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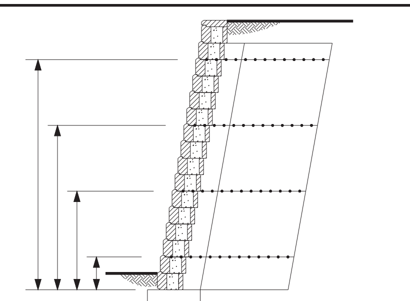
Analyzing Internal Stability of a Composite Mass

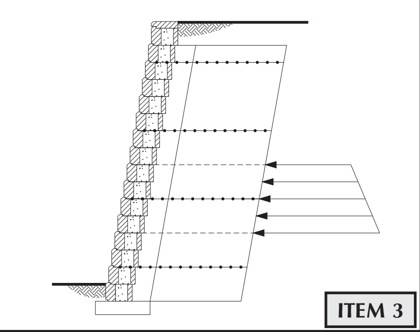
External stability and the size of the reinforced mass was discussed in the January '97 issue of the AB Advantage. In this issue we will discuss the types of checks that must be done to ensure that your mass will hold together. These checks determine if your mass has sufficient internal strength to have this composite structure act as a coherent mass. This process evaluates the internal stability of the design and makes sure that the potential failure plane stays behind the reinforced soil mass.

A comprehensive internal stability analysis will evaluate the following:

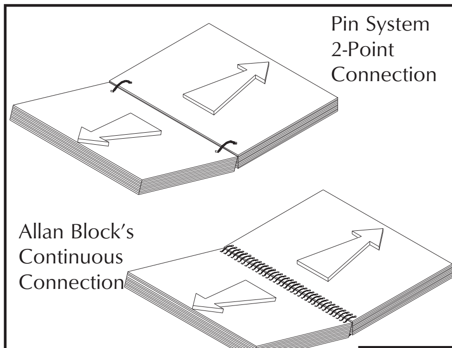
1. Number of grid layers required.
2. Location of grid layers.
3. Maximum tensile stress present on each layer of grid.
4. Design strength of grid after reduction factors have been incorporated.
5. Pullout of the grid from the wall facing.
6. Pullout of the grid from the soil behind a *line of maximum tension* (LMT) within the composite mass.
7. Localized stability between grid layers.



ITEM 1&2



ITEM 3



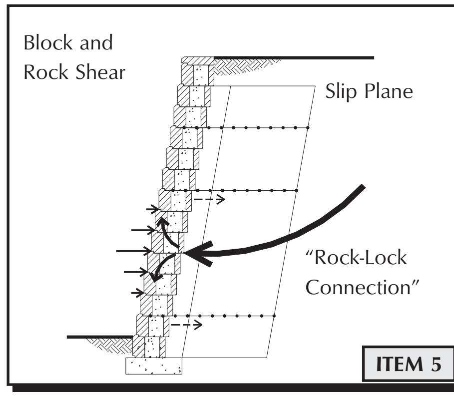
ITEM 4

• **Items 1 and 2** can be resolved by following the procedure outlined in the Allan Block Engineering Manual, or the ABWalls97 software program. These calculations determine the location, number of layers, and strength of geogrid required based on the stress levels calculated for the application. Refer to page 20 of the AB Engineering Manual to review the methods we use. Once the reinforcement layers have been properly sized and positioned a baseline is set for the rest of our internal stability analysis. Strengths of grid being used and/or distance between layers may need to be altered to satisfy the other items in our analysis.

• **Item 3** must be satisfied after the grid is located in the composite mass and the maximum tensile load at each layer of grid is calculated. Based on the active earth pressures over a distance halfway above and below the adjacent layers of grid a worst case loading may be evaluated. Instrumented walls* have shown actual grid strain is between 0.5 to1.0 percent. These strains only increase when the force on the soil mass exceeds the internal shear strength of the soil. Such soil failure is developed from loads generally greater than 10 times the design load. The Colorado DOT has demonstrated successful buttress walls with surcharges in excess of 2500 psf (119.7 kPa). Low strain on geogrid is generally attributed to an underestimation of the strength of properly compacted backfill and overestimation of actual loads. These same studies have shown a fairly uniform distribution of stress along the entire grid length; thus dispersing point loading and reducing localized straining.

• **Item 4** relates to real life degradation issues that may be present when installing and using geogrid for soil reinforcement. These issues include allowances for damage to the grid during construction, as a result of chemical degradation, and due to other uncertainties. By reducing the long term allowable design strength of the grid for each situation relevant in the design, these factors are taken into account. After these strength reduction factors are incorporated an additional factor of safety of 1.5 is used to determine the design strength of the grid.

