

## STUDY ON UNCONFINED COMPRESSIVE STRENGTH OF MAGNESIUM CARBONATE AND SOIL MIXTURES

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### 1. INTRODUCTION

In response to the ever-growing urgency to stem global temperature rise, there is now a need for widescale development and implementation of negative emissions technologies. As such, one promising research comes in the form of a conversion process proposed by Myers and Nakagaki (2021), wherein desalination brine is converted into a set of widely used industrial products using entirely electricity-based evaporation and temperature control. The commercially viable products, which include water, gypsum, hydrochloric acid, etc. reduce the need for conventional production processes and their subsequent CO<sub>2</sub> emissions. In addition, this process is further capable of bringing negative emissions by CO<sub>2</sub> mineralization using the by-product Magnesium Oxide (MgO) to produce MgCO<sub>3</sub>. In the end, the mitigation effect from reducing dependency on conventional methods and the 4.5 kg-CO<sub>2</sub>/m<sup>3</sup>-brine negative emissions from CO<sub>2</sub> mineralization, would together mean a 22.9 kg-CO<sub>2</sub>/m<sup>3</sup>-brine reduction when using conventionally produced electricity. Furthermore, if we were to rely entirely on renewables for electricity production, this net reduction amount would increase to 43.9 kg-CO<sub>2</sub>/m<sup>3</sup>-brine and can bring about 231 Mt-CO<sub>2</sub>/y of negative emissions, which is a figure comparable to the current requirement of 10's Gt-CO<sub>2</sub>/y. Therefore, due to this process's immense potential for bringing about negative emissions, it became important to next consider feasible applications for the large amounts of MgCO<sub>3</sub> that would be produced if implemented.

In this study, the use of MgCO<sub>3</sub> as a geomaterial was evaluated through a series of uniaxial compression tests to determine unconfined compressive strength ( $q_u$ ) of soil mixtures with 10 wt.% MgCO<sub>3</sub>. The main goals were twofold- to evaluate the maximum  $q_u$  of MgCO<sub>3</sub>-soil mixture samples at different compaction degrees and compare the obtained results with those of pure soil samples.

### 2. TEST MATERIALS AND PROCEDURE

This study makes use of two commercially available materials- Clay Sand and MgCO<sub>3</sub> fine powder. Experimental results found their specific gravity to be 2.69 and 2.30 respectively. Clay sand is a plastic silt with 11.9% plastic limit and 64.1% liquid limit. The MgCO<sub>3</sub> fine powder is non-plastic with potential hygroscopic properties. Compaction experiments by Khan et al. (2021) found the optimum water content is ~21% for the Clay Sand (hereafter pure soil), and ~26% for 90 wt.% Clay Sand and 10 wt.% MgCO<sub>3</sub> powder mixture (hereafter MC mixture). Accordingly, the maximum dry density ( $\rho_{d,max}$ ) of pure soil and MC mixture were around 1.453 g/cm<sup>3</sup> and 1.323 g/cm<sup>3</sup> respectively. The obtained compaction curves were flat in shape and indicated only minute differences in their dry density values at varying water contents. Therefore, to evaluate strength of pure soil and MC mixture, they were initially mixed with water to a target initial water content of 26% and cured for several days. Note that the prepared soil was made such that it passed through the 4.25mm sieve.

4 pure soil specimens and 4 MC mixture specimens were prepared with 5 cm diameter and 10 cm height, using a detachable cylindrical mould. Variations were made in the void ratios ( $e$ ) of the specimens. This was done by initially selecting specimen compaction degrees ( $D_c$ ), and in turn, void ratios in the range of 81.6-92.2% and 1.09-1.34 respectively. Based on this, total required mass of each specimen was determined. Then, by using the mould, every specimen was made by compacting in 10 layers, each having 1/10<sup>th</sup> of the total required mass. The compaction side of the topmost layer of each specimen was carefully trimmed to keep an even surface. Once prepared, each specimen was wrapped by film and cured in sealed bags for 3-7 days. Thereafter, they were placed in the uniaxial compression device to undergo unconfined uniaxial loading at an axial strain rate of around 1% /min. The load cell and displacement sensor solutions to measure axial stress and axial strain are 1.28kPa and 0.01mm respectively. Finally, water content was measured upon specimen failure.

