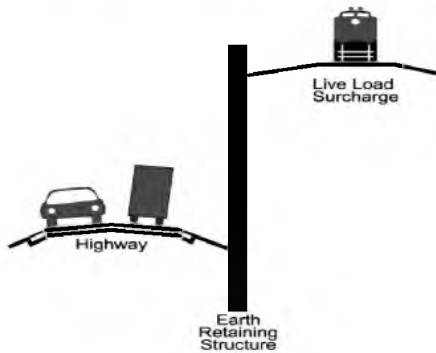


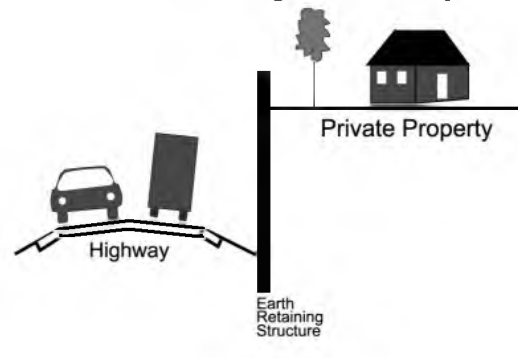
**DESIGN CONSIDERATIONS  
AND  
ALTERNATIVES FOR EARTH  
RETAINING STRUCTURES**

**WHERE TO CONSIDER  
AN EARTH  
RETAINING STRUCTURE**

**Proximate Live Load Surcharge**



**Limited Right-of-Way**



**EARTH RETAINING  
STRUCTURES  
ARE CLASSIFIED INTO  
TWO GROUPS**

**GROUP 1:**

**Designer Must Provide  
Complete Design  
And Plan Details**

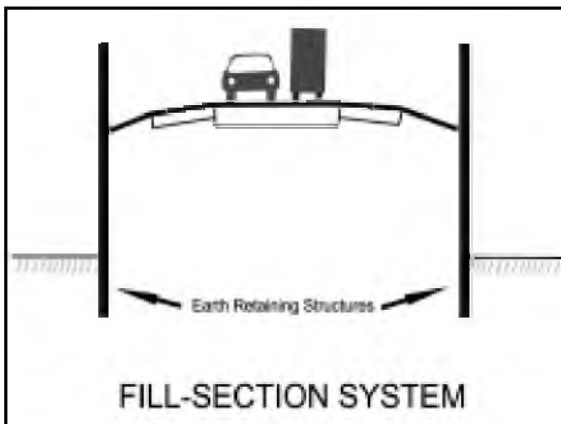
**GROUP 2:**

*Designer Makes Only A Conceptual Application, And Reviews A Contractor-Chosen Proprietary Design After The Letting, Through Shop Plans And Computations*

**EARTH RETAINING STRUCTURES**

**IN FILL SECTIONS**

*Used With Embankment Where Allowance For Side Slopes Is Limited*



**TYPES OF EARTH RETAINING STRUCTURES IN FILL SECTIONS**

**GROUP 1 SYSTEMS**

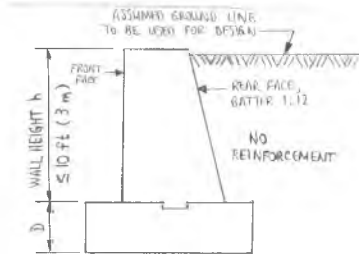
**CONCRETE GRAVITY WALL**

*Height Range  
H = 3 to 10 ft / 1 to 3 m*

*R / W Required  
0.5 to 0.7 of H*

*Cost: \$15 / ft<sup>2</sup> or \$150 / m<sup>2</sup>*

### Concrete Gravity Wall Typical Section



### CONCRETE CANTILEVER WALL

**Height Range**

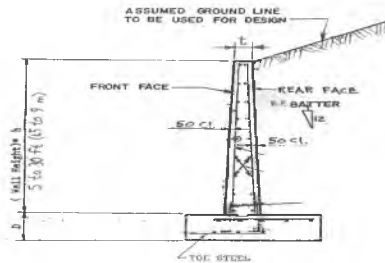
$$H = 5 \text{ to } 30 \text{ ft} / 1.5 \text{ to } 9 \text{ m}$$