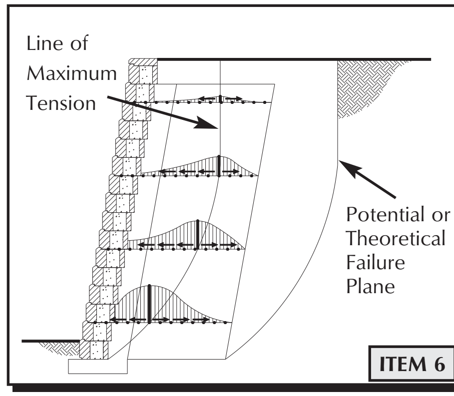
• **Item 5** addresses grid pullout for the block facing. With over 30 million square feet (2.8 million square meters) of wall installed throughout North America our experience has shown that this is not a controlling failure mechanism. The AB Engineering Manual outlines the steps to check for grid pullout from the block, refer to page 25 of the AB Engineering Manual for a more detailed explanation. The Allan Block system provides a continuous interlock of the mats of geogrid to the wall facing by allowing compacted aggregate located in the cores of the block to work with the grid in the wall facing. The hollow core design feature of the Allan Block provides this built in rock-lock characteristic. Additionally the raised front shear lip of the Allan Block provides a structural feature that must be overcome before true grid pullout can occur.



ITEM 5

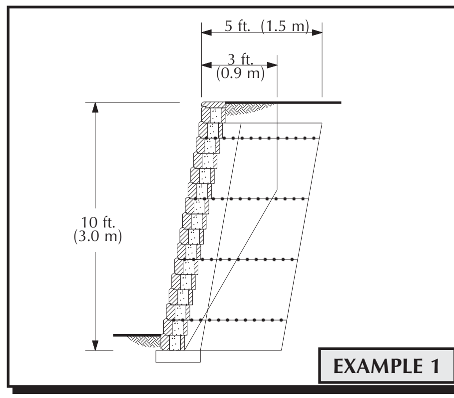
- **Item 6** has been the topic of much debate. Documents published by the FHWA and the NCMA promote the idea that a soil mass reinforced with geogrid act as a giant coherent gravity wall. Allan Block agrees with this concept and has developed a design methodology around this premise. The debate begins with the location, and profile of a LMT (line of maximum tension). Two of the methods used to locate this LMT are based on a Rankine analysis and a log spiral approach at 0.3 times the height of the reinforced mass.

When analyzing the maximum tensile loads present in the top layers of reinforcement it becomes clear that grid lengths required to run beyond a theoretical Rankine surface are excessive and a wasteful engineering practice. Allan Block has used information gathered on inextensible and extensible reinforcement and we have concluded that a more realistic approach follows a two part log spiral type profile. Testing done with inextensible reinforcement (steel straps) by the Reinforced Earth Company provides data that substantiates a two part line of maximum tension when reinforcement lengths exceed half of the wall height. Using this more realistic profile for the LMT for extensible reinforcements (geogrids) we provide a more reasonable approach to embedment lengths for internal stability purposes.



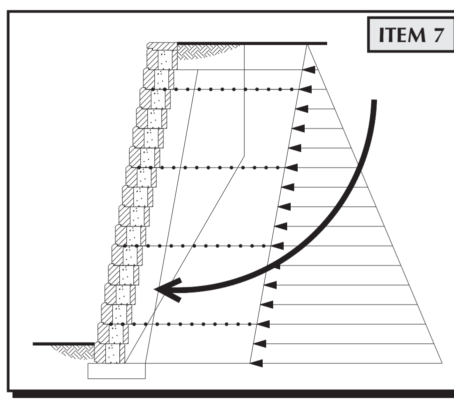
ITEM 6

- **Example 1** - When examining the loads on the top layer of grid for a 10 ft (3.0 m) high wall the maximum tensile load is approximately 133 lb/ft (1,941 N/m) of wall length. The pullout resistance of the geogrid in soil for Fortrac 35/20-20 is approximately 200 lb/ft (2,919 N/m) of embedment per foot (meter) of wall length based on testing performed by Huesker Inc. For this example the vertical line of maximum tension is 0.3 times the wall height and the grid is 0.5 times the wall height leaving an embedment of 0.2 or 2 ft (0.6 m). Therefore using the maximum tensile load for the top layer and a 2 ft (0.6 m) embedment past a vertical LMT we see 400 lb/ft (5,838 N/m) of resisting force versus 133 lb/ft (1,941 N/m) of pullout force, yielding a safety factor of 3.



EXAMPLE 1

- **Item 7** addresses the important issue of localized stability. Localized stability may be compared to a small scale overall stability analysis. The factors that contribute to local stability begin to analyze the reinforced mass as a composite structure. By combining the zone of influence from the geogrid reinforcement with the shear properties of the facing system and the shear strength of the soil we can analyze the structural capabilities of the design. A more detailed review of localized stability will be handled in a future article.

ITEM 7


The evaluation of these parameters will help ensure that the geogrid reinforced soil mass acts as a unified flexible composite structure. For a more detailed explanation contact the Allan Block Engineering Department.

* Geosynthetic International 1992, - Instrumented field performance of a 6 m geogrid wall