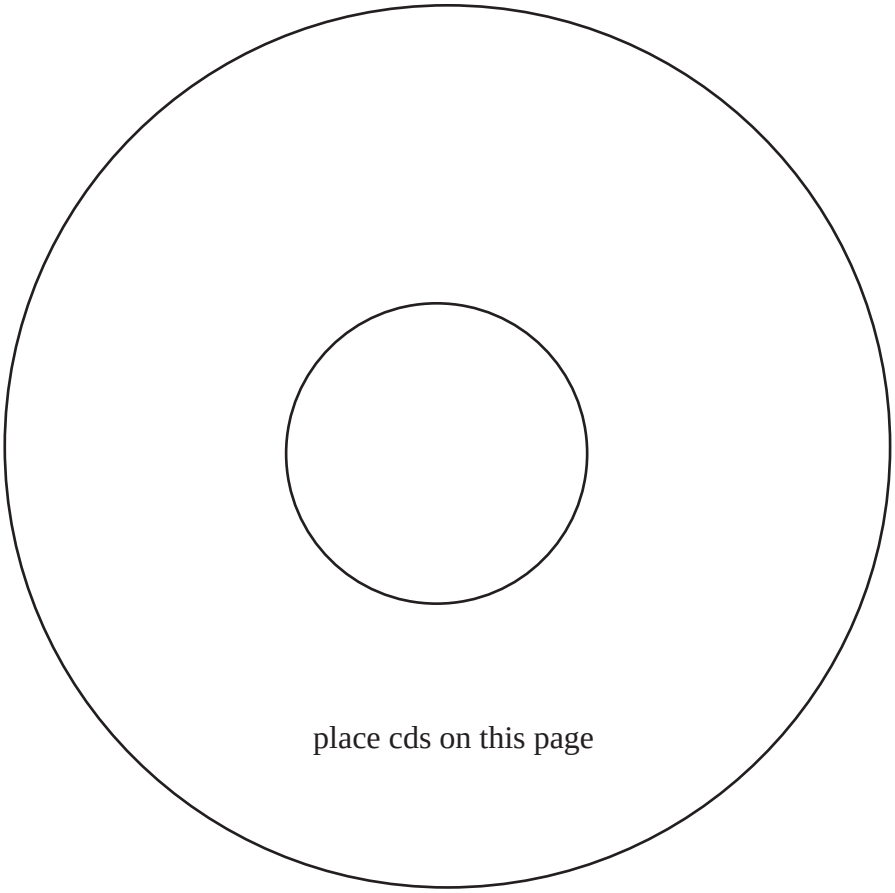

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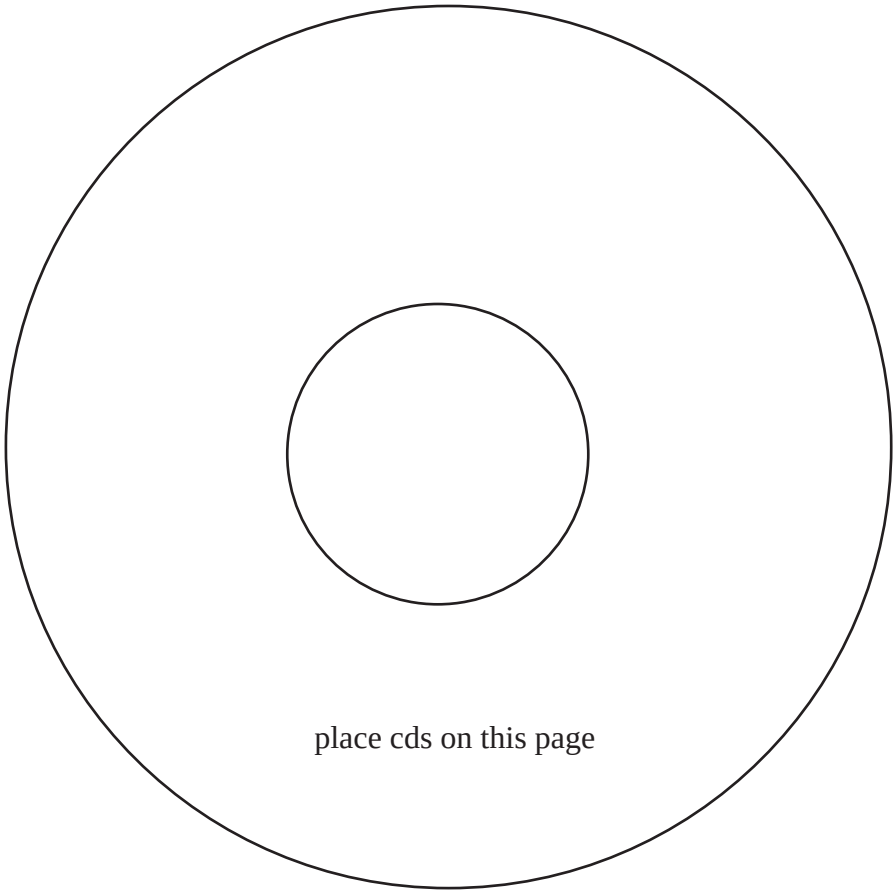