### 3. RESULTS AND DISCUSSION

Fig. 1 shows the recorded axial stress and strain relationships for pure soil and MC mixture. It can be seen that all specimens failed at axial strain of  $\sim 1\%$  for MC mixture and  $\sim 2\%$  for pure soil. Since the  $\rho_{d,max}$  of the two cases are very different, relations between  $q_u$  and  $D_c$  and  $e$  are presented in Fig. 2 and Fig. 3. It is observed that the  $q_u$  of MC mixture specimens were surprisingly higher than that of pure soil specimens under the same  $D_c$  or  $e$ . Even more so, it is also seen that at high compaction degrees, the  $q_u$  of the MC mixture specimens is significantly higher than those of pure Clay Sand. One possible explanation to this could lie in the usage of a water content higher than the optimum water content for the pure soil specimens. It is also conceivable that under the same suction, water content would be greater in MC mixtures than in pure soil. The cementation effect brought on by the use of  $MgCO_3$  is not expected, while it will be confirmed in the future investigation.

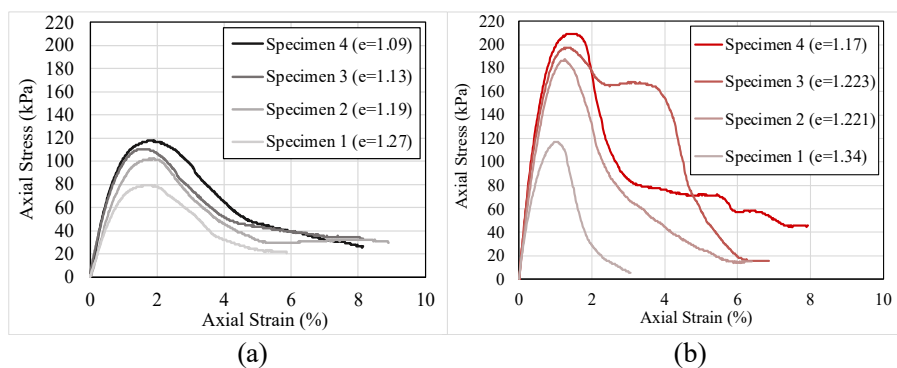


Fig. 1 Axial stress-strain characteristics of (a) Pure Soil and (b) MC mixture

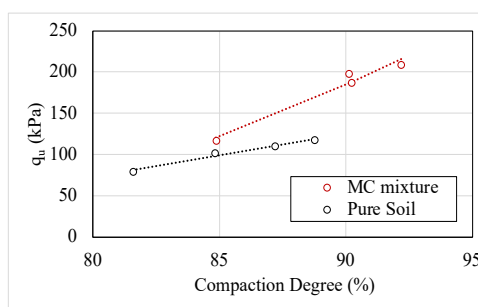


Fig. 2  $q_u$  and  $D_c$  relationship

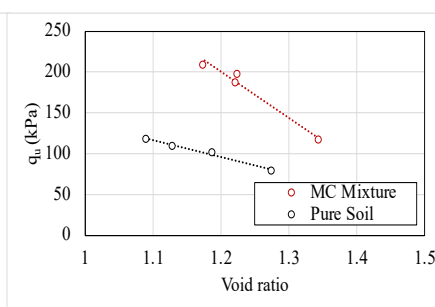


Fig. 3  $q_u$  and  $e$  relationship

### CONCLUSION

As a part of the ongoing research regarding the use of  $MgCO_3$  as a geomaterial, a series of uniaxial compression tests were conducted on MC mixtures around its optimum water content. Each specimen was made with varying compaction degrees. Results showed that  $q_u$  of the clay sand- $MgCO_3$  specimens were higher than those of pure clay-sand, especially at higher compaction degrees. Possible reasons could lie in the use of a water content higher than clay sand's optimum water content or due to MC mixture's suction effect being greater. Based on the obtained results, it is now necessary to carry out further tests to evaluate the performance of samples with higher concentrations of  $MgCO_3$  and investigate a potential cementation effect induced by  $MgCO_3$ .

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### REFERENCES

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