CHAPTER 1

INTRODUCTION

1.1 GENERAL

Concrete is the most commonly used building material on earth, continues to be the popular and cost effective till today. Its success is due to many reasons including versatility, adaptability, formability and economy. Concrete has high compressive strength, workability and durability but a very limited tensile capacity. Conventional concrete may result in honeycombs, inadequate consolidation in thin sections or at congested reinforcements, compromising the strength and durability of the structural elements. To construct strong and durable structures, it is essential to improve the performance of concrete. Continuous research is being carried out throughout the world to improve the properties of concrete, leading to the invention of high performance concrete (HPC) by Al-Jabri et al. (2009). HPC can be designed to have desired level of workability, higher strength and greater durability properties than those of conventional concrete. Production of HPC with expected improved properties may involve enhancements of the following, i) ease of placement without segregation, ii) improved long-term strength properties, iii) early-age strength, iv) toughness, v) volume stability and vi) life in severe environmental conditions. In the recent years, HPC has been widely used throughout the world and to produce it, high quality and relatively expensive materials are needed. Self-compacting concrete (SCC) is a type of HPC that is highly flowable, stable concrete that flows readily under its own weight into places around congested reinforcements, filling formworks without any consolidation and much segregation. The hardened
SCC is strong, uniform with better mechanical properties and durability when compared with vibrated concrete.

1.2 OBJECTIVES OF THE PRESENT STUDY

India is the second most populous country in the world, with over 1.3 billion people, more than a sixth of the world's population. Already containing 17.5% of the world's population, India is projected to be the world's most populous country by 2022, surpassing China, its population reaching 1.6 billion by 2050. Hence the requirements of infrastructure increase alarmingly. Aggregates are one of the main constituents of concrete since they occupy more than 70% of the concrete matrix. In many parts of the world as well in India, there exists a scarcity for natural aggregates, suitable for construction. Also there is an increase in the consumption of aggregates due to the greater demand by the construction industry. Hence this investigation aims in formulating a standard procedure to use copper slag in the manufacture of SCC. The main objectives of this experimental investigation are

i) To formulate mix proportions for SCC from M30 to M100 and evaluate the properties of the above mixes at fresh and hardened state.

ii) To investigate whether copper slag can be used to replace fine aggregate, with and without glued steel fibres and determine the properties of the mixes at fresh and hardened state including the durability.

iii) If copper slag could be effectively used in construction without affecting the strength and durability of SCC, to determine the
optimum proportion of copper slag that could be added to the SCC mix.

If it is feasible to use copper slag in construction, it would be a great support to the construction industry and an easy disposal method for copper slag as well.

1.3 RESEARCH METHODOLOGY

The methodology followed in the current investigation is presented in the form of a flow chart in Figure 1.1.

![Figure 1.1 Research methodology](image-url)

Figure 1.1 Research methodology
Even though there are many research works, published on using copper slag in the manufacture of high performance concrete, they need to be tested with respect to Indian conditions. Using the materials available locally and after testing their properties and suitability, SCC mix proportions need to be arrived. The mixes must be tested at fresh and hardened state to verify they fulfil the expectations. If the mixes succeed, the durability of the mixes needs to be verified.

1.4 ORGANISATION OF THE THESIS

The research strategy that was followed in order to achieve the main objectives listed in the previous section, is described in the following chapters of this thesis.

Chapter 2 presents a general introduction to SCC, the development history of SCC along with the purpose for which the concept of SCC was formulated, the advantages and disadvantages of using SCC, the environmental impact of producing concrete along with an introduction to sustainable construction. There is a suggestion that our current ways of economic and industrial development seem to be unsustainable, results in environmental exploitation. This chapter also suggests that due to industrialisation, several types of by-products and waste materials are generated every day. Effective utilization of these waste materials for the manufacture of concrete reduces our dependence on natural aggregates and formulates an easy way for the effective disposal of the waste materials.

Chapter 3 reviews the characteristics of copper slag and its chemical composition, disposal methods, concludes that copper slag has a high strength-to-weight ratio, making it an effective option for use in the manufacture of SCC.
Chapter 4 surveys the existing literature on the influence of using copper slag for the manufacture of cement, mortar and concrete.

Chapter 5 presents the analysis of the constituent materials – cement, fine aggregate, coarse aggregate, fly ash, copper slag, water, fibres, superplasticizer and viscosity modifying admixture for the manufacture of SCC.

In chapter 6, a detailed investigation on the required performance, selection of constituent materials, design and adjusting the mix composition, verification of the properties of SCC in fresh state in the laboratory and final verification of the performance of the SCC mix in the site, have been discussed.

Chapter 7 investigates the properties of SCC with different copper slag proportions at fresh state. The properties like filling ability, passing ability and segregation resistance have been verified as per EFNARC guidelines.

In chapter 8, the mechanical properties of SCC at hardened state were investigated. Properties like density, compressive strength, split tensile strength, flexural strength and durability of various SCC mixes with copper slag content from 0% to 100% have been tested on 1st day, 3rd day, 7th day, 14th day, 28th day, 56th day and 90th day.

In chapter 9, the test results and conclusions arrived at in this investigations are summarized along with the implications of the results.

Chapter 10 deals with the general discussions and the specific conclusions obtained in the different studies, recommendations are made for further research.