Study on Particle Loss during Dissolution Based on Extreme Stress Condition

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Abstract. The loss process of particles in the soil contains erosion, degradation and dissolution. Either way, caused changes in the inner system of the soil. The intention of this article is to investigate the change of soil volume under particular stress condition. Sand and salt mixture were prepared in this test, which stands for small particles, as test stuff to imitate real sandy soil. The experiment was carried out in an improved consolidator. As for this test, vertical additional stress was used as the variable, as for this experiment, the stress was the maximum value 1000KPa and the minimum value 10KPa, respectively. The experiment was divided by stages: load stage and dissolve stage, the volumetric variation in the facility was recorded by a software called DS7. The results show that the variation of volume was due to total volume variation and dissolution is much more than the volume change in minimal stress. When vertical stress greatly \( \Delta \) value is 0.25, and tiny \( \Delta \) value is 0.14. According to the previous laboratory finding and theory of strong chain, the experimental conclusion are analyzed theoretically

Keywords. Particle Loss, volume change, void ratio, extreme stress condition, laboratory testing, force chain theory.

1. Introduction
The element of particle loss have connection with dissolution, degradation and erosion of soil. Despite of reduction system, granules can be cracked, eventually altering the quantity and organize of the soil, leading to variation in inside state. Soil erosion has a great impact on soil, In Switzerland, almost one quarter of the civilized land is influenced by erosion of water (Ledermann et al., 2010)[8] In the mean time, erosion of soil will result in pathetic soil character and decrease of rich topsoil. In addition, the missing of nitrogen and phosphorus by soil erosion, water pollution, and destruction of land (Di Stefano et al., 2016, Hancock et al., 2015, Tanyaş et al., 2015)[4] in the plateau of northwest loess (640000 - square - kilometer) China has the world's top ratio of soil erosion, produce 1.6 billion tons of sludge of the Yellow River every year, constitute the main danger of flood (high et al., 2016)[5] Seen The other part, degradation can have miserable results for the environment and the ecological, For instance, soil and landscape degradation caused by unsustainable land management and biophysical processes are considered to be critical elements for desertization. (Hutchinson et al., 2005)[6] Soil degradation influence factors contain inadequate agricultural behaviors, uncontrolled clearance, overstocking, fires and the city-usage land. These elements can selectively influence degradation systems such as soil erosion and environmental pressure(Salvati, 2014)[9] In addition, to cause a decline in soil quality, soil degradation eventually lead to personal, chymic and biological extinction. It is operated by incorrect usage, often in farming, ranching or city region. (Khaledian et al., 2017)[7] It ties to the mutual effect of different to personal, chymic and biological extinction of the soil, contains soil contents, terrain and climate-report features (Brevik et al., 2015)[2], on land usage, human elements and...
governance (Camprubi et al., 2015)[3]. The agro type is cheek by jowl have relation to the features of human movement, which determines that artificial substances. For example, chemical fertilizer enter erosion process via soil attachments, river systems, sludge convey. In short, the impact and harm of degradation on soil cannot be neglect.

The purpose of this paper is to identify whether the volume variation coefficient caused by the solubility of mixture will be shifted under the state of final stress. There are few researches on high stress erosion soil at home and abroad. In this paper, the effect of porosity change on the internal environment of erosive soil is discussed. For purpose of pattern the particle loss appearance of small and medium-sized particles under hydraulic action, sand and salt mixture were used as test stuff. The selected salt grains are much smaller than sand grains that are clearly by water erosion. In this case, the dissolution process lead to erosion. The test outcome of Xiao and Shwiyhat (2012) [11] implied soil patterns had little effect on the inner organize of soil patterns. Besides, no shear strength is higher than the uneroded control samples may be due to the effective control of pressure difference if soil system change is clearly in the condition of high pressure, the soil structural support force of the chain would be destroyed, this will have effect on the soil void ratio and affect the internal structure of soil. (Barreto and O Sullivan, 2012)[1] Throughout more experiments, finally found the critical value of structural damage. It is of great significance to explore erosive soil under high stress

2. Test

2.1. Test Materials and Equipment
In this paper, two experiments were carried out. The first experiment caused the dissolution rate to be too slow due to the inability of water to completely enter the container. Therefore, the second experiment accelerated the experimental process by modifying the consolidation tool to guide the entry of water. The device (figure 1) is as shown below.

![Figure 1. Improved device.](image)

2.2. Methodology
This article focuses on studying whether the inner organize of the soil has shifted remarkable after ceiling amount and least vertical stress erosion and avant erosion. Particularly, if the inner structure of the force chain in the soil is broken, it can be observed in real time in DS7 that the consolidation tool will settle to a certain degree, and then the change in void ratio is obtained. Analyzing the value of Λ, it can be more accurate conclusion.
2.3. Experimental Processes

After the consolidation device is full, the 1st load-test is carried out. In time of the upload process of the consolidation device, the other end in software will instantly show the graph of the settlement data in the instrument, flatten out in 10 sec, and keep the device standing for 6 minutes to assure that the instrument will not change again. The settlement values is entirely steady and the displacement data is registered. The second part had the same experimental steps to the first part, in addition to that the pressure was in 1000 KPa condition. Two groups (figure 2, figure 3) are shown as follows.

