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Author(s)	MURAYAMA, Sakuro
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Revision of the "Mechanical Behavior of Soils under Shearing Stress" presented in Vol.18, No.140.

By Sakuro MURAYAMA

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In this paper, the present author intends to revise and improve some unsatisfactory assumptions and treatments used in his previous paper "Mechanical Behavior of Soils under Shearing Stress" presented in the Bulletin, Vol. 18, Dec. 1968.

In advance of these revisions, other errata are listed as follows :

Errata

Page	101, Eq. (11)	change	$\gamma=\gamma/\cos\beta$	to	$\gamma=\gamma_f/\cos\beta$
〃	101, last line	〃	Since P	〃	Since $\bar{P}$
〃	101, 〃	〃	P may	〃	$\bar{P}$ may
〃	103, Fig. 8	〃	$z/\gamma-\gamma$	〃	z^*/γ_p-z
〃	103, Fig. 9	〃	$z/\gamma-\gamma$	〃	z^*/γ_p-z^*
〃	105, line 12	〃	elastic strain	〃	probability of mobilization at $z=0$
〃	106 Eq. (29)	〃	$a=1/(a_2\cdot R_0^2)$	〃	$a=1/(k_r\cdot R_0^2)$

1. Revision in *3*, "Disintegration of Sand Particles due to Deviatoric Stress larger than the Elastic Limit"

In 3, (b) and (c) (p. 102, from line 6 to the end) and Eqs. (18)–(21) are revised as follows :

(b) When $z \geq z_{el}$, it may be supposed that the nearer z approaches a certain large constant value of z_∞, the larger the structural factor at plastic state W_p becomes acceleratively. This may be caused by the quick decreases in the interlocking angle θ_i and the standard deviation ρ. Therefore W_p may be assumed to be expressed by the following expression :—

$$W_p=\frac{b}{z_\infty-z} \qquad b\text{: constant}$$

Since W_p is equal to W_e if z is z_{el}, the constant b becomes :—

$$b=W_e\cdot(z_\infty-z_{el})$$

$$\therefore \quad W_p=W_e\frac{z_\infty-z_{el}}{z_\infty-z} \tag{14}$$

(c) $\bar{P}(=W\cdot z)$ is the probability of the mobilization of particles which directly affects the maximum shearing strain in the plastic state of sand. As $\bar{P}$ consists of the probability at the elastic limit $\bar{P}_{el}$ and that in the plastic state P^*, $\bar{P}$ is given as :—

$$\bar{P}=\bar{P}_{el}+P^*$$

where

$$\bar{P}_{el}=W_e\cdot z_{el}\ , \quad P^*=W_p\cdot(z-z_{el})$$

P^* is the probability of the mobilization produced in the plastic state after passing the elastic limit. Substituting Eq. (14) into the above equation, P^* is given by :—

$$\left.\begin{aligned} P^* &= W_e \cdot z_\infty^* \frac{z^*}{z_\infty^* - z^*} \\ \text{where} \quad z_\infty^* &= z_\infty - z_{el}, \quad z^* = z - z_{el} \end{aligned}\right\} \quad (15)$$

Next, according to the revision of Eq. (15), Eq. (18) (presented in p. 103) is changed as follows :—

$$\left.\begin{aligned} \gamma_p &= A_p \cdot P^* = A_p \cdot W_e \cdot z_\infty^* \cdot \frac{z^*}{z_\infty^* - z^*} \\ \text{or} \quad \frac{z^*}{\gamma_p} &= \frac{1}{A_p \cdot W_e \cdot z^*} \cdot (z_\infty - z) \end{aligned}\right| \quad (18)$$

According to the revision of Eq. (15), Eq. (19) (p. 103) becomes:—

$$G_p = \frac{z^*}{\gamma_p} \cdot \sigma_m = \frac{\sigma_m}{A_p \cdot W_e \cdot z_\infty^*} (z_\infty - z) \quad (19)$$

According to the revision of Eq. (15), the description written on page 103, from Eq, (20) to five lines from the foot of the page should be changed as follows:—

$$\left.\begin{aligned} W \cdot z &= W_e \cdot z_{el} + W_e \cdot (z_\infty - z_{el}) \cdot \frac{z - z_{el}}{z_\infty - z} \\ \therefore \quad W &= W_e \left\{1 + \frac{(z - z_{el})^2}{z \cdot (z_\infty - z)}\right\} \end{aligned}\right\} \quad (20)$$

The structural factor of the sand whose elastic limit is zero is denoted as W_0. Substituting $z_{el}=0$ into Eq. (14), W_0 is obtained as follows :—

$$W_0 = W_e \cdot \frac{z_\infty}{z_\infty - z} \quad (21)$$

Due to the revision stated above, Fig. 10 (p. 105) is changed into the figure shown here :—

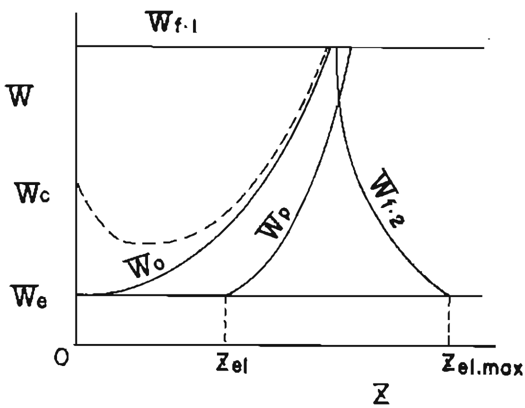

Fig. 10 Relationship between W and z.

