SOIL NAIL WALL BASICS
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Geotechnical Branch
Soil Nail Basics

Soil Nail Walls

- Technique to reinforce and strengthen the soil
- Construction proceeds from the top down
- Nails (grouted steel bars) are passive reinforcement
- Nails limit the displacement of the soil
Soil Nail Basics

Soil Nail Walls

Design
- Layout Sheets
- Detail Sheets

Specification

Construction
- Inspection
  - follow the details
  - Adhere to the specifications
Soil Nail Basics

- Soil Nail Walls Need to Be Designed for the site conditions
- There Are Not Any Standards
- Not a Proprietary System.
- Complete details must be provided.
Wall Layout

- Soil borings through zone to be nailed
- Provide separation from bridge abutment where possible
- Limit base-of-wall embedment
- Consider future excavation at base of wall.
SOIL NAIL DESIGN

Design Tools


- Various Computer Programs are available:
  - GoldNail Computer Program
  - SnailZ Computer Program
  - SNAP-2 Computer Program
Soil Parameters

- Determine drained soil parameters from laboratory testing (difficult), correlation with PI, or experience.

- Drained Cohesion should be very low (0 - 100 psf)

- Drained Angle of Friction (φ’) is normally between 24 and 34 degrees

- Drained soil parameters determine what portion of load is transferred to the nails from the face.

Graph. Relationship between friction angle and plasticity index (after Terzaghi, Peck, and Mesri 1996).
Soil Parameters

- Ultimate Pullout Resistance is the anticipated ultimate shear resistance per foot of nail
- Use Texas Cone Penetrometer (TCP) tests to determine the Ultimate Pullout Resistance
- Same method as calculating skin friction on a drilled shaft or pile
Nail Spacing Guidelines

- Nail Spacing impacts the loading on the soil nails
- For clay soils use a tighter spacing

**Horizontal Spacing 3.0’ – 4.5’**

**Vertical Spacing 3.0’ – 4.0’**

**Top of Wall**

- Top Nail within 2.5’ of Top of Wall

**Bottom of Wall**

- Bottom Nail within 3.0’ of Bottom of Wall
Head Strength

- Head Strength is defined as the capacity of the nail anchorage in the fascia.
- High Head Strength shortens the nails and allows the lowest nails to carry a disproportionate amount of load.
- Do not allow lowest anchors to carry the highest loads.
- If required, adjust the head strength until the upper half of wall is carrying at least half of the total load.

From: FHWA GEC 007
February 2015
Soil Nail Basics

Full-scale wall tests show that the upper nails carry the highest loads.

TxDOT Monitored Soil Nail Wall

Nail loads may increase over time in the wall (high PI clay soils)

<table>
<thead>
<tr>
<th>Nail No.</th>
<th>Design load (kips)</th>
<th>Max. load at end of construction (kips)</th>
<th>Max. service load one year after construction (kips)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nail in first row</td>
<td>21</td>
<td>9.8</td>
<td>10.11</td>
</tr>
<tr>
<td>Nail in second row</td>
<td>18</td>
<td>13.11</td>
<td>12.37</td>
</tr>
<tr>
<td>Nail in third row</td>
<td>18</td>
<td>7.25</td>
<td>9.28</td>
</tr>
<tr>
<td>Nail in fourth row</td>
<td>18</td>
<td>7.47</td>
<td>8.01</td>
</tr>
<tr>
<td>Nail in fourth row</td>
<td>18</td>
<td>6.7</td>
<td>8.3</td>
</tr>
<tr>
<td>Nail in fourth row</td>
<td>18</td>
<td>1.2</td>
<td>6.9</td>
</tr>
</tbody>
</table>

From: FHWA GEC 007
February 2015
Specification is an updated version of the Statewide Special Specification 41.16 and includes materials, equipment, construction, testing, measurement, and payment.
Soil Nailed Walls need to be designed for the site conditions present. There are not any standard detail sheets for them. Each wall needs to be treated individually.
Identify the following:
- top and bottom of wall
- nail locations
- elevations of rows of nails
- non-typical nail spacing
- obstructions
SOIL NAIL LAYOUTS

Sometimes soil nails may need to be angled.

The angle needs to be identified on the layout.

From: FHWA GEC 007
February 2015
SOIL NAIL LAYOUTS

Angle Nails 15° Right

- 94 nails @ 22' length = 2068'
- 16 nails @ 12' length = 192'
- 21 nails @ 18' length = 378'

Soil Nail Anchors:
- 112' length = 41 nails
- 118' length = 60 nails
- 122' length = 509 nails

Total nail length = 12,770

Soil Nail Wall Length (ft) 350.0
Max. Nail Spacing (H x V) 3.0' x 3.0'

*NAIL REINFORCEMENT LENGTH WILL BE THE NAIL LENGTH SHOWN IN THE TABLE PLUS 6 INCHES. SEE DETAIL SHEET.

**SOIL NAIL TEST ANCHORS

### Soil Nail Test Anchors

<table>
<thead>
<tr>
<th>No. of Test Anchors</th>
<th>Length</th>
<th>Minimum Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>22'</td>
<td>22.1'</td>
</tr>
</tbody>
</table>

Soil nail test anchors will be #8 Gr. 75 Baling Threader or equal. Test nails will not be used as production nails.

