MODULAR RETAINING WALLS and THEIR POTENTIAL TO FAIL

RAJA S. EL-AWAR, PE
FES GROUP, LLC

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1. Bio - Raja S. El-Awar, PE

EDUCATION

- **Education:** BSCE 1981 and MSCE 1984,WVU – Geotechnical & Transportation

REGISTRATIONS

- **Professional Engineer Licenses:** MD, VA, PA, DE, NC & DC
- **Contractor Licenses**: MD, VA & DC

EXPERIENCE

- **Experience:** 30+ Years of Design, Inspection & Geotechnical Specialty Contracting Services.

1. NCDOT	1984 – 1989	Geotechnical Section
2. PSI	1989 – 1992 & 1993 – 1995	Geotechnical Consultant
3. Berkel & Company	1992 – 1993	Geotechnical Contracting
4. Geo Design Consultants	1995 – 1996	Geotechnical Consultant
5. Foundation Engineering Science	1996 – 2011	Geotechnical Consultant & Contracting
6. KCI Technologies, Inc.	2011 – 2013	All Disciplines Consultant
7. GC&T	2013 – 2014	Geotechnical Consultant
8. FES Group	2014 – Present	Geotechnical Contractor

ORGANIZATIONS

DFI	Member (Committee Member; Helical Piles & Tiebacks)
TRB	Member (TRB AFP30 Soil and Rock Properties)
ASCE	Member

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2. Modular Retaining Walls (Design/Build)

A. Gravity – Self supported without reinforcement within the soil mass.

B. Reinforced – Require geo-grid reinforcement within the soil mass.

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3. Design Requirements

1. Gravity Modular Retaining Walls
   - A. Internal - None
   - B. External
     1. Sliding
     2. Overturning
     3. Bearing Capacity
     4. Settlement
     5. Global Stability

2. Reinforced Modular Retaining Walls
   - A. Internal
     1. Geogrid (Length, Connection & Location)
   - B. External
     1. Sliding
     2. Overturning
     3. Bearing Capacity
     4. Settlement
     5. Global Stability

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4. Construction Requirements

1. Gravity Modular Retaining Walls
   - A. Footing/Leveling Pad
   - B. Modular Block
   - C. Drainage Column
   - D. Underdrain System
   - E. Gravity Mass
   - F. Cap/Final Grading
   - G. Fence/Guard Rail/Landscaping

2. Reinforced Modular Retaining Walls
   - A. Footing/Leveling Pad
   - B. Modular Block
   - C. Reinforcement
   - D. Drainage Column
   - E. Underdrain System
   - F. Reinforced Mass
   - G. Cap/Final Grading
   - H. Fence/Guard Rail/Landscaping

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5. Failure Modes

1. Design Failures
   - A. Bearing Capacity
   - B. Settlement
   - C. Global
   - D. Geogrid Connection @ Block and Into Reinforced Zone
   - E. Hydrostatic Pressures
   - F. Reinforced & Active Mass Soil Unit Weights
   - G. Soil Parameters
   - H. Final Grading

2. Construction Failures
   - A. Subgrade
   - B. Modular Block (Bulging/Alignment/Quality)
   - C. Reinforcement Placement (@ block and into soil mass)
   - D. Drainage Column
   - E. Underdrain System
   - F. Reinforced Mass (Compaction & Material Types)
   - G. Final Grading

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6. Inspection of Modular Retaining Walls

1. Gravity Modular Retaining Wall
   - A. Footing/Leveling Pad (Dimension/Material Type & Elevation)
   - B. Modular Block (Type, Alignment, Dimension)
   - C. Drainage Column (Materials Types, Width & Location)
   - D. Underdrain System (Location, Dimension, Connection & Daylight)
   - E. Gravity Mass (Classification, Placement & Compaction Requirements)
   - F. Cap/Final Grading (Slope, Material Type & Placement)
   - G. Fence/Guard Rail/Landscaping (Dimension & Location)

2. Reinforced Modular Retaining Wall
   - A. Footing/Leveling Pad - Same
   - B. Modular Block - Same
   - C. Reinforcement – Type, Length, Alignment, Elevation
   - D. Drainage Column - Same
   - E. Underdrain System - Same
   - F. Reinforced Mass – Classification, Thickness & Compaction
   - G. Cap/Final Grading - Same
   - H. Fence/Guard Rail/Landscaping - Same

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7. Permits & Certification

Permits - The permits required for Geotechnical Specialty Construction Services such as Retaining Walls are as follows:

1. Design Drawings & Specifications
2. Geotechnical Engineering Reports
3. Locality Approved Civil Engineering Grading Plans
4. Special Inspections – **Provided by Owner**
5. Shop Drawings & Materials Identified
6. Construction Procedures
7. Equipment & MSDS

Certification - The certification for the completed work is submitted to the Owner/Client and as follows:

1. As-Builts
2. Inspection Reports
3. Certification Letter indicating how the modular wall was built and service life maintenance requirements.

