Concrete production through microbially induced dissolution and re-precipitation of limestone

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More than 10 km^3 of concrete is produced globally every year, making it by far the most used construction material on the planet. The fossil CO_2 released from limestone during calcination, where $CaCO_3$ is processed at high temperatures to produce CaO, and from the fossil fuels used to fuel the calcination process, currently account for more than 5% of global anthropogenic CO_2 emissions. A promising approach for reducing CO_2 emissions in the concrete industry is to make use of naturally occurring mineral-microbe interactions, such as microbially induced carbonate precipitation (MICP), in the production of construction materials.

The low cost and high global abundance makes limestone a favorable raw material for concrete production, and being able to use it as a major binder in concrete without the need to first decompose it at high temperatures would be a great advantage. In this study, we use microbes to transform calcium carbonate from crushed material to a binder in a low temperature process. In the first step, a natural isolate of alkali-tolerant, acid-producing bacteria is used to dissolve crushed limestone. Subsequently, the calcium-containing solution is injected into a sand column together with urea and the ureolytic bacterium *Sporosarcina pasteurii* to re-precipitate calcium carbonate and achieve consolidation. The quality of consolidation is found to depend on a number of factors including the amount of glucose, bacteria and urea, as well as the presence of undissolved chalk and acid producing bacteria in the sand column. SEM observations show that different conditions can produce a large range of morphologies and spatial distribution of precipitated calcium carbonate, which in turn influences the mechanical properties of the consolidated material.

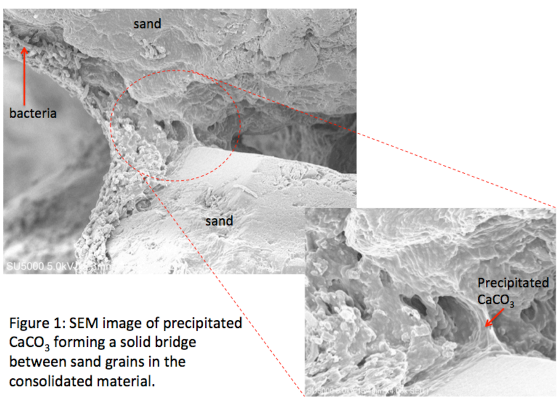

Figure 1: SEM image of precipitated $CaCO_3$ forming a solid bridge between sand grains in the consolidated material.