**R / W Required**

$$0.4 \text{ to } 0.7 \text{ of } H$$

**Cost: \$50 / ft<sup>2</sup> or \$500 / m<sup>2</sup>**

### Reinforced Concrete Cantilever Wall Typical Section



### CONCRETE COUNTERFORT WALL

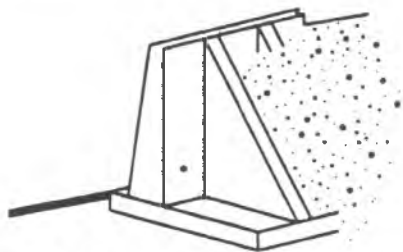
**Height Range**

$$H = 30 \text{ to } 60 \text{ ft} / 9 \text{ to } 18 \text{ m}$$

**R / W Required**

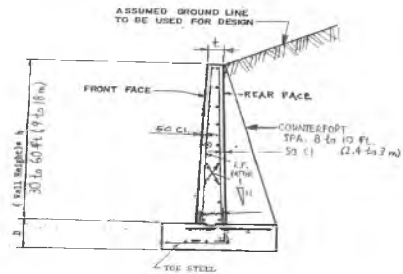
$$0.4 \text{ to } 0.7 \text{ of } H$$

**Cost: \$50 / ft<sup>2</sup> or \$500 / m<sup>2</sup>**



**Reinforced Concrete Counterfort  
Semi-Gravity Wall**

### Reinforced Concrete Counterfort Wall Typical Section



## GABIONS

### Height Range

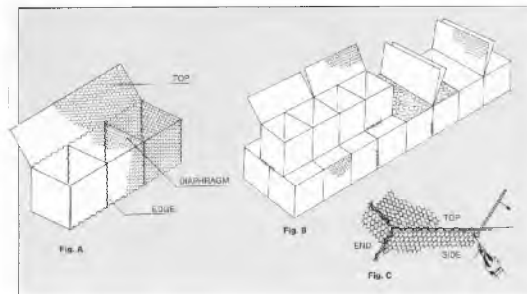
$H = 5 \text{ to } 15 \text{ ft} / 1.5 \text{ to } 5 \text{ m}$

### R / W Required

$0.5 \text{ to } 0.7 \text{ of } H$

Cost:  $\$40 / \text{ft}^2$  or  $\$400 / \text{m}^2$

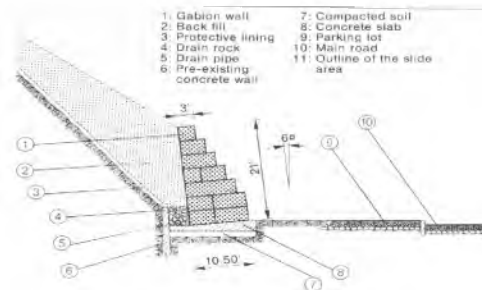
## Gabion Wall Baskets



## Gabion Wall



## Gabion Wall Typical Section



## REINFORCED SOIL SLOPES

### Height Range

$H = 10 \text{ to } 100 \text{ ft} / 3 \text{ to } 30 \text{ m}$

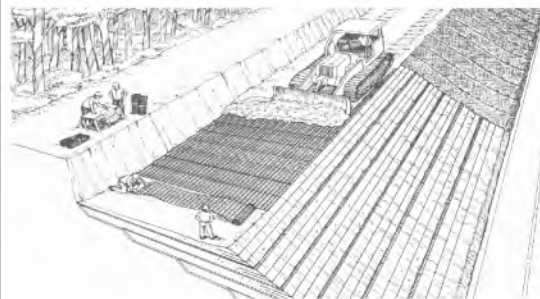
### R / W Required

$0.5 \text{ to } 1.0 \text{ of } H$

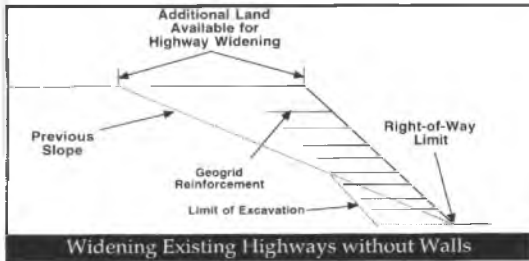
Cost:  $\$60 / \text{ft}^2$  or  $\$600 / \text{m}^2$

May Also Be Used Temporarily.

