# SNAP (SOIL NAIL ANALYSIS PROGRAM)
## User's Manual

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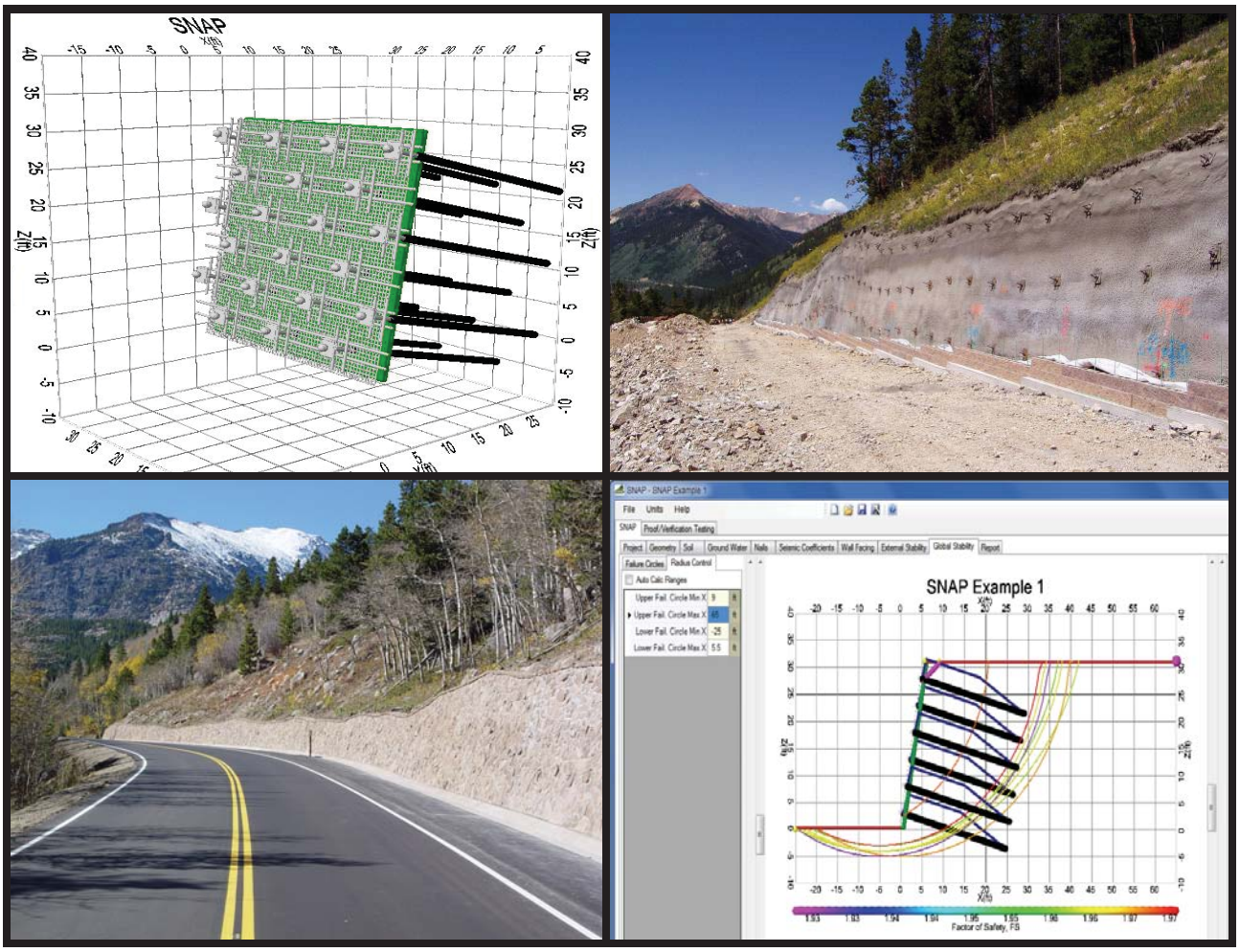



U.S. Department of Transportation
**Federal Highway Administration**

CTIP

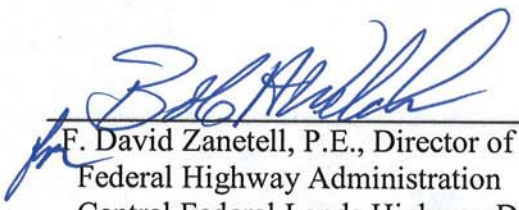
Federal Lands Highway
*Commitment to Excellence*

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

# FOREWORD

The Office of 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, related information, and knowledge sharing to Federal agencies, Tribal governments, and other offices within the FHWA.

