INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: A Study on Fresh Properties, Strength, Microstructure and Chloride Induced Corrosion of Steel Reinforcement in Self-Compacting Concrete

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SHORT ABSTRACT

The placement and adequate compaction of concrete in heavily reinforced sections are the challenges faced during the construction of reinforced concrete structures. However, to obtain good quality concrete in all the structures in general and in heavily reinforced sections in particular, there is a need to ensure proper placement and adequate compaction of concrete. In heavily reinforced sections, there may be segregation and blockage of concrete during its flow through the narrow openings, which will affect the internal structure of concrete leading to inadequate strength and durability properties. To avoid the problems related to the flow of concrete into every corner in the formwork of the structural elements especially in heavily reinforced sections and subsequent compaction, the self-compacting concrete (SCC) has been used in the construction of structures worldwide. Over the years, the SCC has become an attractive option in the area of construction as compared to normal vibrating concrete. The SCC is designed specially to provide excellent deformability in heavily congested reinforced sections and also it has the ability to flow into every corner of formwork under its self-weight during the placement process, without requirement of vibration for compaction. The reinforced concrete structures are subjected to several durability problems during their service life. Among the durability problems, chloride induced corrosion of steel reinforcement is the most significant one that occurs in the reinforced concrete structures. The aggressive agents such as chloride and sulfate ions can enter into the concrete through its ingredients during the time of preparation or can penetrate into the hardened concrete from the surrounding environment during the service life of concrete structures.

In this research work, an experimental investigation has been carried out to evaluate the effect of admixed chloride at different concentrations on the behaviour of self-compacting concrete (SCC) through fresh properties, strength development assessed through variations in hydration products with curing age, chloride binding, changes in microstructure and thermal behaviour, and chloride induced corrosion of steel reinforcement. In addition, the performance of SCC mixes has been evaluated against external chloride and combined chloride-sulfate exposure conditions. For this purpose, the SCC mixes were prepared with different types of binder and water-to-binder (w/b) ratios, and admixed with different concentrations of chloride ions. Moreover, the SCC mixes (without admixed chloride) were exposed to external chloride and combined chloride-sulfate solutions. Various tests for fresh

properties, compressive strength, chloride concentration, pH, thermal behaviour, microstructural analyses and corrosion of steel reinforcement in SCC were conducted.

From the obtained results, it is observed that all the SCC mixes satisfied the acceptance criteria with respect to filling ability, passing ability and segregation resistance as per EFNARC guidelines. The SCC mixes made with PPC exhibited higher filling ability, passing ability and segregation resistance as compared to those made with OPC+20% FA followed by OPC based SCC mixes. The results of analysis of variance of compressive strength showed that curing age has more significant effect on the compressive strength of SCC mixes followed by w/b ratio, binder type and admixed NaCl concentration. The Ca/Si ratio of C-S-H obtained from EDX analysis in OPC based SCC mixes increased whereas it decreased in PPC and OPC+20% FA based SCC mixes with curing age, which is consistent with the compressive strength development of SCC with curing age in OPC, PPC, and OPC+20% FA based SCC mixes. The results of XRD, TGA, FESEM and FTIR analyses indicated that NaCl admixed at various concentrations influenced the microstructure and thermal behaviour of SCC mixes. The variations in formation of calcium hydroxide (CH) with binder type, curing age, admixed NaCl and w/b ratio as indicated by the XRD results are well explained by the CH content calculated from the mass loss in TGA as a result of its dehydration. The chloride binding as indicated by bound chloride concentration was higher in OPC based SCC mixes as compared to that in OPC+20% FA and PPC based SCC mixes. A strong linear relationship exists between free chloride and total chloride concentrations in the SCC mixes.

From the results of corrosion monitoring of steel reinforcement in SCC, it is observed that OPC based SCC mixes showed better corrosion performance as compared to PPC and OPC+20% FA based SCC mixes during the early exposure period in the presence of internal chloride however, the opposite variation was observed during the later ages after exposure to 5% NaCl solution. For external exposure condition, the SCC mixes made with PPC and OPC+20% FA showed better corrosion performance as compared to that made with OPC based SCC mixes against external chloride (NaCl) and combined chloride-sulfate (NaCl + Na_2SO_4 and NaCl + $MgSO_4$) exposure solutions. While comparing the exposure solution, the corrosion performance of steel reinforcement in SCC mixes decreased in the order of: NaCl + $MgSO_4$ > NaCl + Na_2SO_4 > NaCl.