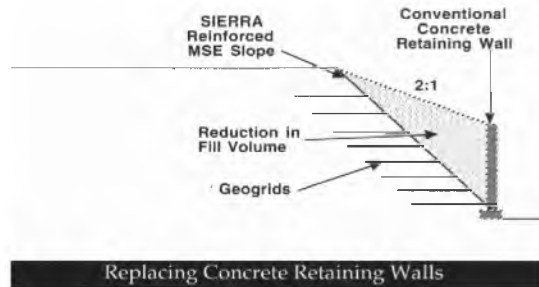
## Reinforced Soil Slopes (RSS)



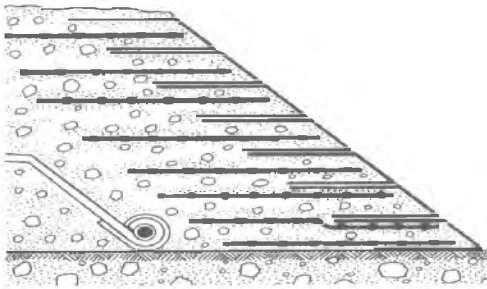
### RSS -- Typical Section



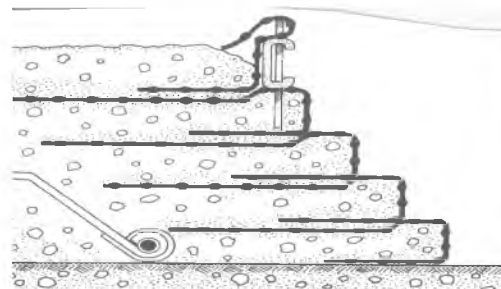
### RSS -- Typical Section



### RSS -- With Straight Reinforcement



### RSS -- With Bent Reinforcement



## GROUP 2 SYSTEMS

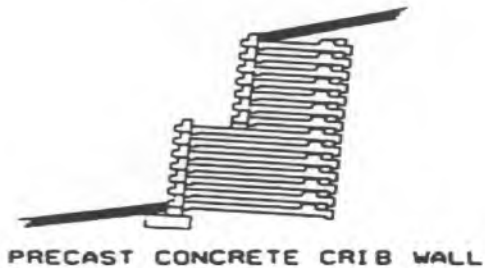
### CONCRETE CRIB WALL

Height Range  
 $H = 5 \text{ to } 35 \text{ ft} / 1.5 \text{ to } 11 \text{ m}$

R/W Required  
 $0.5 \text{ to } 0.7 \text{ of } H$

Cost:  $\$30 / \text{ft}^2$  or  $\$300 / \text{m}^2$

**Concrete Crib Wall  
Typical Section**



**MECHANICALLY STABILIZED  
EARTH, PRECAST PANELS**

**Height Range**  
 $H = 10 \text{ to } 65 \text{ ft} / 3 \text{ to } 20 \text{ m}$

**R / W Required**  
 $1.7 \text{ to } 2.0 \text{ times } H$

**Cost: \$50 / ft<sup>2</sup> or \$500 / m<sup>2</sup>**

**MSE Wall, Precast Panels --  
Steps and Walkway**



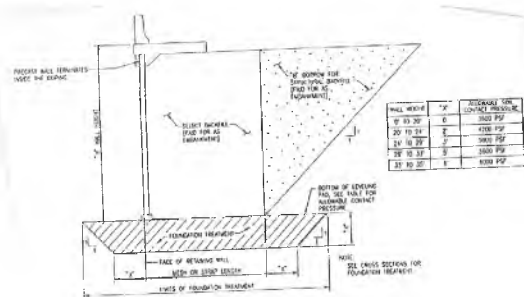
**MSE Wall, Precast Panels --  
Railroad Overpass and Wing**



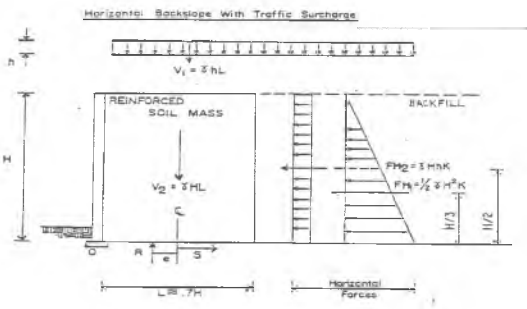
**MSE Wall, Precast Panels --  
Roadway Overpass Abutment**



