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Calcite content evaluation for calcite precipitation method using acid procedure: Effect of soybean powder grain size

Keywords: Acid leaching procedudre, calcite precipitation, grain size, soybean powder

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Introduction

Calcite precipitation is one of the alternative novel methods of soil improvement using the high purity urease enzyme as the catalyst to precipitate calcite in soil grain. This method could increase the UCS of sand soil from 0.4-1.6 MPa [1]. However, according to calculation by Oktafiani et al. [2], the utilization of high purity urease enzyme in large scale soil improvement is not economically efficient, therefore, another subsitute material should be utilized to reduce the cost. Based on research by Lofianda et al. [3], soybean powder proved to be an alternative of subsitute material for calcite precipitation. According to Putra et al. [4], soybean had a high-enough hydrolysis rate to be used instead of commercial urease enzyme. However, the use of soybean powder will result in undissolved soybean powder mass. The undissolved mass could affect the calcite formation reaction to be less effective and block soil pores and make the calcite can not distributed evenly in the soil [5]. Different soybean powder grain size can result in different soultion viscosity and urea hydrolysis rate [6]. In order to quantify the amount of calcite and undissolved soybean mass, hydrochloric acid will be used in this research, due to its ability to dissolute carbonate [7]This study will evaluate the effect of different soybean powder grain size on calcite precipitation method using soybean extract solution obtained by filter treatment.

Methodology

a. Soybean powder treatment

The soybeans used in this study were purchased purchased from Kouta Happy Food Market and locally grown in Hokkaido, Japan. Fresh soybean smashed into powder and separated using sieve. The soybean powder sieved through 3 different size, which retained in 150 μm, 300 μm, and 425 μm size. The sieved soybean powder used for next evaluations.

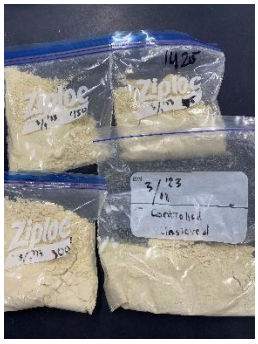


Figure 1 Sieved soybean powder

b. Test tube evaluation

Test tube is the main evaluation of this research. This evaluation was conducted to determine the amount of precipitated calcite produced using 3 different types of soybean powder with different size. Based on the research by Lofianda et al. [3], the 20 g/L soybean solution extract then filtered using a No. 400 sieve (0.037 mm). Each 1 mol/L reagent ($CaCl_2$ and $CO(NH_2)_2$) mixed with soybean powder solution from each size. The solution was then mixed and given 3, 5, 7, 10, and 14 days of curing time in the tubes.

c. Calcite precipitation evaluation using acid procedure

After the curing time was completed for each day respectively, the tube then opened and filtered using filter paper No. 4. Then, the tube and filter paper were put into the oven and heated for 48 hours at 60°C to remove the remaining liquid. After the tube and filter paper dried using oven, the total precipitated mass which contains calcite and undissolved soybean can be quantified.

In order to determine the amount of calcite and undissolved soybean in the tube. The 10%-dilluted-hydrochloric acid poured into the tube to dissolute calcite in the sample and then filtered using filter paper. This step was repeated for 3 times to make sure all calcite was dissoluted. Then, the tube and filter paper were put into the oven and heated for 48 hours at 60°C. The lost mass from the tube considered as the calcite mass and retained mass considered as the undissolved soybean mass. The reaction can be seen below.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

Results

a. Calcite precipitation evaluation tube test

The concentration 20 g/L soybean extract used in this research based on the evaluation of the optimum calcite precipitation ratio [3,4]. The result of evaluation of precipitated mass can be seen in Figure 2. There is an increase in the calcite precipitation ratio along the smaller grain size, the higher of precipitated mass produced, including calcite and undissolved soybean mass. Smaller soybean powder grain size produced higher precipitated mass [6].

Based on Figure 2, there is in an increase of precipitated mass ratio along with the longer curing time. However, precipitated mass trend reached optimum point in 7 days of curing time. According to Baiq et al. [8], UCS strength of EICP using soybean powder has maximum strength in 7 days of curing time, because the reaction was peaked at that time. Figure 2 shows that precipitated mass ration exceeded 100%, which means, actual precipitated mass amount in the tube is more than theoretical calcite mass. Therefore, there is another undissolved soybean mass left in the tube which could not catalyze the reaction of calcite precipitation.

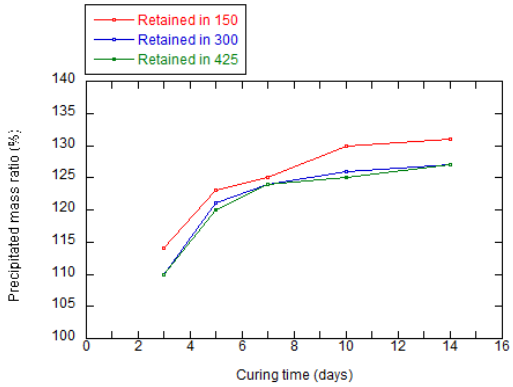
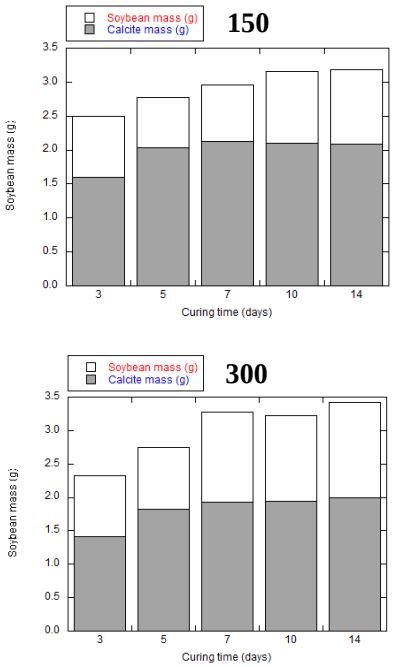


Figure 2 Precipitated mass evaluation result

b. Acid procedure evaluation

Based on Figure 3, it clearly shows that smaller soybean powder grain size produced higher calcite precipitation compared to larger soybean powder grain size. The highest calcite precipitated calcite mass can be achieved using Retained 150 soybean powder, while the highest undissolved soybean mass can be found achieved using Retained 425 soybean powder. According to Shu et al. [6], smaller soybean powder grain could precipitates a higher calcite mass. Lower calcite precipitation mass might be caused by higher undissolved mass in the solution [5].



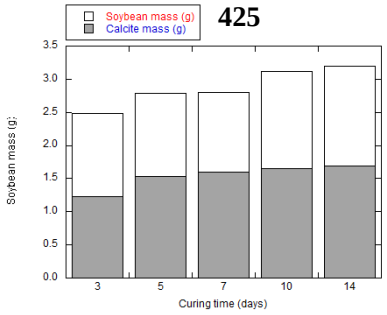


Figure 3 Calcite and undissolved soybean composition

Conclusion

Based on sample precipitated calcite evaluation, smaller grain size soybean powder produced higher percentage of precipitated calcite. Curing time also affects the calcite precipitation reaction, which in this research optimum curing time achieved in 7 days.

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