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GEOGRID REINFORCED SOIL RETAINING WALL SYSTEMS

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ABSTRACT: The advent of high strength geogrids in 1980 focused attention on geogrid reinforced soil retaining walls. (GRSRW's). Since then various facing types and systems have been developed which offer stable, aesthetic and easy to construct solutions at much lower cost than the traditional alternatives. This paper discusses the evolution of GRSRW's and some commercial and technical advantages and shortcomings of various systems.

KEYWORDS: Geogrid. Reinforced Segmental Wall. Soil Reinforcement.

1. INTRODUCTION

The development of modern reinforced soil techniques has been rapid. The introduction of Tensar geogrids, the first structural polymer grids produced specifically for soil reinforcement, began in 1980. The manufacturing process starts with a continuous sheet of polyethylene or polypropylene which is punched with a regular pattern of holes. Once heated, the sheet is stretched so that the randomly orientated long-chain molecules are drawn to an ordered and aligned state. This process increases tensile strength and stiffness and creates an integral high strength junction between longitudinal and transverse ribs.

Since 1980 a variety of new applications and products have been developed, driven by economic advantages and underpinned by increased confidence and understanding of material properties and test methods, structural mechanisms and recognised design methods. The progress of GRSRW's and bridge abutments has been equal to that of any reinforced soil application. Performance has been verified from monitored full scale structures (1). Versatile and efficient wall systems continue to evolve.

2. REINFORCED SOIL DESIGN FUNDAMENTALS

The cross section of a typical GRSWR. is shown in Figure 1. The design process must address two stability conditions:

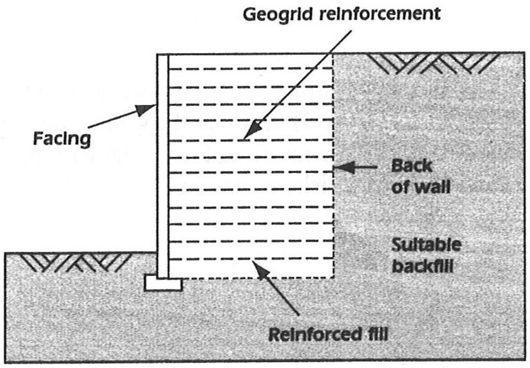

Figure 1. Typical wall cross-section

- External Stability. This follows the same approach as with a gravity retaining wall, i.e. sliding, overturning, bearing and overall deep slip failure mechanisms must be satisfied.
- Internal Stability. This essentially checks grid reinforcement tension and pull-out failure mechanisms within the reinforced zone. (Figure 2).

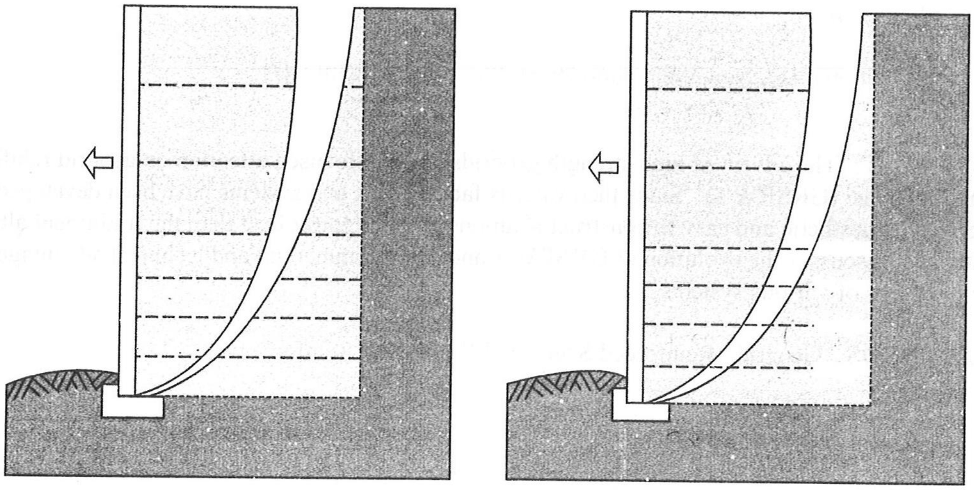

Figure 2. Internal Stability. Potential failure mechanisms

The wall facing is not considered as a primary structural element although it must satisfy some modest structural demands, e.g. withstanding installation forces, localised long-term in-service stresses and sometimes rapid dynamic loading and accommodating differential settlement. Aesthetics and cost are often dominant factors when selecting the type of facing.

