III－502 Degradation Friction Modeling of Soft Rock/Structure Interfaces

GEOTOP (Research Fellow, Osaka University) K. C. San
Osaka University (Professor) T. Matsui

1. Introduction

Shear strength of the soft rock/structure interface reduces significantly due to the damage of the asperity of the soft rock/structure interface during shearing. Such decrease of shear strength is often called degradation friction characteristic. The degradation friction characteristic is an important consideration in the design of pile in soft rock. Fig. 1 shows the mechanism of concrete pile in soft rock during shearing. As shown in Fig. 1 (a),the interface between the concrete pile and soft rock is the rough wall of the rock socket with asperity angle β of its initial value of *i*. As shown in Fig.1(b), the socket diameter tends to expend during shearing. Such tendency of expansion of socket eventually causes the damage of the asperity (i.e., reduce of asperity angle).The shear strength of the interface with asperity angle of can be represented by an apparent friction angle ϕ_a and is defined as,

$$\phi_a = \phi_\mu + \beta \tag{1}$$

in which ϕ_μ is the material friction angle of the interface.

From (1), it can be seen that the reduce of consequently degrades the shear strength of the interface. The authors have proposed a generalized interface modeling (San and Matsui, 1992). In this paper, the proposed model is extended to include the effect of the degradation of the shear strength. Example is given to illustrate the applicability of the proposed model to the degradation problem of interface.

2. Characteristic and modeling of degradation of interface

Fig.2 shows the idealization of the degradation characteristic of the interface between soft rock and structure. Fig.2(a) represents the bilinear relationship between the shear strength and the shear displacement. The shearing process can be divided into two stages. In the first stage, the shear displacement progresses without any damage of the asperity of the interface. In the second stage, the asperity of the interface suffers gradually damage during shearing. Fig.2 (b) represents the relationship the asperity angle and the shear displacement. The damage of the asperity of the interface is expressed as an exponential function of the shear displacement.

For case of granular soil, the potential surface and loading surface are characterized by two variables, M_g and M_f . M_g is the slope of the critical line, can be expressed as

$$M_g = \frac{6\sin\phi_r}{3-\sin\phi_r} \tag{2}$$

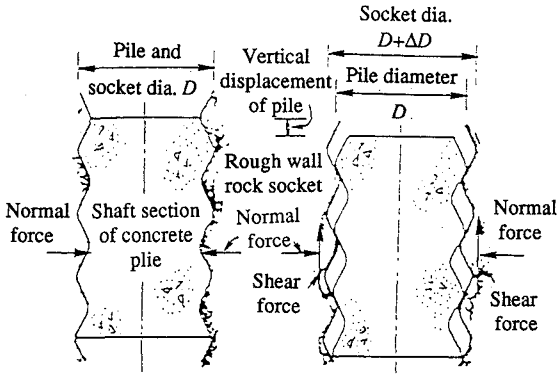
where ϕ_r is the residual angle of internal friction.

M_f can be related to the dilatancy ψ, such as

$$M_f / M_g = f(\psi) \tag{3}$$

Note that the angle of internal friction ϕ can be related to ϕ_r and ψ by the following expression,

$$\phi = \phi_r + \psi \tag{4}$$



a) Pile before displacement b) Pile after displacement

Fig. 1 Concrete pile in soft rock

The similarity between (1) and (4) suggests the mimicry model for soft rock is reasonable. To include the degradation, the M_g and M_f are characterized by two step functions, such as

$$M_g = M_{go} = \frac{6\sin\phi_\mu}{3-\sin\phi_\mu} \qquad (0 \le \xi \le s) \qquad (5)$$

$$M_f / M_g = M_{fo} / M_{go} = f(i) \qquad (0 \le \xi \le s) \qquad (6)$$

$$M_g = AM_{go}\exp\{-B(\xi - s)\} \qquad (\xi \ge s) \qquad (7)$$

$$M_f = CM_{fo}\exp\{-D(\xi - s)\} \qquad (\xi \ge s) \qquad (8)$$

where A, B, C and D are material properties.

3. Example

Fig. 3 shows the comparison between the analytical prediction from the proposed model ands the test results of a regular triangular concrete/rock joints (Johnston and Lam, 1989). The material properties are summarized in Table 1. Good agreement between the test results and prediction demonstrated the applicability of the proposed model for the soft rock/structure interaction problems.

4. References

(1). Johnston, I. M., & Lam, T. S. K., "Shear behavior of regular triangular concrete/rock joints-evaluation", Journal of Geotechnical Engineering, ASCE, 115-5, pp. 728-740, 1989.
(2). San, K. C., & Matsui, T., "Application of finite element method system to reinforced soils", Proc. Int. Symposium on Earth reinforcement Practice, Kyushu, pp403-408,1992.

Table 1 Material Properties

M_{go}	2.17
M_{fo}	2.00
K_n(MPa)	80.00
K_s(MPa)	594.00
H_o(1/m)	6000.00
β_o	4.00
β_1	0.40
A, B	0.80
C,D	-75
s(mm)	11

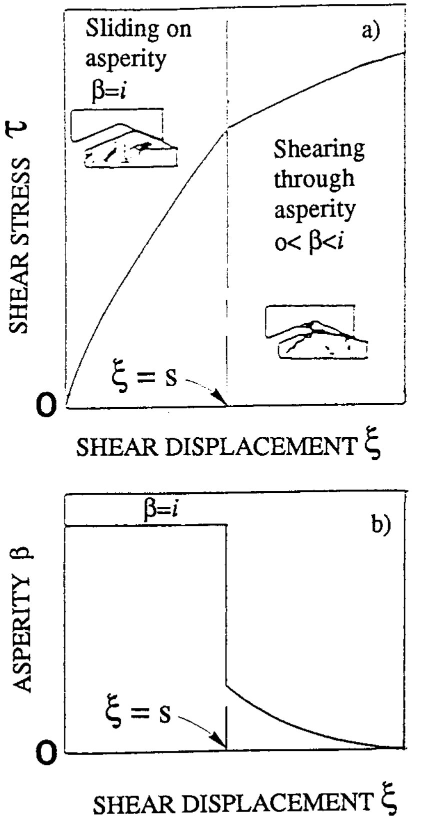


Fig. 2 Idealization of soft rock/structure interface degradation

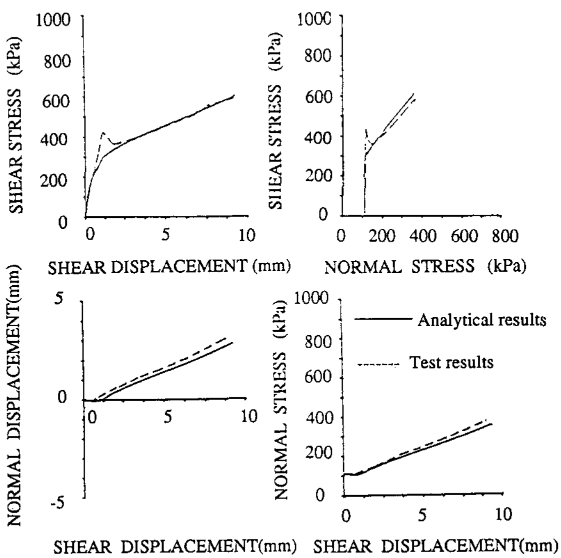


Fig. 3 Comparison between prediction and test results