# III-224 VERIFICATION OF THE HYBRID SLOPE STABILITY ANALYSIS METHOD

OSAKA UNIVERSITY T. MATSUI
K. C. SAN

## INTRODUCTION

A hybrid finite element stability analysis method for a slope cutting has been proposed by the authors.*1) In this paper, the verification of the satbility method through a field test data*2) is presented.

## THE HYBRID SLOPE STABILITY ANALYSIS METHOD

The proposed slope stability analysis method is a kind of hybrid method of the finite element and limit equilibrium methods. The safety factor is determined from the local safety factor surface and the failure slip surface is obtained by examing the development of the shear strain. The safety factor of the slope is defined as the average of the local safety factors along the slip surface. In order to trace the development of the failure slip surface of the slope, the shear strength reduction technique is employed. The reader can refer to our previous paper.*1)

## VERIFICATION OF THE SLOPE STABILITY ANALYSIS METHOD

Fig.1 shows the finite element mesh for the field test. The material properties used in the present analysis are summarized in Table 1. Fig.2 shows the measured and analytical axial force distributions of reinforcements at the stable condition after the completion of the excavation test. Both results show that the maximum tensile force is located at near the end of the reinforcements.

Fig.3 shows the comparison of the local safety factor surfaces between the unreinforced and reinforced slopes at each excavation step. It is clear that the local safety factors are significantly increased in the reinforced slopes due to the effect of reinforcements.

Table 1 Material Properties

| | Decomposed granite | Soft rock | Reinfo-rcement |
|---|---|---|---|
| Elastic modulus E (MPa) | 22.0 | $1.4\times10^3$ | $2.1\times10^5$ |
| Unit weight $\gamma$ ($kNm^{-3}$) | 18 | 20 | - |
| Poisson's ratio $\nu$ | 0.3 | 0.3 | 0.3 |
| Friction angle $\phi$ (degree) | 19 | 45 | - |
| Cohesion c (kPa) | 10.0 | 10.0 | - |
| Coefficient of earth pressure at rest $K_0$ | 0.67 | 0.67 | - |
| Hyperbolic constant K | 210 | - | - |
| Hyperbolic constant $K_{ur}$ | 420 | - | - |
| Hyperbolic constant n | 1.02 | - | - |
| Failure ratio $R_f$ | 0.69 | - | - |
| Cross section area A ($m^2$) | - | - | $5.2\times10^{-4}$ |

