ABSTRACT

Improvement of tensile and flexural ductility along with durability (without degrading other characteristics – such as compressive strength) is one of the specific requirements for conventional concrete structures. The research carried out in this study aims to achieve the above mentioned two main objectives of improvement of ductility (assessed through direct tensile tests, flexure tests, blast tests as well as mixed mode fracture tests using an Arcan test setup) and durability (assessed through Rapid chloride penetration test, Rapid chloride migration test, and Shrinkage tests) through use of fiber reinforced cementitious composite materials. The cementitious composite material (CCM) being used for this study differs from conventional concrete material in its constituents – since no coarse aggregates are being used and fine aggregates being used is sand having sizes less than 150 microns. Two different types of cementitious composite materials have been developed as part of study – one a supplementary cementitious material having specified proportions of fly-ash and silica fume added to cement and another having no cement as one of its constituents but being based entirely on alkali activation of fly-ash, ground granulated blast furnace slag and silica fume. Different types of fiber reinforcements (treated jute and ramie fibers along with synthetic fibers such as polypropylene, polyester, poly-vinyl-alchohol, kevlar) are added to these cementitious composite materials with an aim to improve the ductility and durability characteristics of the resultant material. It has been demonstrated in the study (through detailed rheometer studies of the cement slurry along with XRD, FTIR, DSC and TGA of 28 days' cured samples) that addition of fiber reinforcements not only improves the ductility characteristics but also retards the setting time for cement hydration.

Suitability of different fibres in alkaline environment (as present during hydration of cement) has been assessed and out of the fibers being evaluated, polypropylene fibers demonstrates the best option. It has also been observed that out of the fibers being evaluated treated jute fibers demonstrates faster retardation of the rate of hydration. From the study, it can be concluded that addition of just addition of one type of fiber is not the only criteria for improvement of ductility; various physical (fibrillation, change in surface characteristics) and chemical (change in percentage of constituents, chemical bonding with matrix) as well as mechanical (tensile strength and elongation at break of a single fiber) characteristics influence the behaviour of the fiber reinforced cementitious composite material. Case studies have been presented to demonstrate the importance of factors influencing the ductility characteristics of the resultant mix. Apart from ductility, durability enhancement is also demonstrated with fiber reinforced cementitious composites. In addition to the development of a supplementary cementitious material, a new material based on alkali activation of waste materials (without using cement as its constituent and thereby reducing CO_2 emission to atmosphere during production of cement clinkers) is also developed as part of this work in which the compressive strength and efflorescence characteristics of the material are chosen for optimizing the proportion of the constituents. The alkali activated material is also fiber reinforced to demonstrate improvements in ductility properties of the material.