The geogrid should be designed in accordance with its creep limited tensile strength appropriate to the design life and in-soil temperature (2). This strength is factored to allow for confidence in test data and reliability of material properties, together with the effects of any construction damage during installation and environmental effects. This approach is embodied in recognised standards (3). Seismic design checks can also be carried out, based on lower factors of safety.

The strength of the connection between the facing and the reinforcement is generally considered to control the upper limit for the safe design strength of the reinforcement itself.

3. FACING TYPES

Geogrid reinforced soil walls have been constructed with numerous facing types. These include *soft* facings such as the *wraparound* face (Figure 3) in which the grid is temporarily supported and wrapped up to form the face and secured back into the reinforced fill. The wrapped grid is normally lined with turf to prevent loss of the fill and help establish vegetation.

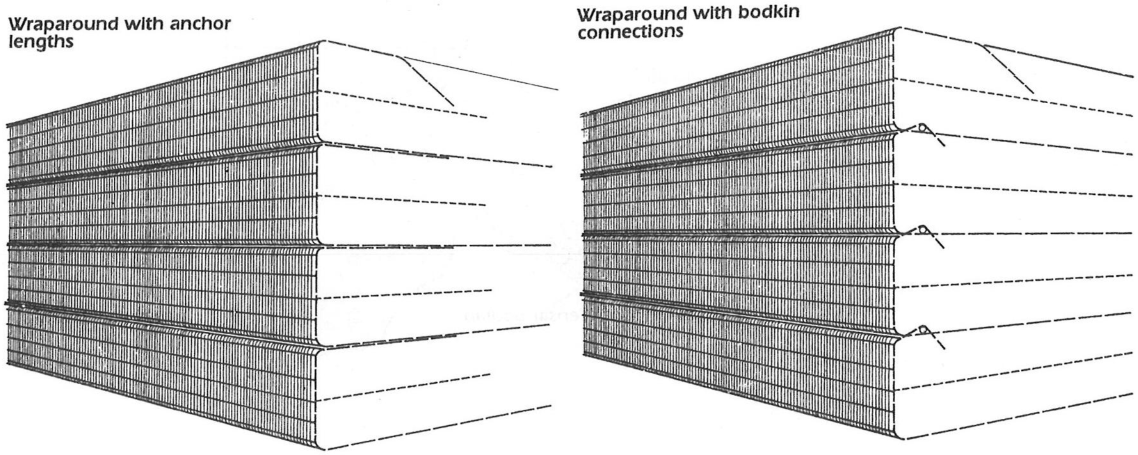

Figure 3. Two types of geogrid wraparound face showing anchor length and bodkin connections

However, a hard facing is generally used for very steep or vertical walls. Gabion facings, 1.0m wide, to which the grid reinforcement is connected are sometimes used (Figure 4), however, concrete facings are usually preferred.

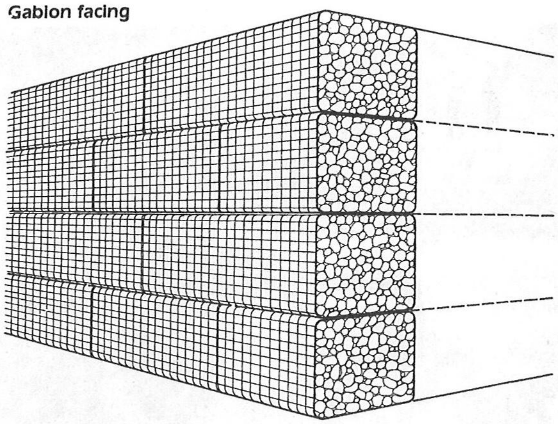

Figure 4. Gabion faced reinforced soil wall

3.1 Concrete Facings

Cast in-situ full-height reinforced concrete facings are common in Japan (4). The concrete is cast against a previously constructed wraparound wall. This produces very stable structures which, however, have the disadvantage of requiring two separate facing operations.

Outside Japan the use of pre-cast rather than cast in-situ concrete facings for GRSRW's is more common. Short *starter tails* of Tensar grid reinforcement can be securely cast into the back of the panels at predetermined spacings. This enables a high strength connection to be subsequently formed with the main reinforcement length. Adopting this approach and using a unique polymer bodkin with Tensar uni-axially orientated grids, provides a full-strength joint (Figure 5).