![Figure 2](image1.png) 1st Load-stage image in 10KPa cases.  
![Figure 3](image2.png) 1st Load-stage image in 1000KPa cases.

It can be concluded from the figure 2 and 3, only during the loading process, the displacement in low stress circumstance (about 0.055) is less than that high stress circumstance (about 1 mm).

The next step is dissolution experiment. The completion of experiment is decided based on the changes of solution conductivity and the settlement changes shown in DS7 software.

As can be seen from FIG. 4 and FIG. 5, under the condition of low-stress, the curve of dissolution is fairly gentle, but under the condition of high-stress, the dissolution process is twisted. The results show that under the condition of 10Kpa stress, the displacement invited by corrosion is bigger than under the condition of high stress, achieve about 2.5mm, but under the condition of 1000kpa high stress, the settlement caused by corrosion is only about 1.6mm.

![Figure 4](image3.png) 1st Dissolution-stage image under 10KPa circumstance.  
![Figure 5](image4.png) 1st Dissolution-stage image under 1000KPa circumstance.

The results of the second experiment are basically the same as those of the first experiment. Shown in figure 6 and 7.
3. Data Analysis

3.1. Definition of Dissolution-Induced Volume Change Parameter

This experiment is fit in with previous reports (McDougall et al., 2013), the least and ceiling amount void ratios of the Leighton Buzzard sand in this experiment were set as 0.67 and 0.78 respectively.

For the first test, the displacement height of the mixture with vertical stress of 10kpa was 2.424mm and the initial void ratio was 0.671. According to the report, McDougall et al. (2013)[10], the quantitative explanation of dissolution course and dissolution volume effect is given, change the parameter $\Lambda$ solubility - induced roll is given below.

$$\Lambda =\frac{dv_v}{dv_s}$$  \hspace{1cm} (1)

Where $dv_v$ is the volume change of the void volume, $dv_s$ is the volume change of the solid volume.  

$dv_v = dv_t - dv_s$

Where $dv_t$ is the volume change of the total volume.

The main data for $\Lambda$ are listed in table 1 and Figure 10.

| Reference values of $\Lambda$ | Void ratio | Volumetric response |
|-------------------------------|------------|---------------------|
| $\Lambda = -1$                | Maximum increase | Nochange in overall volume |
Λ=

| Λ = 0       | Increasing | No change in void volume |
| Λ = e      | Constant   | -                        |
| Λ > e      | Decreasing | Maximum change in overall volume |

The value of the 1st experiment Λ 10 kpa is 0.14. You can see that the internal voidage increases. When the vertical stress is under 1000kpa condition, the height of displacement is 2.65mm and the inner voidage is 0.674.

3.2. Analysis of Dissolution-induced Volume Change Parameter

After calculation, the value of first experiment’s Λ in 1000 KPa is -0.25. According to the table 1, the increase rate of the internal void ratio of the consolidation instrument is more obvious than 10 KPa, which is -0.14.

Figure 6-9 shows the data of the second experiment. The results are roughly the same as the first experiment. However, the second experiment was to break the chassis of the instrument when loading 1000 KPa, so the Λ value could not be used as a reference factor.

![Figure 10. Experimental data table provided by McDougall.](image)

After calculation, \( A_1 \) equals -0.14 \( A_2 \) is -0.25 \( A_3 \) is +0.08. The results of this experiment are still quite satisfied.

4. Results and Conclusion

The above data implies how vertical stress controls the total volume and void fraction of the soil at the missing particles in two extreme stress states (very low and very high). There is a pertinence between displacement and stress. In all experiments, voidage increased to varying degrees. But the correlation is not significant. Referring to previous studies, a mechanism for volume change can be proposed to explain the seen dissolution effect. One is a fairly small element. The other is inert gravel. On account of the existence of small elements, these small elements are located in the void around the large elements and have no carrying capacity. Removing these small elements will boost the voids in the entire mixture. This resulted in a clearly boost in porosity. For larger sand grains, it is the mean body of the whole sample force chain and the crucial component of the entire connection chain. The grains of sand do not dissolve, so the entire displacement is kind of stable. Nevertheless, the salt disappearance from smaller particles inserted in the middle of the larger elements still causes the entire displacement, while at high strength, the particles are rearranged because of the broken down of the strong chains. At this point, the enhancement in porosity is bigger than that at low stress.

5. Summary

A found from the experiment data in the strength of the low pressure little higher than that of low pressure strength in high stress strength, this means that each of the solid space volume loss in the high
stress strength is more than low strength. Although is not obvious, there are still certain relationship between the stress strength and Λ data, thus we can draw conclusion that in the case in high pressure, unit sand - salt dissolved with the larger the volume of a solid mixture loss

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