**MSE Wall, Precast Panels  
Typical Section**



### MSE Wall, Precast Panels Typical Section Showing Forces



### MECHANICALLY STABILIZED EARTH, GEOGRID FACING

**Height Range**

$$H = 5 \text{ to } 50 \text{ ft} / 1.5 \text{ to } 15 \text{ m}$$

**R/W Required**

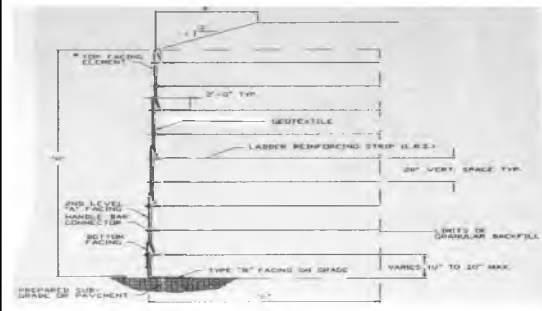
$$0.7 \text{ to } 1.0 \text{ of } H$$

**Cost: \$20 / ft<sup>2</sup> or \$200 / m<sup>2</sup>**

### MSE Wall, Geogrid Facing



### MSE Wall, Geogrid Facing Typical Section



### MODULAR BLOCK WALL WITH REINFORCEMENT

**Height Range**

$$H = 3 \text{ to } 10 \text{ ft} / 1 \text{ to } 3 \text{ m}$$

**R/W Required**

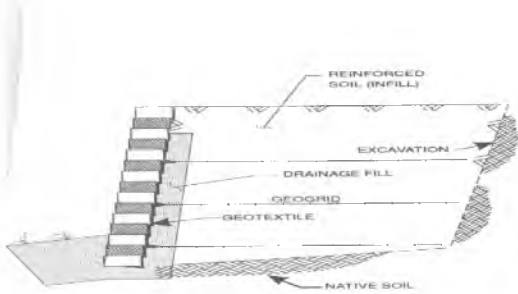
$$0.7 \text{ to } 1.0 \text{ of } H$$

**Cost: \$20 / ft<sup>2</sup> or \$200 / m<sup>2</sup>**

### Modular Block Walls



**Modular Block Wall With Reinforcement -- Typical Section**



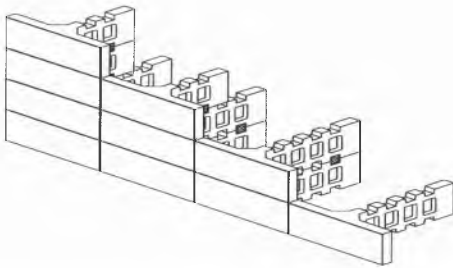
**MODULAR BLOCK WALL WITHOUT REINFORCEMENT**

**Height Range**  
 $H = 2 \text{ to } 5 \text{ ft} / 0.5 \text{ to } 1.5 \text{ m}$

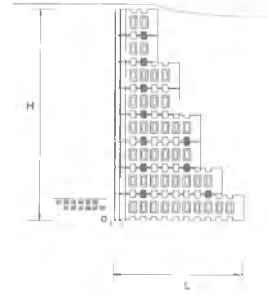
**R/W Required**  
 $0.5 \text{ to } 0.7 \text{ of } H$

**Cost: \$35 / ft<sup>2</sup> or \$350 / m<sup>2</sup>**

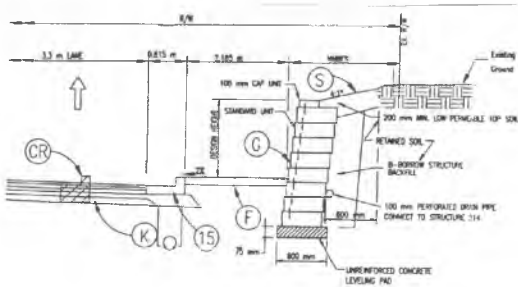
**Modular Block Wall Without Reinforcement**



**Modular Block Wall Without Reinforcement -- Plan View**



**Modular Block Wall Without Reinforcement -- Typical Section**



**BINWALL**

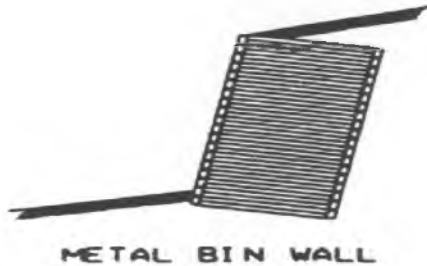
**Height Range**  
 $H = 5 \text{ to } 35 \text{ ft} / 1.5 \text{ to } 11 \text{ m}$

