SYNOPSIS

Durability is still the most important factor for the service life of most concrete structures, both in terms of economy and safety. Of the various types of deteriorating mechanisms, reinforcement corrosion is at present considered the main cause of premature deterioration in most countries. Other common deteriorating mechanisms are freeze/thaw action, chemical attack and alkali aggregate reactions. Also, the degradation of mortar/concrete in sewers by some acidophilic microorganisms has been well established. However, permeability of the concrete plays the major role in the durability-based design and thus various innovative approaches are proposed with times by the concrete technologists. The main purpose is to reduce the permeability of cement-based materials by the pore size distribution particularly in the Interfacial Transition Zone to extend the service life. Use of mineral admixtures such as silica fume, fly ash, metakeolin and blast furnace slag with some typical chemical admixtures helped to develop such high performance cement-based mortar/concrete. These materials are normally optimized to perform a well-defined set of tasks.

In the biosphere, some special microorganisms can function as geochemical agents, promoting the dispersion, fraction and/or concentration of matter. These processes, which are being more and more valued from the point of view of various scientific disciplines. The microbial processes resulting in the concentration of matter and the formation of minerals in cement-based matrix constitute an area of research of growing interest. Use of this concept leads to the potential invention of new cement-based material, an inherent and self-repairing biomaterial that can be used to remediate the cracks in concrete structures. The ability of some microorganisms to improve the
properties of cement based materials has been started by a research group at Technological University of South Dakota of Mines and Technology, USA. Their research reports indicate that the use of aerobic microorganisms such as, *Bacillus pasteurii* and *Pseudomonous aeruginosa* improve the impermeability, stiffness, and compressive strength of mortar/concrete by the process of biomineralisation. However, the research work is in progress to understand the significance of such type microorganisms in mortar/concrete. A development of biological cement using microorganism which converts sand to sand stone has been reported elsewhere. It has been generally accepted that the identification of suitable microorganisms for their beneficial effect on the mortar/concrete environment is one of the important area.

In this study, a facultative anaerobic microorganism has been incorporated to improve the properties of cement mortar/concrete. This microorganism is thermophilic in nature, iron reducing and belongs to *Shewanellla species [(S. alga u 91544)-sequence assigned by RDP]* and obtained from the hot spring at Bakreshwar, India. This microorganism has been incorporated at different cell concentrations along with a designed media as nutrient both in mortar and concrete environment. The microorganism and the media have been added to the mortar/concrete during the process of mixing. The standard *Escherichia coli (E. coli)* microorganism was also incorporated in mortar for comparison. The experimental investigation involves basically the estimation of strength with ages incorporating such microorganisms at different cell concentration. The micro structural study such as Scanning Electron Microscope (SEM) analysis, X-ray Diffraction (XRD) analysis and Image analysis of both treated and untreated samples has been performed. The pore size distribution of such samples has been also made through
Mercury Intrusion Porosimetry test. Finally, an attempt has been made to correlate the strength results to its durability performances.

Results indicate a substantial improvement in compressive strength of mortar/concrete due to the addition of this facultative anaerobic iron-reducing microorganism. And maximum improvement in compressive strength at 28 days has been noted for mortar (about 25%) and concrete (about 21%) at a cell concentration of $10^5$ /ml of water used. No such improvements were notice with the addition of standard *E. coli* microorganism and there is no specific role of addition of media (as nutrient) on the strength improvement of cement-sand mortar. It has been concluded that the strength improvement due to the addition of these microorganisms at an appropriate cell concentration is due to growth of filler material within the pores of the mortar and concrete. SEM and Image analysis confirmed the role of microbiologically induced precipitation within the pores of mortar and concrete matrix. XRD analysis also shows that a new crystal is developed within the pores of the cement sand matrix due to the addition of microorganisms. The improvement in pore size distribution due to this crystal growth has been observed. Ultrasonic pulse velocity and water absorption test also confirms the positive effect of microorganisms within the mortar/concrete matrix. It may be mentioned here that this microorganism is environmentally innocuous and can be cultured in the laboratory with a designed process. Thus the use of such microorganism can be treated as environmental friendly and to some extent economic. However, a long term research is needed to understand the significance of microorganisms in concrete structures fully, so that this methodology may be extended for the remediation of cracks and fissures in old concrete structures to enhance its stability.