The current design process for soil nail earth retention systems is inefficient because multiple tools are needed for facing, internal, external, and global design. These tools do not communicate with one another, and are often used by different staff members. The main objective of this work was to develop a single State-of-Practice computer program for designing the entire soil nail earth retaining structure, including nail elements, facing elements, global stability, and evaluation of internal and external wall stability based on the current AASHTO design standards. By combining all these assessment tools into one package, we take another step towards assuring high quality and efficient designs and accelerating project delivery.



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16. Abstract

Soil nail walls are internally stabilized earth-retaining structures. Soil nail walls use a top-down construction with in situ reinforcement to support temporary or permanent excavations. In certain conditions, soil nailing is a viable alternative to other ground anchor systems, considering technical feasibility, cost, and construction duration.

Although the use of soil nail walls for highway applications has increased dramatically in the past decade, computer programs for the design of soil nail walls are not up to date. The main objective of this work is to develop a state-of-the-practice computer program (Soil Nail Analysis Program) for designing all components of soil nail retaining structures, including nail and facing elements. The program will evaluate the internal and external wall stability (including limit-equilibrium global slope stability) based on the current standards in the ASD method. In addition, the program may be used to evaluate verification and proof field test results. All design and evaluation procedures are according to the FHWA guidelines presented in 1) The Manual for Design and Construction of Soil Nail Walls, Report No. FHWA-SA-96-069R, and 2) Geotechnical Engineering Circular No. 7 - Soil Nail Walls, Report No. FHWA-IF-03-017.

This user's manual discusses the theoretical basis for the computer program, gives a comparison of available soil nail wall design guidelines, discusses program execution including inputs and outputs, and includes two worked examples to demonstrate use of the program.

| 17. Key Words | 18. Distribution Statement |
|---|---|
| **SOIL NAIL, COMPUTER PROGRAM, GLOBAL STABILITY, EXTERNAL STABILITY, INTERNAL STABILITY** | No restriction. This document is available to the public from the sponsoring agency at the 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<br>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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## LIST OF SYMBOLS AND ABBREVIATIONS

| | |
|---|---|
| A | Peak ground acceleration due to seismic loading |
| AASHTO | American Association of State Highway and Transportation Officials |
| ASD | Allowable Stress Design |
| B | Wall base length |
| CalTrans | California Department of Transportation |
| CFLHD | Central Federal Lands Highway Division |
| CIP | Cast-in-place |
| COTR | Contracting Officer's Technical Representative |
| DOS | Disk Operating System |
| FHWA | Federal Highway Administration |
| FLH | Federal Lands Highway |
| ft | foot (feet) |
| $ft^2$ | square feet |
| $ft^3$ | cubic feet |
| FS | Factor of Safety |
| in | inches |
| $in^2$ | square inches |
| $K_a$ | Active earth pressure coefficient |
| $k_h$ | Horizontal seismic coefficient |
| kip | kilo pound (1000 pounds) |
| kN | kilo Newton(s), SI unit of force |
| kPa | kilo Pascal |
| $k_v$ | Vertical seismic coefficient |
| lb | pounds of mass |
| lbf | pounds of force |
| $L_{BV}$ | Maximum bond length to avoid overstressing the nail during a verification or proof field test |
| LRFD | Load Resistance Factor Design |

| | |
|---|---|
| m | meter |
| $m^2$ | square meters |
| $m^3$ | cubic meters |
| MSE | Mechanically Stabilized Earth |
| $N_c$ | Bearing capacity factor |
| $N_q$ | Bearing capacity factor |
| $N_\gamma$ | Bearing capacity factor |
| NCHRP | National Cooperative Highway Research Program |
| $P_{AE}$ | Dynamic horizontal thrust force due to seismic loading |
| psi | pounds per square inch |
| Q | Allowable pullout resistance between grout and soil, e.g., pounds/foot (or kN/m) |
| $Q_u$ | Ultimate pullout resistance per unit of nail length (grout-ground bond) |
| SI units | International System of units (e.g. m, N, kPa, etc.) |
| SNAP | Soil Nail Analysis Program |
| $T_F$ | Allowable nail head load, e.g., kips (or kN) |
| $T_N$ | Allowable nail tendon load, e.g., kips (or kN) |
| $T_{FN}$ | Controlling nominal nail head load |
| US units | United States customary units (e.g., ft, lbf, psi, etc.) |
| $\phi$ | Internal friction angle of a soil |

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