**R / W Required**  
 $0.5 \text{ to } 0.7 \text{ of } H$

**Cost: \$30 / ft<sup>2</sup> or \$300 / m<sup>2</sup>**



**Typical Section**



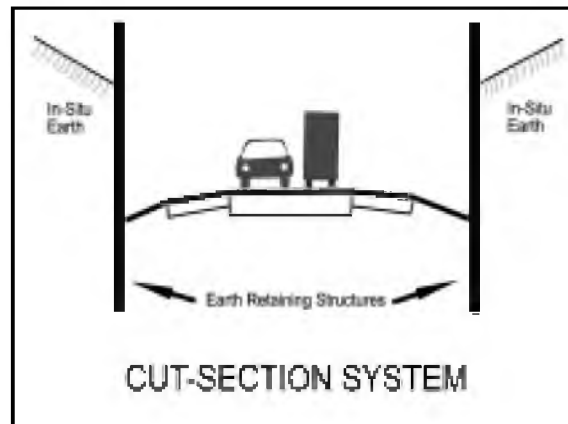
**Typical Section**



**EARTH RETAINING  
STRUCTURES**

**IN CUT SECTIONS**

*Used In Cut Sections  
Where Extensive  
Backslopes Are Impractical,  
Or Soil To Be Retained  
Is Of Poor Quality*



**TYPES OF  
EARTH RETAINING  
STRUCTURES  
IN CUT SECTIONS**

**GROUP 1 SYSTEMS  
ONLY**

## SHEET PILING

### Height Range

$H = 0$  to 15 ft / 0 to 5 m

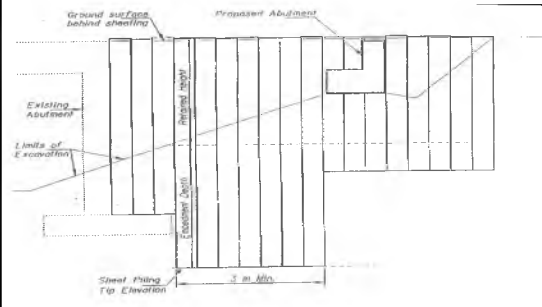
### R / W Required

None

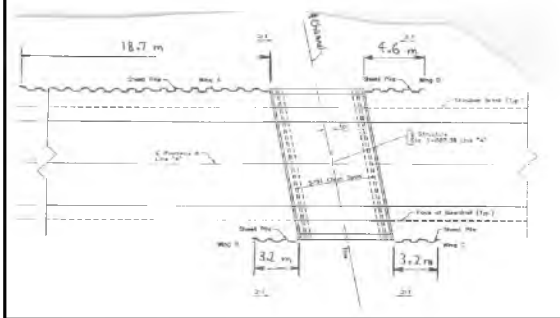
Cost: \$100 / ft<sup>2</sup> or \$1000 / m<sup>2</sup>

May Also Be Used Temporarily

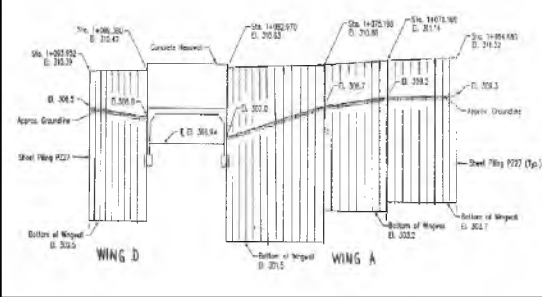
## Sheet Piling at Bridge Abutment -- Elevation View



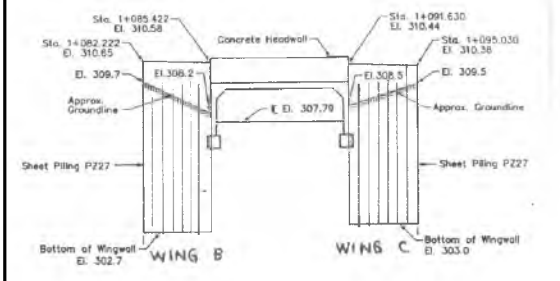
## Sheet Piling Wings at Box Culvert -- Plan View



