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# Reinforced Segmental Retaining Walls

**by**
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## Lecture Notes

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| 1 | Introduction |
| 2 | Geosynthetic reinforced segmental retaining walls are composite structures constructed with a hard facing of dry stacked (mortarless) concrete modular blocks. The blocks (segmental units) are attached to horizontal layers of geosynthetic reinforcement that extend into the reinforced soil zone to form a gravity mass.<br>In addition to providing structural stability to the composite facing-geosynthetic-soil structure, they also act as a temporary form work during placement and compaction of backfill soils.<br>While most segmental walls are constructed with geosynthetic reinforcement products (geogrids and woven geotextiles) there are systems on the market that use metallic reinforcement in the form of steel ladders and wire mesh. |
| 3 | The modular concrete facing units are typically produced using machine moulded (masonry) methods and are available in a wide range of shapes, sizes and finishes. The dry-stacked (mortarless) concrete blocks are discrete units that transmit shear through interface friction, concrete keys, mechanical connectors or a combination of these methods. Most proprietary units are 80 to 600 mm in height, 150 to 800 mm in width (toe to heel), and 150 to 1800 mm in length. The modular units typically vary from 14 to 48 kg each. The modular concrete units may be solid, hollow, or hollow and infilled with a free-draining granular soil. Segmental retaining walls are usually constructed with a stepped face that results in a facing batter that ranges from 3 to 15° from the vertical.<br>Modular facing systems are not restricted to masonry concrete materials. Wet-cast concrete units, timber facings, expanded polymeric geocells (Bathurst and Crowe 1992) and wire mesh gabion units (Simac et al. 1997a,b) have also been employed to construct reinforced walls. In some cases, geogrids have been substituted for the metallic wire in stone-filled baskets used in gabion structures (O'Rourke 1987).<br>However, this mini lecture series will focus on geosynthetic reinforced segmental retaining walls constructed with masonry concrete units. |
| 4 | Dry cast masonry units are manufactured using standard block forming equipment with a different mould for each type of modular block style. |
| 5 | Reinforced segmental retaining walls are popular with landscape architects and government agencies because of the wide variety of aesthetic appearance. |

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| 6 | The technique has seen rapid growth particularly in North America, Australasia and many parts of Asia. |
| 7 | A large part of the attraction is the wide variety of finishes and colours which are available allowing the creation of structures which are sympathetic to their environment |
| 8 | In North American terminology, reinforced segmental retaining walls fall within the class of *Mechanically Stabilised Earth* structures. Geosynthetic reinforced soil walls have been shown to be economical when compared to conventional unreinforced soil structures. The above slide shows the results of a survey of US State Departments of Transportation bid documents for a wide range of different retaining wall solutions carried out in 1998. The vertical axis is the total installed cost of the wall in US dollars per square face meter.<br>Other sources have reported that segmental retaining walls in excess of 1 m in height typically offer a 25% to 45% cost saving over comparable conventional cast-in-place concrete retaining walls (Berg 1991, Simac et al. 1991, Anderson et al. 1991, Geotechnical Fabrics Report 1994). |
| 9 | Geosynthetic reinforced segmental retaining walls are becoming standard practice for many highway retaining structures |
| 10 | Mortarless modular concrete units are easily transportable and therefore facilitate construction in difficult access locations. The mortarless construction and typically small segmental retaining wall unit size and weight allows installation to proceed rapidly. An experienced installation crew of three or four persons can typically erect 20 - 40 square meters of wall face per day.<br>a) In this slide the geogrid reinforcement is attached to the facing column by extending each reinforcement layer over the concrete shear key to the front of the wall. The connection capacity is generated by friction between the geogrid and the flat surface of concrete units and interlock with the concrete shear key.<br>b) In this slide the geogrid reinforcement is attached to the facing column by extending each reinforcement layer over the fibreglass shear pins at the front of the concrete units and uses the weight of the units to form a largely frictional connection.<br>c) This system uses a mechanical device in the form of a polymeric combs to connect the reinforcement to the modular block facing units.<br>d) This system uses a mechanical device in the form of a polymeric lock bar to connect the reinforcement to the modular block facing units.<br>Most design guides specify a minimum value for the strength of the connection between the facing unit and the reinforcement. |
| 11 | Methodologies for the analysis and design of reinforced soil retaining walls in the United States and the United Kingdom can be found in the following documents:<br>•Standard Specifications for Highway Bridges: American Association of State Highway and Transportation Officials (AASHTO 1996 and 1998 Interim's)<br>•Mechanically Stabilized Earth Walls and Reinforced Soil Slopes: Design and Construction Guidelines (1996), Demonstration Project 82, Federal Highway Administration (FHWA)<br>•Segmental retaining Walls, (Second Edition, 1996) National Concrete Masonry Association (NCMA)<br>•BS 8006: Strengthened/reinforced soils and other fills (1995), BSI<br>In Canada, guidelines based on the FHWA and AASHTO documents are found in the 3rd Edition of the Canadian Foundation Engineering Manual (1992). |

