CHAPTER 1

INTRODUCTION

This chapter introduces the development and application of Self-Compacting Concrete (SCC), and then describes the background, aims and scope of this project. Also, this chapter briefly discusses the organization of the thesis.

1.1 GENERAL

Concrete is the most widely used material in the world, other than water. Nowadays, concrete is used as construction material for most of the buildings and infrastructures in India. Concrete is the only major building material that can be delivered at the job site in a plastic state. This unique quality makes concrete a desirable building material, because it can be molded to virtually any form or shape, and can be used to construct a wide variety of structures.

Self-Compacting Concrete has become the buzzword in the construction industry, and is considered as one of the most crucial advances in the industry over the last two decades. SCC has become a valuable asset with its ability to 'flow' without segregating. One of the greatest strengths of SCC is that it can flow through complex structural elements in its own weight, without leaving any voids, eliminating the need for vibration or any type of compacting effort.
SCC has been introduced in the market recently. This type of high performance concrete has been in use since the late 1980s. Professor Hajime Okamura (University of Tokyo, now Kochi Institute of Technology) initiated the utilization of SCC (in the year 1986), which steadily spread all over the world. The first prototype was developed in 1988 as a solution to the growing problems associated with concrete durability and the high demand for skilled workers.

Due the development of the prototype of SCC, the use of SCC in actual structures has gradually increased all over the world. The main reasons for the employment of SCC are to shorten the construction period, to assure uniform compaction in the structure, and to avoid noise due to vibration. SCC is therefore called ‘the quiet revolution in concrete construction’ (The Concrete Society and BRE, 2005). SCC is also known as “special concrete”.

With regard to its composition, SCC consists of the same components as conventionally vibrated concrete, which are cement, aggregates, water, additives and admixtures. However, the high powder content acts as a “lubricant” for coarse aggregates, and also as a viscosity agent to increase the viscosity of the concrete. It is reported that in most cases, the cost increase ranges from 20% to 60% compared to a similar grade of CVC (Ozawa, 2001, Nehdi et al. 2004). However, in very large structures, the increased material cost by using SCC was outweighed by the savings in labour costs and construction time (Billberg, 1999).

At this stage it is important to define SCC and its characteristics. Literally, self-compacting characteristics are related to the fresh properties. The definitions of SCC given in the literature vary: the most common one is that “a concrete that is able to flow under its own weight and completely fill the formwork, while maintaining homogeneity even in the presence of congested
reinforcement, and then consolidating without the need for vibrating compaction” (The Concrete Society and BRE, 2005).

SCC has three essential fresh properties: filling ability, passing ability and segregation resistance (Testing-SCC, 2005; The Concrete Society and BRE, 2005). Filling ability is the characteristic of the SCC to flow under its own weight and to fill completely the formwork. Passing ability is one of the characteristic of the SCC to flow through and around obstacles, such as reinforcements and narrow spaces without blocking. Segregation resistance is another characteristic of the SCC to remain homogeneous during and after transporting and placing. Both fresh and hardened properties are the keys to the successful application of SCC. Therefore, it can be designed to satisfy both fresh and hardened requirements.

The modern application of SCC is focused on high performance, such as reliability in quality, dense and uniform surface texture, improved durability, high strength and the saving of labour and time. The application of SCC in the Indian construction sector is still new and limited in the precast concrete industry: Kaiga power project work, Delhi metro rail projects, Bangalore Airport works, and Palais Royale, and the tower of 320 m height in Mumbai. Consequently, a lot of further research dealing with this type of concrete technology needs to be carried out to enhance our nation’s capability and quality in construction activities.

1.1.1 Advantages of SCC

It has been proved economically beneficial because of a number of factors as noted below (ENFARC, 2002):

i) Faster construction,

ii) Reduction in site manpower,
iii) Easier placing,
iv) Uniform and complete consolidation,
v) Better surface finishes,
vi) Improved durability,
vii) Increased bond strength,
viii) Greater freedom in design,
ix) Reduced noise levels, due to absence of vibration, and
x) Safe working environment.

1.2 BACKGROUND OF THE PROJECT

To ensure its high filling ability, flow without blockage and to maintain homogeneity, SCC requires a reduction in coarse aggregate content with an increase in the cement content, which would push the cost up, cause a temperature rise during hydration, and most likely affect other properties such as creep and shrinkage. Moreover, significant quantities of additions are often incorporated to replace some of the cement, to enhance the fresh properties and to reduce heat generation. It has the potential to extend the quantity and type of additions; fly ash with different fineness in different ratios is the subject of the research reported in this thesis. The usage of fly ash of different fineness in this aspect of research is still new.

