Segmental & MSE Retaining Wall Design & Best Practices

APWA Construction Inspection Conference 2017
Segmental Block Wall Applications

- Attractive
  (with variable options)

- Versatile

- Cost-effective

[Images of block wall applications in residential, commercial, and highway contexts]
SRW/Auto Dealership/Littleton, CO
Precast SRW/Residential
MSE Panel RTD Along 225
Drycast Manufacturing Process

CONCRETE UNIT SPECIFICATIONS

- COMpressive Strength: Minimum 3000 psi
- Absorption: Maximum 8%
- Reference Standard: ASTM C1372
Drycast Production
Gravity Wall

Keystone Units

Setback/Batter

Total Wall Height

Finished Grade

Embedment Depth

Leveling Pad

Backslope or Surcharge

Low Permeability Soil

Retained Soil Zone

Unit Core Fill/Drainage

Limit of Excavation (Rough cut)

Drainage Collection Pipe (if required)
Reinforced Wall
Segmental Block Retaining Wall (SRW) Reinforced

- Reinforced Earth Retaining Wall Systems
Reinforcement Options

- **Earth Anchor**
- **Rock Anchor**
- **Steel Pile Anchor**
Design Information

- How Does Geogrid Work?
Retaining Wall Functions/Grade Separations/Cut & Fill Walls

Watch out for cut walls at property lines
Design Considerations

- Wall Layout
  (Site Plan, Topography, Utilities, Property Boundaries)

- Surcharge Loads
  (Traffic, Structures, Back-Slope on top of wall)

- Soil Properties
  (Reinforced Fill, Retained Fill, foundation Soils, Low soil shear strength within foundation soil or retained backfill)

- Foundation Bearing Capacity

- Water Conditions
  (Surface Water, Groundwater, Lakes, Ponds, Rivers)

- Multiple Tiered Walls

- Walls Built on a Slope
Design Considerations

- Location 1: Basic drainage
- Location 2: Surface run-off
- Location 3: Embankment flow
- Location 4: Ground water flow
Surcharge Load
Permitting Requirements for Retaining Walls

• Vary from State to State, County to County & City to City.

• Many local ordinances have adopted the 2012 International Building Code as their standard which says:
  
  ▪ **ANY WALL UNDER 4 FEET IN HEIGHT, MEASURED FROM THE BOTTOM OF THE FOOTING (LEVELING PAD) TO THE TOP OF WALL, UNLESS SUPPORTING A SURCHARGE OR IMPOUNDING CLASS I, II, OR IIIA LIQUIDS IS EXEMPT.**

• **EXAMPLE:**
  
  ▪ Minimum recommended block embedment depth for SRWs is 6 inches.
  ▪ Therefore the maximum EXPOSED Wall height under these guidelines is 3.5 feet exposed with a flat and level toe slope and no surcharge above the wall. (parking lot, additional or tiered retaining wall or back slope)
Terraces

- How close is too close? The minimum distance between the wall terraces must be at least equal to twice the height of the lower wall without site specific engineering.

**FIGURE 1.** - Minimum spacing of terraced walls without site specific engineering.

**FIGURE 2.** - Typical design of closely spaced terraced walls with geogrid reinforcement.
Multiple Tiered Walls (according to NCMA)

• Terraces
  - If the total combined height of the tiered walls is less than 6 feet in height, and the distance between walls is greater or equal to 2 times the height of the lower wall, than the wall can be constructed per the manufacturers design chart recommendations.
  - However, if the horizontal spacing is less than twice the height of the lower wall, or if the overall combined height of all the walls is greater than 6 feet in height, the walls should be reviewed by a professional engineer.
Maximum Height Gravity Wall Charts

NEAR VERTICAL - KEystONE COMPAC UNITS

<table>
<thead>
<tr>
<th>MAX. HGT.</th>
<th>BACKSLOPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Type</td>
<td>Level</td>
</tr>
<tr>
<td>Sand/Gravel</td>
<td>3.00' (0.9m)</td>
</tr>
<tr>
<td>Silty Sand</td>
<td>2.33' (0.7m)</td>
</tr>
<tr>
<td>Silt/Lean Clay</td>
<td>2.33' (0.7m)</td>
</tr>
</tbody>
</table>

ONE INCH SETBACK WALL
(1" (25mm) min. setback per unit)

SETBACK OPTION - KEystONE COMPAC UNITS

<table>
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<th>BACKSLOPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Type</td>
<td>Level</td>
</tr>
<tr>
<td>Sand/Gravel</td>
<td>3.67&quot; (1.1m)</td>
</tr>
<tr>
<td>Silty Sand</td>
<td>3.00&quot; (0.9m)</td>
</tr>
<tr>
<td>Silt/Lean Clay</td>
<td>3.00&quot; (0.9m)</td>
</tr>
</tbody>
</table>
Installation

1. Minimum Trench Depth.
   1. 6” inch leveling pad
   2. 6” inches of buried block

2. Aggregate Base material shall be compacted to 95% standard proctor.

3. Width of trench should be 12” inches wider than the depth of the retaining wall unit. (Typ. 6” inches on each side)
Installation Procedures

1. Block Embedment Depth

The recommendations in the table are general in nature and do not replace a comprehensive stability analysis in those areas with erosion or scour, poor soil conditions, or steep toe slopes. Special consideration should always be given to man-made fill slopes which can exhibit poor structural performance.

