Microbiologically induced calcite precipitation (MICP) following the ureases is a bio-geo-chemical soil improvement technique in which the microorganism facilitates to create an environment for the precipitation of carbonates among the grains. This results in binding the loose granular media and prevention against mechanical failure. However, the bio-cemented processes and media have been studied in the past in qualitative sense with experimental programs, but the mathematical and numerical modelling techniques to quantify the strength parameters are rare. In this article we propose the lattice element methodology which can perform numerical computations of unconfined compression test for the bio-cemented sands. The goal is to study the macroscopic response and also to quantify the process for engineering applications. The developed model with embedded discontinuity is able to capture the macroscopic behaviour from meso-scale element failure, where the diagonal shear cracks which are seldom inherent to compression failure of granular cemented media lead the specimens to final failure. The model is able to capture the complex interaction of the cracks such as initiation and propagation, branching, coalescence and fingering at a very low computation cost. The developed model is followed by the experimental study where the numerical and experimental results show good agreement to a large extent. The developed model is general in nature and is suitable to study brittle and quasi brittle cemented granular media.