## Sheet Piling Wings D and A at Box Culvert -- Elevation View



## Sheet Piling Wings B and C at Box Culvert -- Elevation View



## SOLDIER PILING OR TIEBACK WALL

### Height Range

$H = 0$  to 15 ft / 0 to 5 m

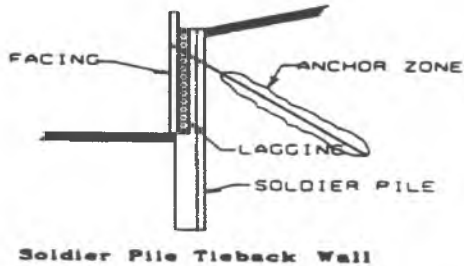
### R / W Required

None

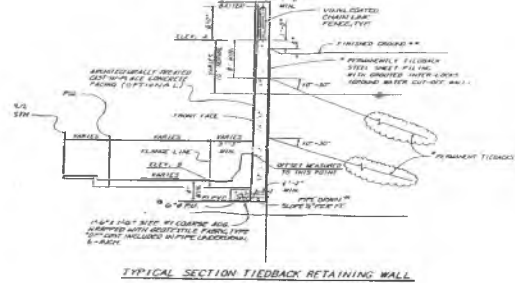
Cost: \$25 / ft<sup>2</sup> or \$250 / m<sup>2</sup>

May Also Be Used Temporarily.

### Soldier Pile Typical Section



### Tieback Wall Typical Section



### ANCHORED WALL

#### Height Range

$H = 15 \text{ to } 65 \text{ ft} / 5 \text{ to } 20 \text{ m}$

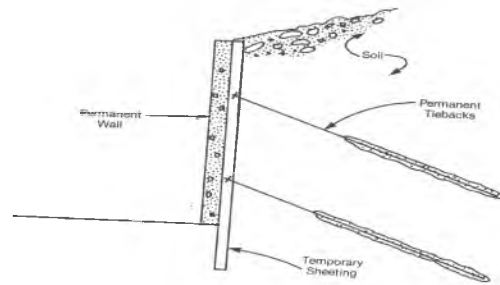
#### R / W Required

$0.5 \text{ of } H, \text{ plus anchor bond length}$

Cost: \$60 / ft<sup>2</sup> or \$600 / m<sup>2</sup>

May Also Be Used Temporarily.

### Anchored Wall Typical Section



### SOIL NAILING

#### Height Range

$H = 10 \text{ to } 65 \text{ ft} / 3 \text{ to } 20 \text{ m}$

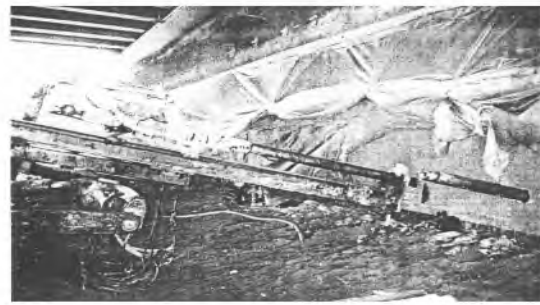
#### R / W Required

$0.6 \text{ to } 1.0 \text{ of } H$

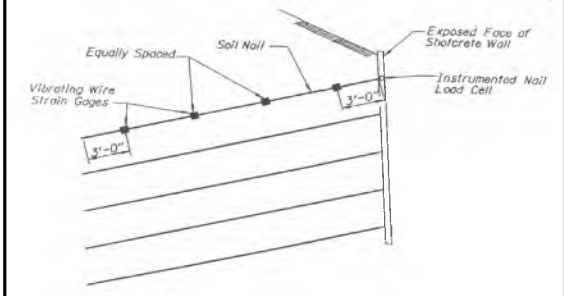
Cost: \$45 / ft<sup>2</sup> or \$450 / m<sup>2</sup>

May Also Be Used Temporarily.

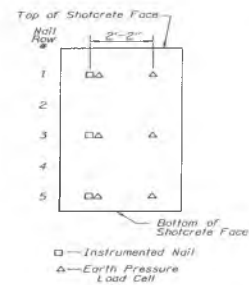
### Soil Nailing Work In Progress



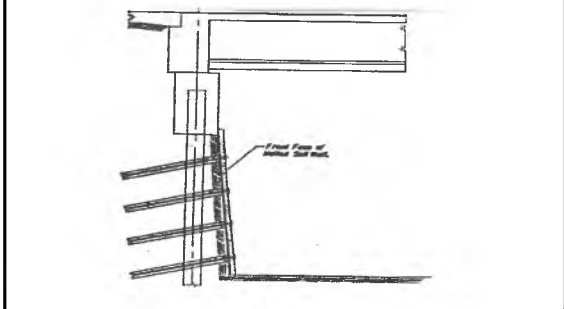
**Soil Nailing  
First Soil Nail in Place**



