ABSTRACT

Concrete, the proven building material over hundred years, continues to enjoy the status as the most popular construction material. The popularity of concrete as a building material for the construction of civil engineering structures is mainly due to its ease in production, mouldability and low maintenance. It may be easily produced from locally available ingredients namely cement, aggregates and water with minimum experience and effort. In order to construct strong and durable structures, it is necessary to improve the properties of concrete. Due to serious research and development efforts over a period of time, improvements in concrete quality have been achieved in its mix design, production, placement, testing and performance.

Self-compacting concrete (SCC) is an innovative construction material that doesn’t require external or internal vibration for casting and compaction. SCC can flow freely under its own weight, completely filling formwork, achieving full compaction even at locations of congested reinforcement. The hardened concrete is dense and homogeneous, has the same engineering and durability properties as traditional vibrated concrete. SCC is distinguished from conventional concrete by its total deformability without any kind of mechanical intervention. High deformability and stability enables SCC to pass through congested reinforcements and fill the entire formwork under its own weight without vibration or segregation. SCC has made it possible to cast concrete structures with best quality which was not possible with the existing concrete technology. Hence SCC has been widely accepted throughout the world.
Originally formulated to offset a growing shortage of skilled labour, SCC has proved beneficial economically because of a number of reasons including faster construction, reduction in manpower requirement, better surface finishes, easier placing of concrete, improved durability, greater freedom in design and execution resulting in thin concrete sections, lesser noise levels, absence of vibration and safer working environment.

Population growth and urbanization have contributed to a great expansion in energy, manufacturing and transportation sectors of the economy during the twentieth century. The world is witnessing a rapid growth in the construction industry. Large-scale production of portland cement and the rapid exploitation of the environment for aggregates have a dramatic impact on the environment and society. It leads to change in climatic conditions, reduction of water table, environmental pollution and irregular rainfall pattern.

Natural resources are depleting throughout the world and at the same time, the wastes generated from the industry are increasing substantially. Due to industrialization, new by-products and waste materials are generated from various industries. The disposal of industrial by-products is a serious concern for many industries since huge volume of waste by-product is generated, increasing cost of operating landfills and scarcity of landfill sites. With growing environmental awareness regarding potential health hazards, recycling / utilization of industrial by-products has become an easy alternative to disposal. Some of the industrial by-products could possibly be used for the production of concrete. The use of industrial solid wastes / by-products to make concrete is environmentally friendly because it reduces
the consumption of natural resources, the environmental pollution that concrete production generates and the power it consumes.

The major generators of industrial wastes are thermal power plants producing coal ash, iron and steel mills producing blast furnace slag, steel melting slag, non-ferrous industries like aluminium, zinc, iron and copper producing mud and tailings, wood ash, cement plants producing cement kiln dust, silica fume, etc. For many years, by-products such as fly ash, silica fume and slag were considered as waste materials. During the last two decades, intensive research studies have been carried out to explore all possible reuse methods. Concrete prepared with such materials showed improvement in workability and durability when compared to normal concrete and has been used in the construction of power, chemical plants and under-water structures. The utilization of industrial wastes or secondary materials has a great potential in concrete industry, encouraged the production of cement and concrete in construction field.

Copper slag is an industrial by-product material produced from the process of manufacture of copper. Current management options of this slag are recycling, recovery of metal, producing value added products and disposal in slag dumps or stockpiles. But the disposal of slag in landfills is not the most correct option due to the environmental problems, high cost and lack of availability of lands especially in the industrial areas and copper plants. In addition, the landfill becomes another potential source of pollution of soil, water and air, affects the human health, growth of plant and vegetation etc.

Despite the increasing rate of using copper slag, the huge amount of its annual production is dumped in landfills or stockpiles. One of the potential applications for reusing copper slag is for the manufacture of cement
and concrete. Many researchers have already experimented the use of copper slag in the production of cement, mortar and concrete as replacement for cement, coarse and fine aggregates. The use of copper slag in cement and concrete provides environmental as well as economic benefits for all, particularly in areas where copper manufacturing plants are present.

This thesis presents the results of an experimental work undertaken to investigate the possibility of utilising copper slag as fine aggregate in SCC. The ten series of tests, involving various copper slag proportions ranging from 0% to 100% were used to prepare SCC specimens, either with or without the addition of steel fibres, with water to powder ratio ranging from 0.24 to 0.40. Test procedures selected to verify the characteristics of SCC in fresh state include Abrams slump flow, L–box, U–box and V–funnel tests. Properties of SCC in hardened state like density, compressive, flexural, split tensile strength, modulus of elasticity and durability were studied.

The use of copper slag as fine aggregate when compared with usual fine aggregate resulted in a 28-day compressive strength increase of about 6–10%, flexural strength of about 5-8% and a splitting tensile strength increase of 3–5%. With the addition of steel fibres to the above SCC mixes, the use of copper slag as fine aggregate resulted a further increase in 28-day compressive strength of about 5–8%, flexural strength of about 4-6% and a splitting tensile strength increase of 3–5%. Hence it can be concluded from the results of this study that using copper slag as fine aggregate in SCC is technically possible and useful.