The use of fly ash in concrete is well established and widespread; it is not only economical but also improves the fresh and hardened properties of the concrete. It also helps to solve the problem of storage and disposal of the ash. The typical usage is about 15-30% replacement of cement. High-volume fly ash (HVFA) concrete, with more than 50% of the cement replaced by fly
ash, developed by Canadian Centre for Mineral and Energy Technology (CANMET) in 1985, is attractive for environmental and sustainability reasons.

When used in SCC, fly ash helps to maintain the viscosity of concrete, reduces the risk of blocking, and decreases the amount of superplasticizer required to achieve similar fresh properties. The research implementation is to study, and determine the compatibility of fly ash of different fineness and of different ratios as cement replacement material, using a superplasticizer of SNF grade as an admixture to produce SCC. Hopefully, this research can contribute to other findings in developing SCC and can be applied in our local construction industry.

1.3 RESEARCH AIM AND OBJECTIVES

The aim of this research is to produce a suitable concrete compound which can be categorized as SCC, using fly ash of different fineness as cement replacement material, together with a superplasticizer of SNF grade alone as admixture. The compatibility of both materials to bind together will also be observed.

The objectives of the research are given below:

i) To develop and produce SCC using Fly ash of different fineness and ratios, and a superplasticizer of type Sulphonated Naphthalene Formaldehyde (SNF).

ii) To investigate the variation in fresh properties and strength development of SCC.

iii) To investigate the developed mixes for chloride diffusivity by the Rapid Chloride Permeability Test.
1.4 RESEARCH SCOPE AND PURPOSE

In executing the research, the scope boundary needs to be defined and a few limiting factors drawn, to avoid a very wide scope and unfocussed study. The scope and limitations of this research are;

i) The mixtures of SCC use only the fly ash of different fineness and different ratios as cement replacement material and superplasticizer of type Sulphonated naphthalene formaldehyde (SNF) as admixture.

ii) The developments for the proposed SCC mix have used Ordinary Portland Cement (OPC).

iii) The free water for all the mixtures is fixed as 195 liters, and the fine aggregate to the total aggregate ratio is fixed as 0.52 to 0.54 for all the mixtures. The dosage of the superplasticizer alone was adjusted, depending upon the requirement of the fresh state properties of SCC.

The purpose of this project is to develop and evaluate the properties of fly ash based SCC made with locally available materials, and to study its flow, segregation, strength and permeability.

1.5 RESEARCH SIGNIFICANCE

The advantages of SCC have already been recognized by the concrete industry. The design and construction specifications are urgently needed, to give the designers another option in meeting the demands of the present and the future, for Self-compacting concrete in construction sector.

From the research, a clear picture of the differences between SCC and normal concrete can be observed and understood. There will be a high
payoff in not requiring vibration to achieve compaction, and the low noise level to meet stringent environmental requirements in urban and suburban construction. Less labour and speedier construction will result in substantial cost savings, less traffic disruption and reduced risk.

The use of fly ash with different fineness and different ratios as cement replacement material in SCC will also help in the disposal of industrial waste. The use of fly ash can reduce the cost of concrete with less use of cement, and at the same time, reduce the huge amount of power plant industry waste material. The demand for and the consumption of portland cement can be reduced while conserving the natural resources. Moreover, replacing portland cement with fly ash can reduce cement production, and hence, reduce CO₂ emissions.

SCC using fly ash of different fineness has good potential for greater acceptance and wider applications in civil infrastructure works in India and in other parts of the world. Hopefully, this research can guide the civil engineering community and the concrete industry to utilize the advantages of a new breed of SCC.

1.6 ORGANISATION OF THE THESIS

Chapter one gives an introduction to the topic of the research.

Chapter two describes the review of literature pertaining to the effect of the constituent materials on the self compactability of SCC, its rheological characteristics, testing of the key properties, the mix design guidelines, the hardened concrete properties, and its durability aspects.
Chapter three illustrates the experimental investigation, which includes the study of the material properties, the mix proportioning, mixing, casting and curing of specimens.

Chapter four describes the characteristics of SCC in the fresh and the hardened states. The fresh concrete properties include passing ability, filling ability and resistance to segregation. The hardened concrete properties include compressive strength, split tensile strength, flexural strength, and resistance to chloride ion penetrability. The analysis and discussion of results are also given.

Chapter five presents the summary of the research study, concluding remarks and suggestions for future work.