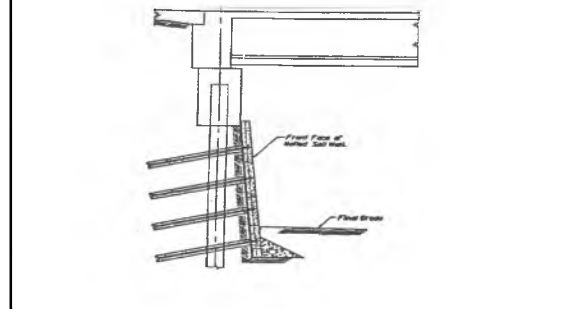
**All Soil Nails in Place --  
Front View**



**All Soil Nails and Wall  
in Place -- Typical Section**



**All Soil Nails, Wall, and Final  
Grade in Place -- Typical Section**



**GEOTECHNICAL  
CONSIDERATIONS**

*Most Foundations Are Shallow,  
Without Piles, On Dense Sand  
Or Silty Clay,  
And Not On Soft Soils  
Such As Peat, Marl, Or Silt.*

**GEOTECHNICAL  
CONSIDERATIONS**

*Reinforced Concrete Cast-In-  
Place Group 1 Walls  
In Fill Sections May Be  
Founded On Piles, So As  
To Get Through Soft Soils.*

**SYSTEM SELECTION  
CONSIDERATIONS**

*Future Uses Of The Site*

*Differential Deflection Or  
Settlement Of Wall Sections*

*Project-Specific Special Features*

**SYSTEM SELECTION  
CONSIDERATIONS**

*Long- And Short-Term  
System Stability*

*Comparable Degree Of Safety*

*Accessibility To Construction  
Site*

**SYSTEM SELECTION  
CONSIDERATIONS**

*Staged-Construction Limitations*

*Right-Of-Way Limits*

*Site-Imposed Physical  
Limitations*

**SYSTEM SELECTION  
CONSIDERATIONS**

*Seismic Activity*

*Wall Inundation*

*Aesthetics*

**SYSTEM SELECTION  
CONSIDERATIONS**

*Environment Sensitivity*

*Construction Time Restraints*

*Economics*

**ECONOMIC CONSIDERATIONS  
WHEN SELECTING A  
GROUP 2 SYSTEM**

*Fill Section Or Cut Section?*

*Wall Area*

*Average Wall Height*

**ECONOMIC CONSIDERATIONS  
WHEN SELECTING A  
GROUP 2 SYSTEM**

**Foundation Conditions**

**Availability And Cost Of  
Select Backfill**

**Availability And Cost Of  
Right Of Way**

**ECONOMIC CONSIDERATIONS  
WHEN SELECTING A  
GROUP 2 SYSTEM**

**Complex Horizontal And  
Vertical Alignment Changes**

**Need For Temporary Excavation  
Support Systems**

**Maintenance Of Traffic  
During Construction**

**GEOTECHNICAL INFORMATION  
REQUEST**

**Field Check Plans Stage:**

**System's Beginning And  
Ending Stations**

**Top And Bottom Elevations**

**Locations Of Steps**

**DESIGN GUIDELINES**

**Earth Retaining Systems Are To  
Be Designed In Accordance With  
AASHTO Standard Specifications  
For Highway Bridges.**

**In The Current Edition,  
This Information Is Mostly In  
Part I, Section 5.**

**DESIGN GUIDELINES**

**Chapter 68 of The Indiana  
Design Manual's New  
Part VI, Structures,  
Is Forthcoming This Year, And  
Will Include Everything We've  
Discussed Today In More Detail.**

