Earth Reinforcement, Ochiai, Yasufuku & Omine (eds) © 1996 Balkema, Rotterdam. ISBN 90 5410 833 9

A design approach to geosynthetic reinforced slopes for the agriculture saving heat room

Zhang Yemin
Liaoning Institute of Technology, Jinzhou, People's Republic of China
Wu Zhengrong
Construction Bureau of Shenyang Developing District, People's Republic of China
Liu Yixan
Dalian Institute of Railway Technology, People's Republic of China

ABSTRACT: A new kind of agriculture saving heat room which north wall is constructed with the geosynthetic reinforced slope and wall. It is the first time appearance in north China. This paper outlines a reasonable design approach, based on limit equilibrium analysis, considering various aspects of stability and accounting for the effects of facing blocks. The design procedure is verified with a series theoretical deduction. The geotextile tension the wall(in Fig. 1) with the action of the soil-block gravity but the brick wall is strutted by the soilblock also.

1 INTRODUCTION

In north China, more and more agriculture saving heat rooms are being developed. They provide not only vegetable fruit, flower, meat, but also a right way on which the peasants go to well-to-do prospects. The saving heat room which is often taken is made of a 490mm north wall. This causes a higher cost. A lower design approach was put on in this paper.

Geosynthetic reinforced wall was used in the approach. It was showed in Fig. 1.

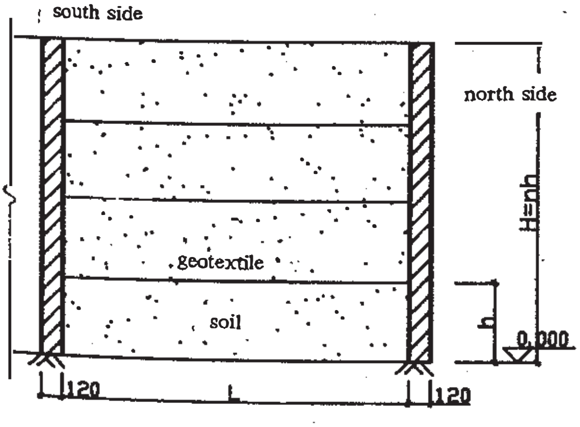

Fig. 1 The North Wall and the Soil Block

Geosynthetic reinforced wall and steep slopes are quite often cost-effective compared with alternative methods of construction. Carefully controlled full-scale tests, however, indicate that the performance of near vertical reinforced walls is significantly better than predicted by simplified analysis (e. g. , Bathurst et al. 1988; Wu 1992; Tatsuoka 1992). That is, analytical predictions for walls are overly conservative. Conversely, predictions for reinforced steep slopes are reasonably conservative (e. g. , Fannin and Hermann 1990; Christopher and Leshchinsky 1991) although, in principle, the same type of analysis is used for both steep slopes and walls.

In two walls, the soil block is used as part of the construction. Ultimately, the block provide an saving heat appearance to the completed structure. The block has both high interblock friction and soil-block friction. However, they may be not quite expensive. These factors combined with the overly conservative predictions of current analysis create the engineering and economic incentives to include the potential stabilizing effects of the facing blocks in the analysis so as to reduce the required reinforcement length and strength. The objective of this paper is to present a unified design philosophy and analysis that is equally applicable to reinforced soil walls.

the developed design oriented analytical approach is based on well established procedures in geotechnical engineering. A parametric study implies that facing walls have significant effects on the required reinforcement strength and length when near vertical slopes are considered.

2 DESIGN-ORIENTED ANALYSIS

Limit equilibrium (LE) analysis has been used for decades in the design of earth structures. Consequently, its extension to the design of geosynthetic reinforced soil structures is quite natural. Attractive features of LE analysis include experience of practitioners with its application, simple input data, useful (though limited) output design information, tangible modeling of reinforcement, and results that can be checked for "reasonableness through simplified charts or hand calculations. The main disadvantage of LE analysis is its inability to deal directly with displacements and hence, the serviceability issue. It is assumed in prictice, though, that prescribed minimal values of safety factors will not only produce a structure possessing an acceptable margin of safety against collapse (i. e., limit state), but that they will also render acceptable displacements and deformations at normal working load conditions.

In principle inclusion of a reinforcement in LE analysis is a straightforward process; i. e., the reinforcement tensile force is integrated directly into the limiting equilibrium equations to assess its effects on stability. However, the inclination of this force must be assumed. Physically, its inclination may vary between the as-installed (typically horizontal) and parallel to the slip surface. Leshchinsky and Boedeker (1989) and Wright and Duncan (1991) have demonstrated that for a granular backfili, this inclination has negligible effects on both required strength and layout of reinforcement. Consequently, the dilemma of force inclination can practically be resolved by assuming it to be horizontal. The end result then is reasonably conservative for cohesionless material (i. e., typical backfill). A more significant problem in LE analysis of reinforced soil is the need to know the mobilized tensile force of each reinforcement layer at the verge of collapse. This force may vary between zero and ultimate strength of the reinforcement. Assuming the actual force is known in advance, as typically done in analysis-oriented computer packages (e. g., STABGM: Duncan et al., 1985), implies the reinforcement force is actually an active force, regardless whether it is needed or not. The designer then needs to assume the active force for each reinforcement layer. The design outcome may be greatly influenced by this assumption. Trying to superimpose the facia effects on the assumed active force in the reinforcement layers then is even more challenging. As a result, facia effects are ignored altogether in most LE analysis, although experience indicates it may have significant influence on walls performance (e. g., Wu, 1992, and Tatsuoka, 1992).