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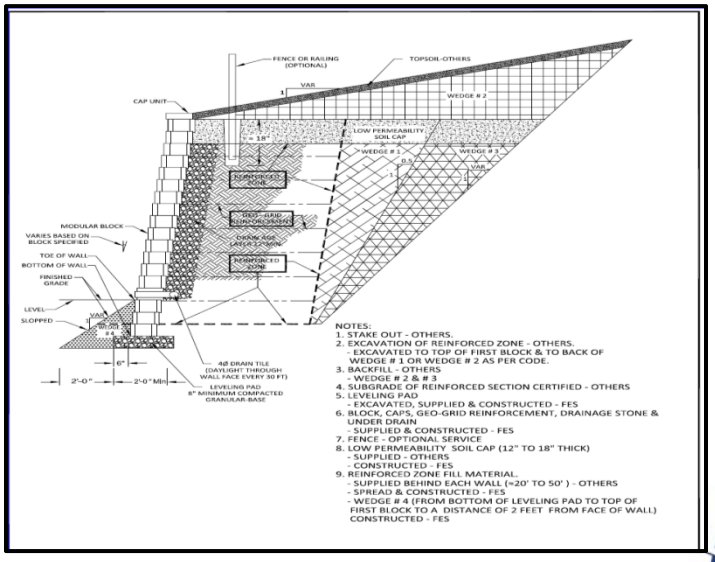
8. TYPICAL WALL CROSS-SECTION



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9. How to Avoid Failures

1. Geotechnical Engineering Report.
2. Specific Modular Retaining Wall Design.
3. Coordinate Design with Civil, Structural and Utility Engineers, Architects and Landscape Designer.
4. Geogrid Maximum Spacing 16 inches. (NCMA - Industry Still Allows 24" C-C)
5. Obtain Subgrade Certification.
6. Install Modular Walls in Accordance with Best Practice.
7. Extensive Knowledge in Site Soil Conditions.
8. Modifications to Design during Construction must be Approved by Designer.
9. Materials Used must meet or exceed project Design.
10. Experienced Wall Contractor.
11. Experienced Site Inspectors.
12. Special Inspections for all Design Elements.
    A. Subgrade, Levelling Pad Construction & Quality Control
    B. Block Quality Control, Dimensions, Alignment, Levelness, Elevation & Construction
    C. Reinforced Mass & Active Zone Construction & Quality Control
    D. Geo-grid Location, Type and Length
    E. Underdrain Location and Dimension
    F. Drainage Column Location and Dimension
    G. Final Grade, Landscape & Fences

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10. Investigating Failures

1. Gravity & Reinforced Modular Retaining Walls – Obtain the following documents.

A. Geotechnical Engineering Report
B. Civil Grading, Utility, Landscaping & Structural Plans
C. Retaining Wall Analysis, Engineering, Plans & Shop Drawings
D. Materials Data Sheets
E. Material Invoices
F. Inspection Reports & Invoices
G. Inspectors Resumes
H. Project Photos – Taken Prior, During and Post Construction.
I. Survey Cut Sheets
J. As Built Plans
K. Interview personnel - Design & Construction Phases.
L. Perform Analysis & Engineering of the Constructed failed Wall.

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11. Repair of Potential Failures

Repairing Failed Retaining Walls:

A. **Tear Down and Re-Build**
B. **Stabilize in Place**
C. **Combination of A & B**

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12. SAMPLE PROJECT PHOTO'S


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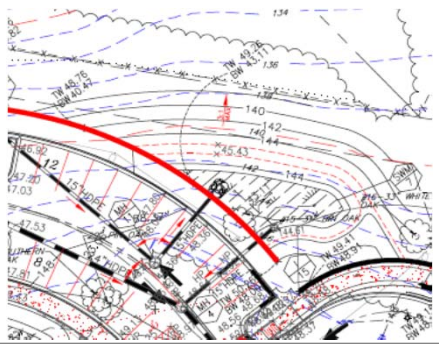

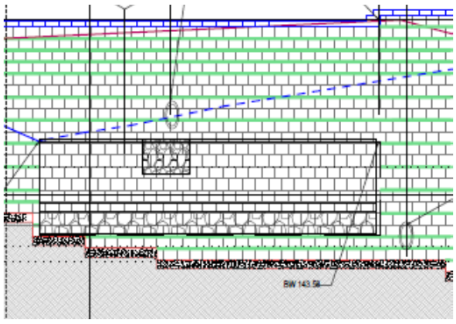






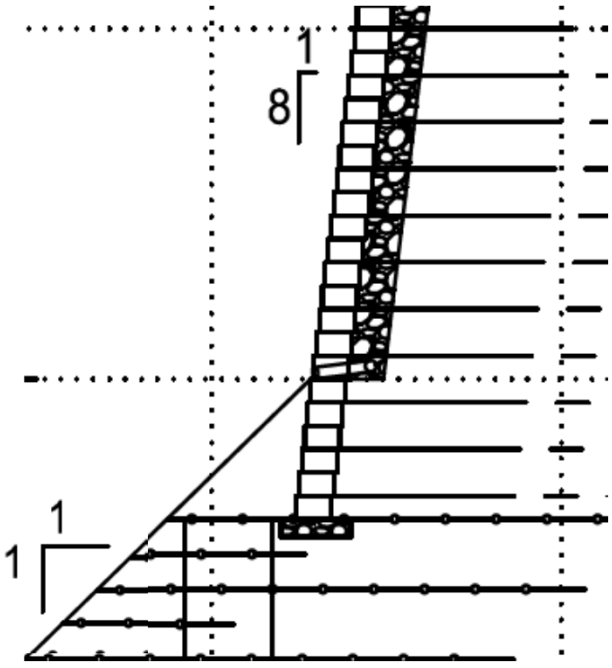
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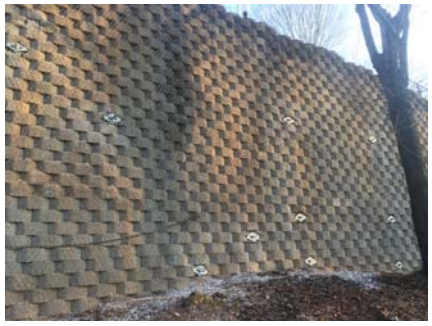





13. QUESTIONS

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