**SUMMARY OF WALL TYPES AND PROPERTIES**

WALL TYPE	HEIGHT RANGE Meters Feet	R/W REQD.	COST PER sq ft	SPECS	COMMENTS
<b>FILL, GROUP 1</b>					
CONCRETE GRAVITY	0.5-1.5 1-5	0.5-0.7	150 15	SS	USED FOR SHORTEST CONCRETE WALL REQUIRED.
REIN. CONC. CANTILEVER	1.5-9 5-30	0.4-0.7	200 50	SS	THE BASIC MOST COMMON GROUP 1 WALL TYPE.
REIN. CONC. COUNTERFORT	9-10 30-30	0.4-0.7	200 50	SS	USED IF TALLER CANTILEVER WALL REQUIRED.
GABIONS	1.5-5 5-15	0.5-0.7	400 40	RSP	BEST WHERE AESTHETICS NOT A CONCERN.
REINFORCED SOIL SLOPES	3-30 10-100	0.5-1.0	100 60	U	RELATIVELY NEW.
<b>FILL, GROUP 2</b>					
CONCRETE GRABBALL	1.5-11 5-35	0.5-0.7	300 30	U	RARELY USED.
MISC. PRECAST PANELS	3-20 10-65	1.7-2.0	500 50	RSP	THE MOST COMMON GROUP 2 WALL TYPE.
MISC. GEOGRID PANELS	1.5-15 5-50	0.7-1.0	200 20	U	RARELY USED.
MODULAR BLOCK, WITH REIN.	1-3 3-10	0.7-1.0	350 35	RSP	STILL LIMITED USE, MOSTLY LOCAL AGENCIES.
MODULAR BLOCK, W/O REIN.	0.5-1.5 2-5	0.5-0.7	1000 100	RSP	GROUP 2 COMPLEMENT TO CONCRETE GRAVITY WALL.
GRABBALL	1.5-11 2-35	0.5-0.7	300 30	U	RARELY USED.
<b>CUT, GROUP 1</b>					
SHEET PILING	0-5 0-15	0	1000 100	SS	MOST COMMON CUT WALL TYPE, MOST OFTEN TEMP.
SOLMER PILES OR TIEBACK	0-5 0-15	0	250 25	U	MAY BE TEMPORARY.
ANCHORED WALL	5-20 15-65	0.5	100 60	U	RELATIVELY NEW, MAY BE TEMPORARY.
SOIL NAILING	3-20 10-65	0.6-1.0	450 45	U	RELATIVELY NEW, MAY BE TEMPORARY.

R/W REQD. - Required Portion of Wall Height Shown  
 SPECS - SS: In Standard Specifications  
 RSP: Among Requiring Special Provisions  
 U: Unique Special Provision Currently Required

## SUMMARY OF WALL TYPES AND PROPERTIES

WALL TYPE	HEIGHT RANGE		R / W REQD.	COST PER	
	Meters	Feet		m <sup>2</sup>	ft <sup>2</sup>
FILL, GROUP 1					
CONCRETE GRAVITY	0.5-1.5	1- 5	0.5 - 0.7	150	15
REINF. CONC. CANTILEVER	1.5- 9	5-30	0.4 - 0.7	500	50
REINF. CONC. COUNTERFORT	9 -18	30-60	0.4 - 0.7	500	50
GABIONS	1.5- 5	5-15	0.5 - 0.7	400	40
REINFORCED SOIL SLOPES	3 -30	10-100	0.5 - 1.0	600	60
FILL, GROUP 2					
CONCRETE CRIBWALL	1.5-11	5-35	0.5 - 0.7	300	30
MSE, PRECAST PANELS	3 -20	10-65	1.7 - 2.0	500	50
MSE, GEOGRID FACING	1.5-15	5-50	0.7 - 1.0	200	20
MODULAR BLOCK, WITH REINF.	1 - 3	3-10	0.7 - 1.0	350	35
MODULAR BLOCK, W / O REINF.	0.5-1.5	2- 5	0.5 - 0.7	1000	100
BINWALL	1.5-11	2-35	0.5 - 0.7	300	30
CUT, GROUP 1					
SHEET PILING	0 - 5	0-15	0	1000	100
SOLDIER PILES OR TIEBACK	0 - 5	0-15	0	250	25
ANCHORED WALL	5 -20	15-65	0.5	600	60
SOIL NAILING	3 -20	10-65	0.6 - 1.0	450	45

R / W REQD. – Required Portion of Wall Height Shown

SPECS – SS: In Standard Specifications

RSP: Among Recurring Special Provisions

U: Unique Special Provision Currently Required

SPECS COMMENTS

SS USED FOR SHORTEST CONCRETE WALL REQUIRED  
SS THE BASIC MOST COMMON GROUP 1 FILL WALL TYPE  
SS USED IF TALLER CANTILEVER WALL REQUIRED  
RSP BEST WHERE AESTHETICS NOT A CONCERN  
U RELATIVELY NEW

U RARELY USED  
RSP THE MOST COMMON GROUP 2 WALL TYPE  
U RARELY USED  
RSP STILL LIMITED USE, MOSTLY LOCAL AGENCIES  
RSP GROUP 2 COMPLEMENT TO CONCRETE GRAVITY WALL  
U RARELY USED

SS MOST COMMON CUT WALL TYPE; MOST OFTEN TEMP.  
U MAY BE TEMPORARY  
U RELATIVELY NEW; MAY BE TEMPORARY  
U RELATIVELY NEW; MAY BE TEMPORARY