MODULAR BLOCK FACED REINFORCED SOIL WALLS

ZIDURI DE SPRIJIN DIN PĂMÂNT ARMAT CU FAȚADĂ DIN BLOCURI MODULARE

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ABSTRACT. The introduction of modular facing blocks to the portfolio of facings of reinforced soil has proved to be a popular solution. This paper will discuss the design and construction of such systems and describe a number of projects where these systems have been adopted.

REZUMAT. Introducerea blocurilor modulare de fațadă la zidurile de sprijin din pământ armat s-a dovedit a fi o soluție foarte eficientă şi populară. Articolul prezintă aspecte legate de proiectarea şi execuția acestor sisteme, precum şi câteva studii de caz ale unor proiecte unde această soluție a fost aplicată.

1. Introduction

Reinforced soil in its many forms using many different types of reinforcement materials has become a standard technique for the construction engineer. Over the last 20 – 30 years there have been a number of advances, not only in material development, but also in the techniques of construction. The use of modular blocks as the wall facing has become a very popular application and this technique will be discussed in this paper with many examples of successful projects from Central Europe.

2. General

The increase in popularity of modular block systems is a combination of the ease and efficiency of construction and the aesthetic possibilities that result from the adoption of relatively small individual units.

The placing and manipulation of the blocks does not require craneage and access to the front face of the construction is not required. The blocks are placed and positioned by hand and this can be done from the upper construction surface. Of course safety measures are required when the structure reaches significant height.

Whilst the actual construction process is a simple, repetitive, process it is very important that it is carried out with care and in accordance with the suggested construction procedure, which will be available from the supplier of the system. Control of the line of the wall face is critical to the success of the structure and should be monitored continuously during the construction process.

3. Concept

The components of a reinforced soil modular block system are:

1) The blocks themselves. (See Fig 2 for schematic examples)

2) The reinforcement and some form of connection between the block and the reinforcement.

3) The soil fill material.

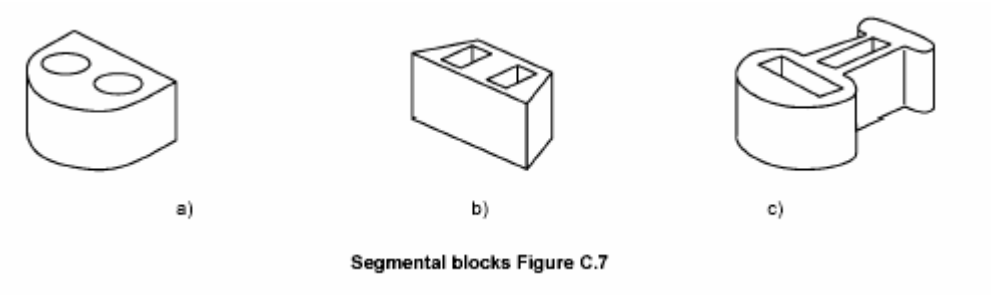

Figure 1. Example schematics

From a practical point of view the connection between the reinforcement and the block face is a very important detail in ensuring that the system is continuous and there is no potential for movement in that vulnerable area. The connection is also a very important area for the design process and this will be covered later.

The interaction between the blocks is also very important to control the line of the face and to give continuity to the face for serviceability. This is particularly relevant at the courses of the blocks that have no reinforcement and, even more so, in areas of seismic activity. The value of a good mechanical connection cannot be overemphasised in the seismic situation.

The fill material should be placed and compacted in the normally specified way with the compaction plant close to the face restricted to smaller dead weight machines. Heavy plant close to the face can cause local movement in the face, particularly at the course levels where there is no reinforcement, and the consequent movement can be very difficult to reverse.

4. Design

The design of modular block faced reinforced soil walls is exactly the same as for other reinforced soil walls with the exception of the connection between the facing and the reinforcement. The individual block dimensions and their interaction with each other can also play an important part in defining the maximum spacing between layers of reinforcement.

The actual design methods are the normal National Standards, if they exist, eg British Standard Code of Practice BS8006, Australian Standard AS 4678, AASHTO in the United States, etc.

All these design methods require the reinforced soil block, composed of the soil and the reinforcement, to be of such dimensions as to satisfy the standard external stability criteria that any retaining wall must satisfy:

1) The block must not slide forwards.

2) The block must not overturn.

3) The bearing pressure applied by the block must not exceed the bearing capacity of the foundation soils.

4) There should not be any unsatisfactory potential failure surfaces which pass around the block, ie global stability.

A diagram showing typical applied forces is shown below (Fig 2).