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| 12 | The most comprehensive set of guidelines for the design, analysis, construction and specification for reinforced segmental retaining walls is published by the National Concrete Masonry Association in the United States. |
| 13 | The NCMA design manual for segmental retaining walls has been extended to include recommendations for the design of these systems in seismic areas. |
| 14 | The design of reinforced segmental retaining walls is based on acceptable margins of safety against different modes of failure.<br>Potential (collapse) failure mechanisms are classified as external, internal, facing or global modes of failure |
| 15 | External Modes of Failure:<br>The length of the structure measured from the face of the structure to the back of the reinforced soil mass must be great enough to prevent horizontal sliding along the foundation base and to prevent overturning of the reinforced soil block. The foundation must have sufficient bearing capacity to prevent failure of the foundation and to prevent excessive settlement. |
| 16 | Internal Modes of Failure<br>The length of layers of reinforcement must be sufficient to develop the full design strength without slippage between the soil and the geosynthetic in the anchorage zone behind the failure plane assumed in the design.<br>The strength and layout of the reinforcement must be such that the forces determined by the design can be developed without rupture of any layer or excessive reinforcement strain.<br>The friction developed between the soil and the reinforcement must be sufficient to prevent sliding along any interface within the structure. |
| 17 | Facing Modes of Failure<br>It is a common misconception that the modular facing blocks are only required to give an attractive appearance and prevent erosion at the face. It is now accepted that the system needs to be designed to ensure adequate connection capacity between the reinforcement and the blocks, a block design which prevents shear slippage between the blocks and sufficient layers of reinforcement connected to the face to prevent toppling of parts of the facing structure particularly at the top of the wall.<br>Special attention to facing stability is required in seismic areas. |
| 18 | Global Stability<br>As with all geotechnical structures, consideration needs to be given to the overall or global stability of the structure. |
| 19 | Although recommended factors of safety vary between the several design guidelines, the table above shows a typical mix of values |
| 20 | Standard Construction Sequence ( some systems require amended or additional items );<br>Excavate trench for levelling pad<br>Lay compacted granular layer or unreinforced concrete levelling pad to form the base of the wall<br>Install the first layer of blocks ensuring that each block is level and in the correct alignment. |
| 21 | Backfill carefully behind the first layer of units ready to lay the first layer of reinforcement |
| 22 | Connect pre cut lengths of reinforcement to the facing using the specified connection system. |
| 23 | Install two or three additional layers of blocks. |

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| 24 | Pull reinforcement tight to eliminate any loose folds and begin filling. Compact fill using only lightweight compaction equipment within 1 metre of the wall face. |
| 25 | Install wall ties where the segmental block wall is to be faced with brickwork or blockwork to match existing buildings. |
| 26 | Continue the sequence of placing blocks, reinforcement and fill until the specified height is achieved. |
| 27 | Traffic barriers can be designed as part of the wall structure |
| 28 | In other locations, fences or handrails are more appropriate. |