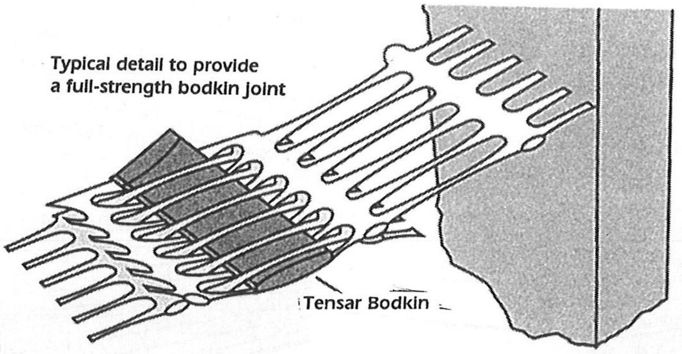

Figure 5.

In addition, these grids are manufactured from high density polyethylene which is virtually inert (5) and, unlike polyester-based materials, they are unaffected by alkaline environments such as those associated with concrete. Most early structures were formed using large, thin panels. Occasionally with the panel length equal to the full height of the wall (Figure 6).

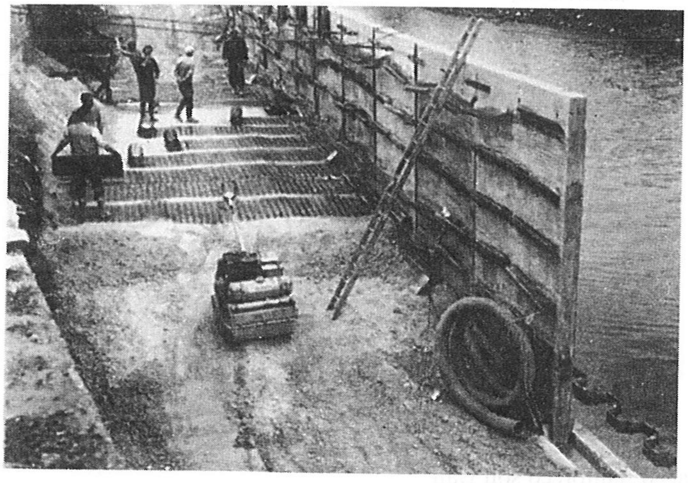

Figure 6

The size of these panels required crane handling and temporary propping. Steel reinforcement in the concrete is necessary and designed to cope with the lifting stresses. Additionally, the need for large shutters and the relatively high amount of special non-standard sizes, resulted in relatively high costs.

Temporary propping of facings can be a problem, particularly in tidal situations. Mass concrete blocks with a stable geometry are able to resist tidal flow during construction. A typical block would be 50cm high x 35cm wide with a step key on the top and bottom faces. Special wave reflector copings can be cast (Figure 7) as well as "L" shaped corner units. Moulds are simple and the blocks can be cast, including *starter tails*, locally on site.

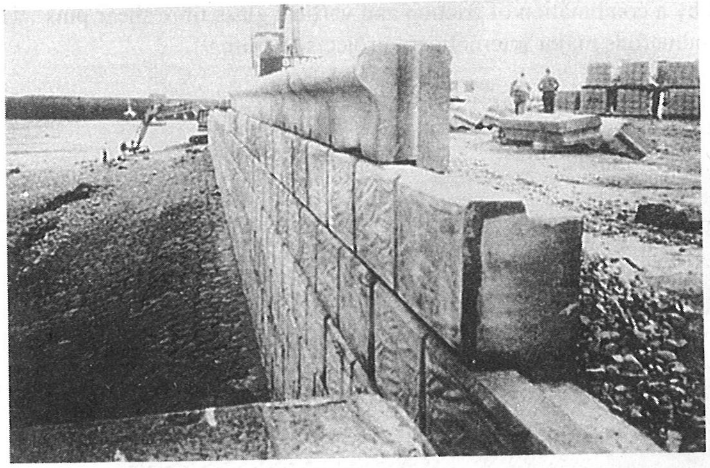

Figure 7. Mass concrete marine unit

Similar units, with a more slender cross section, have been successfully cast on site and installed in non-tidal locations. (Figure 8).