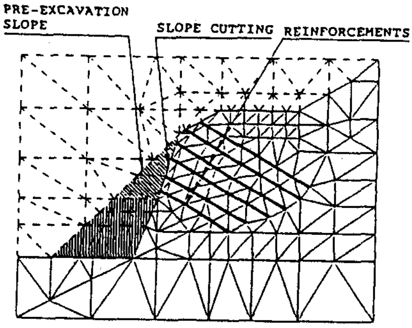


FIGURE 1

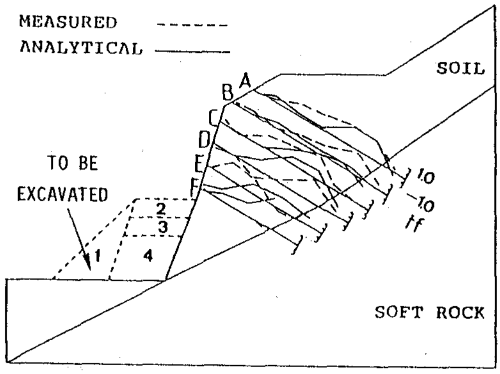


FIGURE 2

Table 2

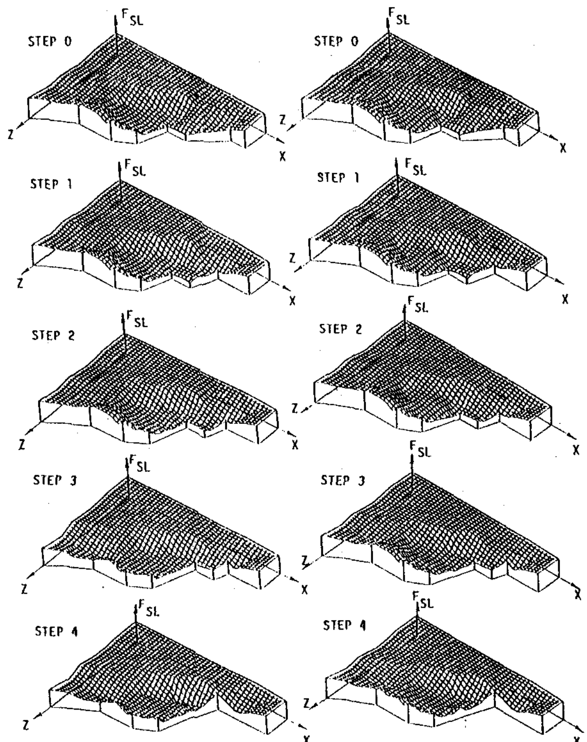
Factors of Safety of Unreinforced Slope at Each Excavation Steps

| Case | Slice method | Finite element |
|---|---|---|
| 1 | 0.84 | 0.88 |
| 2 | 0.76 | 0.79 |
| 3 | 0.73 | 0.76 |
| 4 | 0.67 | 0.71 |
| 5 | 0.62 | 0.58 |

Table 3

Comparisons of Factors of Safety between the Reinforced and Unreinforced Slopes Obtained by the Finite Element Method

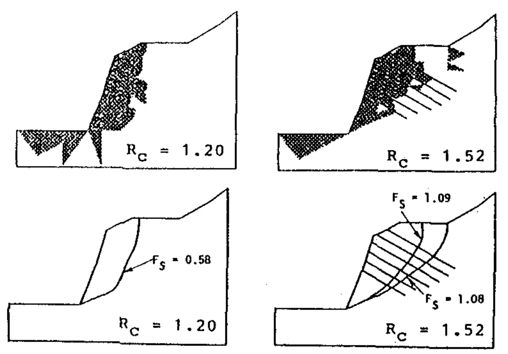
| Case | Unreinforced | Reinforced |
|---|---|---|
| 1 | 0.88 | 1.27 |
| 2 | 0.79 | 1.20 |
| 3 | 0.76 | 1.17 |
| 4 | 0.71 | 1.12 |
| 5 | 0.58 | 1.08 |




a) Unreinforced slope b) Reinforced slope

FIGURE 3

The factors of safety of the unreinforced slope at each excavation step obtained by the slice method and the finite element stability analysis method are close to each other, as shown in Table 2. The factor of safety of the reinforced slope at each excavation step is significantly greater than that of the unreinforced slope, as shown in Table 3.




(a) UNREINFORCED SLOPE (b) REINFORCED SLOPE

FIGURE 4

Fig.4 shows the failure patterns and corresponding inferred slip surfaces of the reinforced and unreinforced slopes at the final excavation step. The failure slip surfaces of the reinforced slope move away from the slope surface comparing with that of unreinforced slope. Two possible failure slip surfaces in the reinforced slope could happen. One passes the mid-point and the other passes the location at near the end of the reinforcements. The safety factor obtained from the finite element stability analysis method for the mid-point slip surface is 1.09 and that passing the locations of measured maximum tensile forces is 1.08. This means that the potential slip surface is the latter case.

REFERENCES:

1) Matsui, T., and San, K.C. (1988):" Finite element stability analysis method for reinforced slope cutting," Proc. Int. Geot. Symp. of Earth Reinforcement, Fukuoka, pp317-322.

2) Matsui T., San K. C., Amano T. and Otani Y. (1988): "Field measurement on a slope cutting with tensile inclusions," Proc. 2nd International Conference on Case Histories in Geotechnical Engineering, St. Louis, Vol.2, pp1099-1105.