2. Revision in **5** " Residual Strain due to Repetitional Stress Application to Sand "

In 5, the description written on page 106, from line 4 to line 19 is revised as follows :—

Here it may be convenient to introduce a new concept of the " latent plastic particle " tentatively designated which has a possibility of sliding along the adjacent particle surface over its peak and then settling at a stable non-mobilizing orientation of the minimum potential under a certain stress ratio. Such latent plastic particles are distributed at random in the sand and the probability of their existence among the sand particles as a whole is denoted by R. The more the latent plastic particles exist in the sand, the weaker the structure of the sand becomes. Since the ability of the plastic mobilzation of the structure is evaluated by the structural factor (W_p-W_e), the relation between (W_p-W_e) and R may be assumed as follows :—

$$W_p- W_e=k_1 \cdot R \quad (k_1 : \text{constant}) \tag{27-1}$$

Substituting Eq. (14) into the above equation, it becomes :—

$$z-z_{el}=\frac{k_1}{W_e}\cdot(z_\infty-z)\cdot \mathrm{R} \tag{27-2}$$

In this case, as the applied stress ratio of the repetitional loading z is always constant, $(z_\infty-z)$ becomes a constant. Therefore :—

$$\left.\begin{aligned} &(W_p-W_e)\cdot(z-z_{el})=k_r \cdot R^2 \\ \text{where}\quad &k_r=k_1{}^2\cdot(z_\infty-z)/W_e \qquad (\text{constant}) \end{aligned}\right\} \tag{27-3}$$

As stated above, the probability of the stabilized particle at the end of the one loading cycle which causes the residual in the maximum shearing strain is expressed by $(W\cdot z-W_e\cdot z)$ ·

$$\begin{aligned} W\cdot z-W_e\cdot z&=W_e\cdot z_{el}+W_p\cdot(z-z_{el})-W_e\cdot z \\ &=(W_p-W_e)\cdot(z-z_{el}) \end{aligned}$$

As this value of probability is that of the stabilized particle in each loading cycle, $(W_p-W_e)\cdot(z-z_{el})$ shows the decrement in R for the cycle, which is denoted by ΔR_n. Therefore :—

$$-\frac{\Delta R}{\Delta n}=(W_p-W_e)\cdot(z-z_{el})$$

Where n is the numer of the cycle of the repetitional loading and Δn means a unit cycle of repetitional loading. Subustituting Eq. (27-3) into the above equation, we get :—

$$-\frac{\Delta R}{\Delta n}=k_r\cdot R^2$$

Next, according to the above revisions, the description on page 107, from line 9 to 12 including Eq. (31) should be changed as follows :

The relation between z_{el} and n can be expressed by the following equation which is obtained from Eqs. (27−2) and (29).

$$z_{el}=z-\frac{1}{k_1}\cdot\frac{k_r\cdot R_0}{1+k_r\cdot R_0\cdot n} \tag{31}$$

3. Improved solution in **6** " Compaction of Sand due to Shearing Stress "

*In **6**, the description written from the line below Eq. (33) on page 107 to line*

11 on page 108 is improved as follows :—

Here we denote the structural factors of such loose sand as W_c and W for the stress ratio zero ($z=0$) and z respectively. According to the similar consideration given to Eq. (27-1), the relation between the structural factor and the probability of existence of the latent plastic particles may be expressed by the following equations :—

$$\left.\begin{array}{l} W_c-W_e=k_1\cdot R_{c0} \\ W-W_e=k_1\cdot R=k_1\cdot R_c+k_1\cdot R_d \qquad (k_1 : \text{constant}) \end{array}\right\} \qquad (34\text{-}1)$$

As the particles belonging to R_d have a similar character to that of the particles in the sand whose elastic limit z_{el} is $z_{el}=0$, the structural factor of sand due to R_d-particles may be expressed by W_0 in Eq. (21). Therefore, $k_1\cdot R_d$ may be expressed as :—

$$k_1\cdot R_d=W_0-W_e=W_e\cdot\frac{z}{z_\infty-z} \qquad (34\text{-}2)$$

From Eqs. (34-1) and (34-2),

$$k_1\cdot R_c=W-W_0 \qquad (34\text{-}3)$$

It may be supposed that the latent plastic particles expressed by R_c decrease in proportion to the number of particles mobilized by the application of stress ratio dz upon the sand mass whose structural factor is $(W-W_0)$. Therefore, we get :—

$$-dR_c=(j/k_1)\cdot(W-W_0)\cdot dz \qquad (34\text{-}4)$$

Where (j/k_1) is a proportional coefficient. Though the character of j should be determined through the experiments, j is tentatively assumed as a constant. Substituting Eq. (34-3) into Eq. (34-4), it becomes :—

$$-\frac{dR_c}{dz}=j\cdot R_c \qquad (34\text{-}5)$$

Integrating Eq. (34-5) under the condition that $R_c=R_{c0}$ at $z=0$, we get:—

$$R_c=R_{c0}\cdot e^{-j\cdot z} \qquad (34\text{-}6)$$

From Eqs. (34-1), (34-2) and (34-6), we get: —

$$W=(W_c-W_e)\cdot e^{-j\cdot z}+W_e\cdot\frac{z_\infty}{z_\infty-z} \qquad (34\text{-}7)$$

The first term of the right hand side of Eq. (34-7) is the decreasing function with the increase of z and the second term is the increasing one. Therefore the relationship between W and z is represented by a curve with a minimum point at a certain value of z as shown by a dotted line in Fig. 10.

The maximum shearing strain γ can be represented by the following relation :—

$$\gamma=A_p\cdot W\cdot z \qquad (35)$$

Postscript

The author wishes to express his regret for the revision of some parts of the preceding paper. However, it is fortunate that the fundamenal results remain unchanged, in spite of these revisions.