**SOIL NAIL PROOF ANCHORS

<table>
<thead>
<tr>
<th>No. of Test Anchors</th>
<th>Length</th>
<th>Minimum Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>22'</td>
<td>14.3'</td>
</tr>
<tr>
<td>4</td>
<td>12'</td>
<td>7.8'</td>
</tr>
</tbody>
</table>

Soil nail proof anchors will be #6 Gr. 60 Baling Threader or equal.

Texas Department of Transportation

Bridge Division

SP 515/SH 105E

NORTH RETAINING WALL

SOIL NAIL LAYOUT
Soil Nail Basics

SOIL NAIL LAYOUTS

Angle Nails 15° Right

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>21 nails</td>
</tr>
<tr>
<td>12</td>
<td>16 nails</td>
</tr>
<tr>
<td>22</td>
<td>94 nails</td>
</tr>
</tbody>
</table>

Soil Nail Anchors (12' length): 41 nails, 492 ft
Soil Nail Anchors (18' length): 60 nails, 1080 ft
Soil Nail Anchors (22' length): 509, 1119 ft
Total nail length: 12,770 ft

Soil Nail Wall Length: 350.0 ft
Max. Nail Spacing (H x V): 3.0' x 3.0'
SOIL NAIL LAYOUTS

- Soil Nail Anchors (22' length) = 94 nails
- Soil Nail Anchors (12' length) = 16 nails
- Soil Nail Anchors (18' length) = 21 nails

**SOIL NAIL TEST ANCHORS**

- Number of Test Anchors: 2
- Minimum Development Length: 22 ft
- Nail Reinforcement Length: 22 ft

**SOIL NAIL PROOF ANCHORS**

- Number of Proof Anchors: 20
- Minimum Development Length: 14 ft

**Notes:** Soil nail test anchors will be #8 Gr. 75 Swaydog threadbar or equal. Test nails will not be used as production nails.

**Texas Department of Transportation**

**SP 515/SH 105E**

**NORTH RETAINING WALL**

**SOIL NAIL LAYOUT**

**Legend:**
- B.O.W. = Bottom of Wall
- S = Soil Nail Location
- C = Constant Nail Elev. Line
- A = Partial Nail Elev. Line
- T = Top of Wall

**Est. No. of Nails**

- Soil Nail Anchors (22' length) = 41
- Soil Nail Anchors (12' length) = 60
- Soil Nail Anchors (18' length) = 509

**Total Nails Length:**

- Total Nails Length = 12,770 ft

**Soil Nail Wall Length (ft):**

- 350.0 ft

**Max. Nail Spacing (H x V):**

- 3.0' x 3.0'

**Additional Notes:**

- Soil nail test anchors will be #8 Gr. 75 Swaydog threadbar or equal. Test nails will not be used as production nails.
SOIL NAIL TESTS

TWO TYPES OF TESTS

1. Verification Tests
   - these are performed prior to construction
   - on sacrificial soil nail anchors
   - tests both the strength of the soil and the Contractor’s methods of installation

2. Proof Tests
   - these are performed on production soil nail anchors
   - performed to a lower load than verification nails
   - tests the Contractor’s methods of installation
SOIL NAIL DETAIL SHEET

TYPICAL SECTION
THROUGH WALL
SEE LAYOUT FOR SPECIFIC NAIL LOCATIONS
SOIL NAIL DETAIL SHEET

NAIL REINFORCEMENT LENGTH WILL BE THE LENGTH SHOWN IN THE SOIL NAIL LAYOUT SHEETS PLUS 6 INCHES.
Weephole Detail

ELEVATION

Cut 2” round hole in drain core at weep hole
Wrap fabric around bottom of core 4” min.

SECTION

Prefab. Drain
Filter Fabric

Bottom of Wall Panel
Permeable Unreinforced concrete leveling pad (Class A)

Concrete Course Aggregate Grade 2 or 3
6” perforated pipe (Type 6)

UNDERDRAIN DETAIL
(The location of the underdrain outfall will be determined by the Engineer)
Make sure to update the General Notes to be consistent with Item 410 “Soil Nail Anchors”
CONSTRUCTION PROCEDURE:

The slope in front of the retaining wall shall be removed in lifts. The depth of each lift shall be limited to the amount necessary to install a single horizontal row of Soil Nails. At no time shall more than 4’-0” of unnailed vertical cut be exposed. The length of each lift removed shall be limited to the amount that can be nailed in one day. At no time shall any un-nailed cut face be exposed for over 24 hours.

Upon completion of each day’s installation of nails, pneumatically placed concrete shall be applied to the cut face. The concrete shall be reinforced with a single layer of Welded Wire Reinforcing Fabric, 4” X 4” - W2.9. and #4 waler bars as shown. Anchor Plate, beveled washer, and nuts shall be tightened up to the face of the PPC.

When all rows of nails have been placed, the permanent Concrete Fascia Wall shall be installed. The permanent concrete fascia wall shall be completed within 30 working days of the completion of nail placement. The items in RED need to match the soil conditions and job.
WHAT TYPES OF FACING OPTIONS ARE AVAILABLE?

Cast in-place

Precast Panels

Sculpted
Shotcrete
SOIL NAIL WALLS DEPEND UPON A PROPER DESIGN AND DETAILS DEVELOPED FOR THE SITE SPECIFIC SOIL CONDITIONS AND GEOMETRY
QUESTIONS?
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