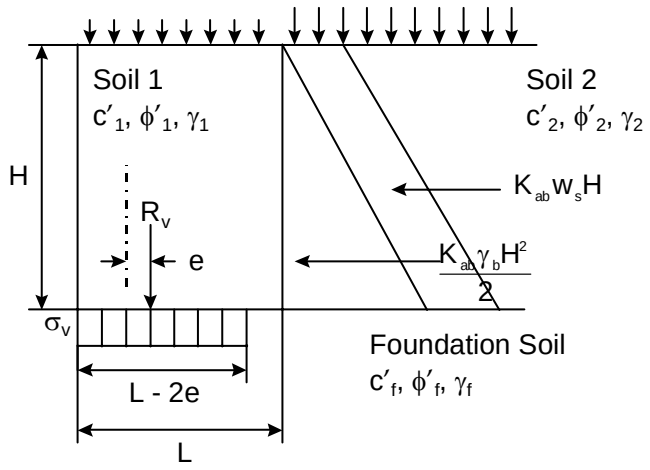

Figure 2. External stability

The internal stability design of the wall again follows the standard approaches where in general the potential failure conditions of tension failure and anchorage (pull-out) are considered. Some Codes of Practice limit the design strength of the reinforcement to the available connection strength at the face. This is the area where an efficient mechanical connection can have benefits over a frictional connection. Figure 3 shows how a frictional connection increases in strength as the depth below the crest increases and Figure 4 shows how a mechanical connection has the full connection strength throughout.

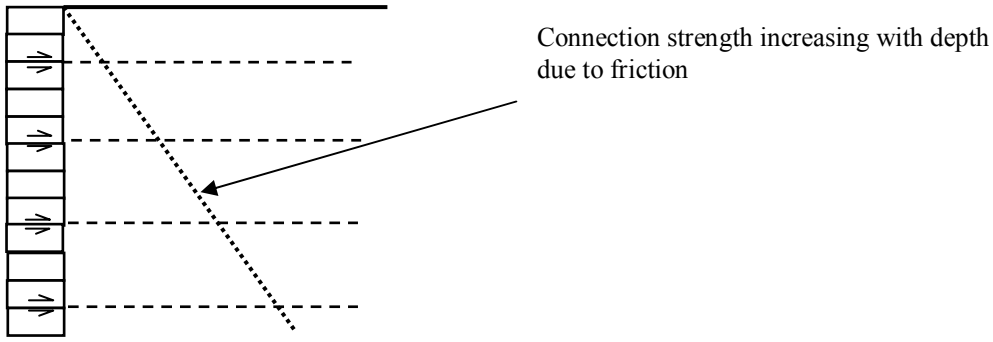

Figure 3. Frictional Connection

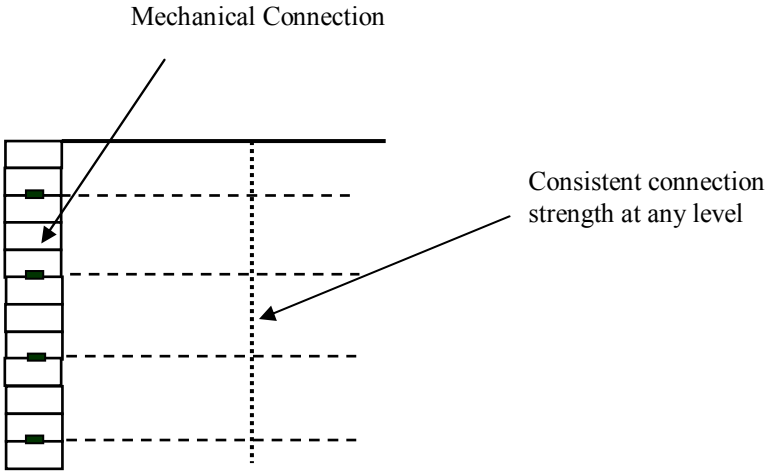

Figure 4. Mechanical Connection

5. Case Histories

1) Olomouc, Czech Republic

Figure 5

Figure 6

The problem for the designer on this project was to construct retaining walls that could satisfy the complex geometry requirements of a road intersection. The ability of the system to be installed to give the two different curves at two levels is a good example of the flexibility of modular block wall systems. Figs 5 & 6. The speed of construction and the cost savings compared with conventional construction made this a very attractive alternative. The difficulties of formwork for curved wall structures formed of reinforced concrete make for both expense and long construction times.

2) Cesky Tesin-Zukov, Czech Republic

The flexibility in plan shown at the Olomouc project is not the only flexibility available in this type of wall facing. Flexibility in elevation is also a very useful capability which is demonstrated in this project. The ease with which an arch structure or any shape of opening through the wall can be accommodated makes this type of facing, and technique, a very attractive proposition to the civil/geotechnical engineer. See Figures 7 & 8.

Figure 7, construction

Figure 8, Final situation

3) Dibba Idhn Tawaian Highway, UAE

A project in the United Arab Emirates required vertical walls up to 18m high to provide the support to a highway through rugged and undulating terrain. The limitations of access and shortage of water for concreting operations combined with very high temperatures made the project a particularly difficult one and the adoption of a modular block faced reinforced soil wall provided a way to overcome these problems.

The use of craneage would have been required for any other type of construction and the logistics of getting heavy construction equipment to such remote areas would have been very difficult. Figs. 9 & 10

Figure 9, during construction

Figure 10, near completion

6. Conclusions

Modular block faced reinforced soil walls have developed over the last few years into a very efficient and economic construction process. The techniques have inherent flexibility with regard to the shapes and profiles to which they can conform. The construction methods are relatively simple in that no large construction equipment is required although care does need to

be taken to keep line and level under control. The ability to construct sophisticated structures in areas of limited access and the available variation of aesthetic finishes have resulted in some dramatic structures which will be described separately.