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Biotechnological Methods for the Grouting of the Tunneling Space

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Abstract : Different biotechnological methods for the production of construction materials and for the performance of construction processes in situ are developing within a new scientific discipline of Construction Biotechnology. The aim of this research was to develop and test new biotechnologies and biotechnological grouts for the minimization of the hydraulic conductivity of the fractured rocks and porous soil. This problem is essential to minimize flow rate of groundwater into the construction sites, the tunneling space before and after excavation, inside levies, as well as to stop water seepage from the aquaculture ponds, agricultural channels, radioactive waste or toxic chemicals storage sites, from the landfills or from the soil-polluted sites. The conventional fine or ultrafine cement grouts or chemical grouts have such restrictions as high cost, viscosity, sometime toxicity but the biogrouts, which are based on microbial or enzymatic activities and some not expensive inorganic reagents, could be more suitable in many cases because of lower cost and low or zero toxicity. Due to these advantages, development of biotechnologies for biogrouting is going exponentially. However, most popular at present biogrout, which is based on activity of urease- producing bacteria initiating crystallization of calcium carbonate from calcium salt has such disadvantages as production of toxic ammonium/ammonia and development of high pH. Therefore, the aim of our studies was development and testing of new biogrouts that are environmentally friendly and have low cost suitable for large scale geotechnical, construction, and environmental applications. New microbial biotechnologies have been studied and tested in the sand columns, fissured rock samples, in 1 m3 tank with sand, and in the pack of stone sheets that were the models of the porous soil and fractured rocks. Several biotechnological methods showed positive results: 1) biogrouting using sequential desaturation of sand by injection of denitrifying bacteria and medium following with biocementation using urease-producing bacteria, urea and calcium salt decreased hydraulic conductivity of sand to 2×10-7 ms-1 after 17 days of treatment and consumed almost three times less reagents than conventional calcium-and urea-based biogrouting; 2) biogrouting using slime-producing bacteria decreased hydraulic conductivity of sand to 1x10-6 ms-1 after 15 days of treatment; 3) biogrouting of the rocks with the width of the fissures 65×10-6 m using calcium bicarbonate solution, that was produced from CaCO3 and CO2 under 30 bars pressure, decreased hydraulic conductivity of the fissured rocks to 2×10-7 ms-1 after 5 days of treatment. These bioclogging technologies could have a lot of advantages over conventional construction materials and processes and can be used in geotechnical engineering, agriculture and aquaculture, and for the environmental protection.

Keywords : biocementation, bioclogging, biogrouting, fractured rocks, porous soil, tunneling space
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