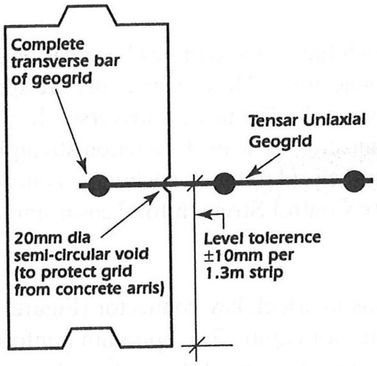

Figure 8. Cross-section of typical block

3.2 Segmental Block facings

Economies of scale and rapid production rates occur with factory produced modular concrete blocks. These are typically produced in man-handleable weights of 20-25kg and with a course height of 15-20cm. They are available in various textures (smooth, split faced, ribbed) and colours. They are dry laid (i.e. with motarless joints) and can be built with stepped or inclined faces and to small radius curves. These are known as segmental walls and are rapid to build and do not need any lifting equipment. An experienced gang of three or four people can typically install 20-40m^2 of wall face per day.

It is not feasible to cast grid *starter tails* into machine made blocks. In the crudest form, soil reinforcement can be accommodated by placing it between block courses at the appropriate level. In this case, the connection strength between the block and the reinforcement relies only on friction and is usually much less than the strength of the reinforcement itself.

One popular system is based on the Keystone segmental block which includes a facing unit which is connected to the grid by a combination of friction and vertical glass fibre shear pins. This system has been widely used on numerous major international projects (Figure 9).

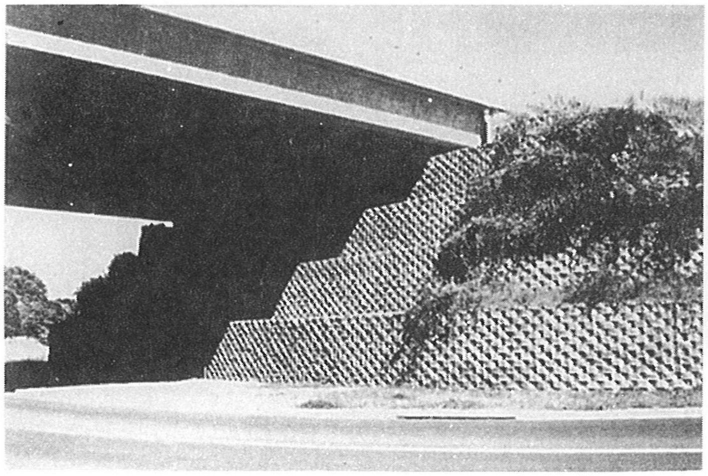

Figure 9. Keystone segmental block-faced bridge abutment reinforced with Tensar geogrids

Other systems are now available in which the facing unit has been designed with a recess in its top surface to accommodate mechanical connectors. These connectors are specially shaped to provide a full-strength joint with a Tensar uni-axial geogrid. The thick transverse rib of the grid bears against the carefully dimensioned inserts of the connector. The grids junction strength (6) between longitudinal and transverse ribs is critical in maximising the grid to block anchorage connection. This junction strength is not less than 100% of the grid's Quality Control Strength for Tensar uni-axial grids.

One of these systems uses a cementitious interlock key connector (Figure 10). Another uses an injection moulded high density polyethylene connector comb. The optimum reinforcement layout can be designed using these connectors, since the full design strength of the grid can be used without any reduction due to connection inefficiency.

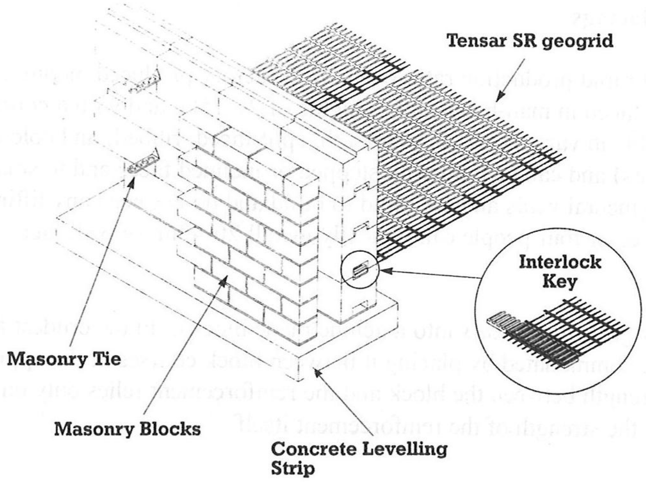

Figure 10.

CONCLUSION

Applications for reinforced soil in general and geogrid reinforced soil retaining walls in particular have been developed extensively since 1980. Numerous, cost effective, versatile and proven wall systems are now available, these have yet to be exploited in many parts of the world. Great potential for further application and development of reinforced wall technology exists.

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