LE analysis also can be thought as a example of catastrophe thecry which can describle not only discontinous but also continous change of matter. In the fold catastrophe model, when LE was abrupted, the discontinous matter occured.

3 THE DESIGN APPOARCH DEDUCED

In Fig 1, between two 120mm width walls. There is a reinforced soil block. Because of the active earth pressure, two walls are pushed out. But because of the soil gravity making the geotextile like a down are, two ends of the geotextile give their anchored walls a pull force. These two kinds force do equilibrium. The geotextile is analysised like a chain which is showed in Fig 2. In a general condition and under the vertical load q (x), its equilibrium shape is ACB. Here, C is the lowest point in the chain. In Fig 2, a random point in the chain vertical coodinate is written as following:

$$z = kx + w \qquad (1)$$

Li Jingyu (1988) have deduced the chain shape equation as following:

$$z = \frac{1}{H}[V_a x - \int_0^x q(\xi)(x - \xi)d\xi] \qquad (2)$$

A random point tensile force in the chain is Z.

$$Z = H[1 + (k + \frac{dw}{dx})^2]^{1/2} \qquad (3)$$

If A and B are same high level, at point C, there is:

$$H = ql^2/8f \qquad (4)$$

the chain is a parabola when the tensile force of the chain is

$$Z = H[1 + 8(\frac{f}{l})^2(1 - 4\frac{x}{l} + 4\frac{x^2}{l^2})] \qquad (5)$$

The largest tensile force Z_{max} occures at two ends.

$$Z_{max} = H[1 + 8(f/l)^2] \qquad (6)$$

After a series deducing: the result can be written as following

$$l^2 = 4h^3 \mathrm{tg}^2(45° - \frac{\varphi}{2})\frac{a\gamma}{n(1 + c_0)}[\frac{1}{n-1} + \frac{2^2}{n-2} + \cdots + \frac{(n-1)^2}{n-(n-1)}] \qquad (7)$$

Here, l — the width of the reinforced soil block;

h — the high level of the soil and walls;

n — the layer number of the reinforced soil block;

a — coefficient of compressibility;

γ — unit weight of soil particles;

e_0 — initial void ratio;

φ — angle of internal friction.

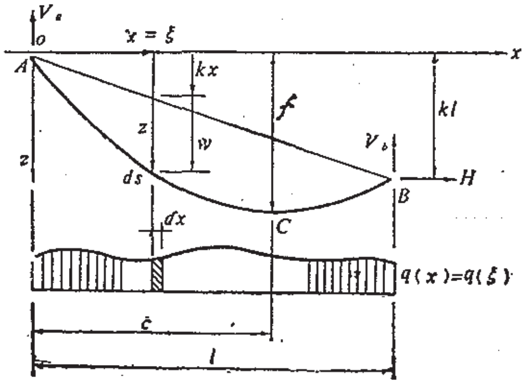

Fig. 2 The Chain Chart

Example: The coil block and two walls are 5 metres high, its φ is 30°; and e_0 is 0.7; n is 5; a is $10^{-5} m^2/kg$, γ is $1.8 \times 10^3 kg/m^3$. The soil block width should be:

$$l^2 = 4 \times 5^3 \times \mathrm{tg}^2(45° - 15°) \times 10^{-6} \times 1.8 \times 10^3 \times (\frac{1}{4} + \frac{2^2}{3} + \frac{3^2}{2} + \frac{4^2}{1}) \div 5 \div 1.7 \qquad (8)$$

So

$$l = 0.88m \qquad (9)$$

4 CONCLUSION

Different limit equilibrium analyses were modified to account for reinforced soilblock. These analyses provide the required reinforcement strength and layout, considering several possible modes of failure. The analyses together with the design philosophy are consistent with each other and are equally valid for both the woil and walls. A chain study gives a formula which can get the width of the filled reinforced soil block. Finally. A calculation example shows the design width method.

REFERENCES

Duncan, J. M., Low, B. K., and Schaefer, V. R. (1985). STABGM: a computer program for slope stability analysis of reinforced embankments and slopesmicrocomputer version. Virginia Polytechnic Institute and State University, Blacksburg, VA.

Leshchinsky, D. and Boedeker, R. H. (1989). "Geosynthetic reinforced earth structures". Journal of Geotechnical Engineering, ASCE, 115(10), 1459～1478

Li Zhujing, (1988). Special Structure. Tsinghua University Press. 187～191

Wright, S. G. and Duncan, J. M. (1991). "Limit equilibrium stability analysis for reinforced slopes". Transportation Research Record. 1330,40～46

Wu, J. T. H. (1992). Geosynthetic reinforced soil retaining walls. Rotterdam: Balkema, 375