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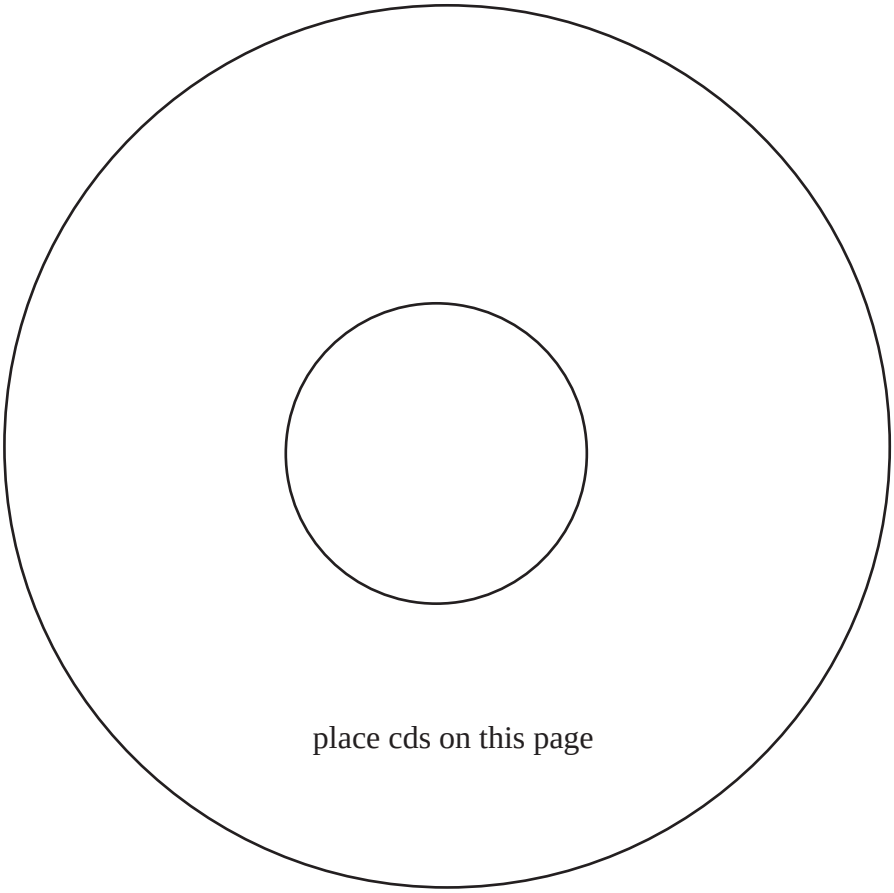

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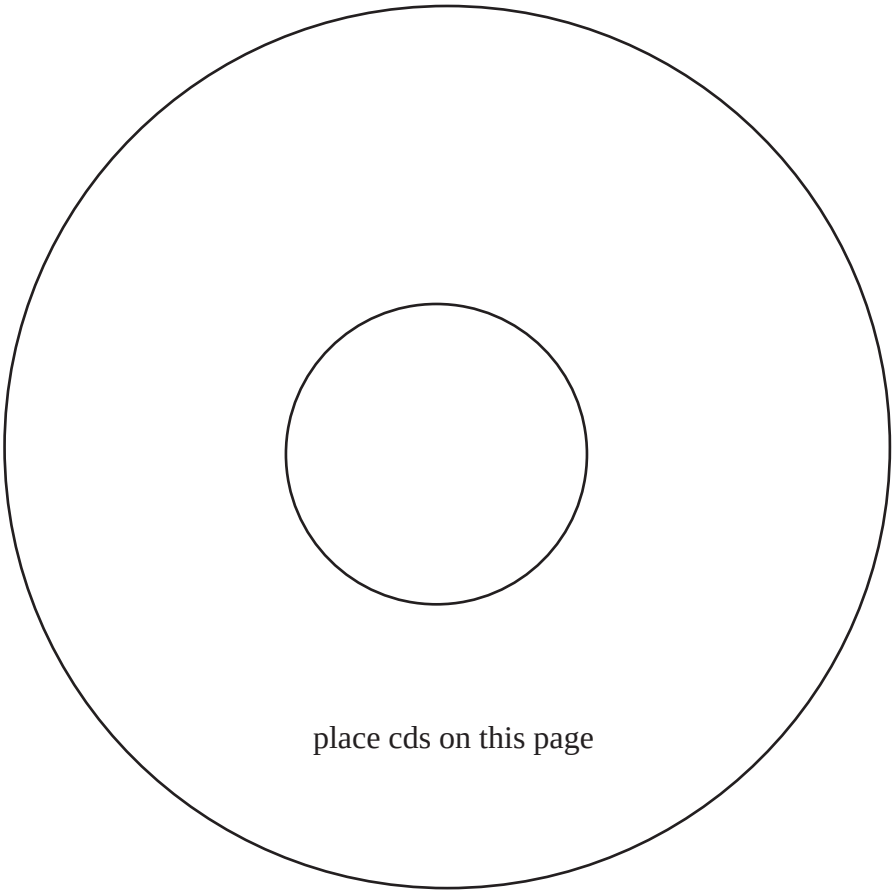

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