<table>
<thead>
<tr>
<th>Toeslope Condition</th>
<th>Bench Embedment</th>
<th>Total Embedment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>10% $H'$</td>
<td>10% $H'$</td>
</tr>
<tr>
<td>4H:1V</td>
<td>10% $H'$</td>
<td>1' +10% $H'$</td>
</tr>
<tr>
<td>3H:1V</td>
<td>10% $H'$</td>
<td>1.33' + 10% $H'$</td>
</tr>
<tr>
<td>2H:1V</td>
<td>10% $H'$</td>
<td>2' + 10% $H'$</td>
</tr>
</tbody>
</table>

(Note: 10% of exposed wall height is good rule of thumb, however, it is possible to reduce embedment to 5% under certain conditions for taller walls where foundation elevations and conditions are clearly established)
2. Prepare the base leveling pad
2. Prepare the base leveling pad (check for level and elevation)
Installation Procedures

2. Prepare the base leveling pad (compact to 95% standard proctor)
3. Set and Align Base Course
Installation Procedures

3. **Set and Align Base Course**
Installation Procedures

4. **Add Unit Corefill**
   1. ¾” inch to 1 inch angular rock.
   2. Placed within SRW unit void area.
   3. Extending 1 ft. behind SRW unit.
5. **Backfill and Compact Soil**

1. Maximum Recommended lift thickness is 8” inches.
2. Compacted to 95% standard.
   1. No. 200 < 35%
   2. PI < 20
   3. LL < 40
   4. Max. Aggregate size 2” inch
Installation Procedures

5. Backfill and Compact Soil
5. Backfill and Compact Soil
5. **Backfill and Compact Soil**

1. Use a light weight mechanical or vibratory system within 3 feet of the back of the SRW units.
Installation Procedures

6. Clean Up and Sweep Units
7. **Place & Tension Geogrid or Soil Reinforcement**

1. Shall be the type as shown on the retaining wall plans.
2. Shall be the length as shown on the retaining wall plans.
3. Shall be placed at the elevations as shown on the retaining wall plans.
4. Secure and tension geogrid prior to placement of additional retaining wall units and additional backfill.
Installation Procedures

8. Stack & Align Additional Courses of Block
Installation Procedures

8. Stack & Align Additional Courses of Block
Design Elements of an MSE Wall

- Coherent Earth Mass Consisting of Soil With Horizontal Inclusions (Soil Reinforcement); aka Engineered Box of Soil
Mechanically Stabilized Earth Retaining Walls

- Segmental Block Facing
- Precast Concrete Panel Facing
- Wire Facing
Soil Reinforcing Elements – Extensible (Geosynthetic)

Geogrid

Geomega™ Reinforcing Strips
Reinforcing Elements – Inextensible (Metallic)

- High Adherence Reinforcing Strips
- 2-Wire (Wide) Ladder Reinforcements
- Bar Mat (WWF) Reinforcements
- Geomega™ Reinforcing Strips
MSE Wall Design – External Stability

Geotechnical Design Parameters:
Select Backfill: $\phi$, Unit Weight
Retained Soil: $\phi$, Unit Weight
Foundation Soil: $\phi$, Cohesion; Bearing Resistance
**MSE Wall Design**

**External Stability**
Sliding & Overturning of MSE Structure

**Internal Stability**
Tension & Pullout of Soil Reinforcing Elements
MSE Wall Design – Global / Compound Stability
MSE Wall Design – Global / Compound Stability

Typical Retaining Wall Section

Not To Scale
Applications – Bridge Abutments

Pile Supported Bridge Abutment
Applications – Bridge Abutments

MSE Supported Bridge Abutment
Extreme Heights

Seattle-Tacoma International Airport, WA

145 ft Max.
Design Ht.
EXTREME SEISMIC RESILIENCY:
Designed for ground acceleration of 0.10g; actual event of 0.40g
Reinforced Earth Wall adjacent to epicenter, Izmit, Turkey
MSE Retaining Walls - Design

Contract Plan
MSE Retaining Walls - Design

MSE Wall Partial Plan View
MSE Retaining Walls - Design

Precast Panel Fabrication Drawings
MSE Retaining Walls - Construction

Material Delivery
MSE Retaining Walls - Construction

Leveling Pad
MSE Retaining Walls - Construction

Setting Panels
Install Reinforcing Strips
Install Reinforcing Soil Reinforcement (Correctly)
Install Reinforcing Soil Reinforcement (Incorrectly)
MSE Retaining Walls - Construction

Backfill
MSE Retaining Walls - Construction

Continue With Panel, Reinforcing Strip, Backfill Installation