CHAPTER 1

INTRODUCTION

1.1 GENERAL

In the recent years, waste management has become a challenge for human community due to abundant growth of industries. The rapid industrialization has brought deterioration in the quality of our environment by generating large quantities of solid waste. The metallurgical industries are among the worst offenders in terms of environmental degradation. Utilization of solid waste is a matter of concern for the society. The accumulation of by-products poses a threat to the environment and occupies prime land near industries. The safe disposal of solid waste is now becoming a primary function of the industries. It has been observed that some of these wastes have hazardous metal concentration in it. These metal wastes require safe disposal in order to avoid possible environmental pollution.

A few waste materials can be effectively utilized for highway construction, as they possess many desirable engineering properties. By using the waste materials as an alternative to the fine or coarse aggregates, the natural stone reserves could be preserved. Utilization of industrial wastes for the construction of highway pavements could solve the problem of environmental pollution and pave way for the bulk disposal.
1.2 SUSTAINABILITY IN HIGHWAYS SECTOR - NEED OF THE HOUR

Presently large-scale road projects are in progress in India at a huge capital cost to create an atmosphere for global investments in the industrial and other sectors. The National Highways Development Project (NHDP) and Pradhan Mantri Grama Sadak Yojna (PMGSY) are the major road projects planned with an investment of about Rs.300 billion per year (Sharma 2006).

The existing road network of 3.3 m km in length is expected to be about 5 m km in the next 20 years (NHAI 2009). PMGSY aims at improving all the existing routes and providing a separate rural connectivity for all the villages. A study on the quantity of stone aggregates requirement for the 20 year period as per the vision document of NHDP is about 350 mt per year for road development (Kadiyali and Bongirwar 2006). In view of enormous road construction activities in the country, which consumes substantial quantum of aggregates, there is a need to develop an alternative material for sustainable road development.

Construction of road is cost intensive and the material cost alone is more than 50% of the total construction cost (Indian Highways Editorial, May 2009). Of this, stone aggregate, the major component, constitutes about 60% of the material cost. Considering the vast impact on economy and environment, demand and supply, the availability of waste materials like fly ash, pond ash, copper slag, plastic waste, etc., has to be explored as an alternative material along with their properties and possible use in the road construction. Since each of the structural layers of a road is expected to perform certain functions, the materials used are also expected to fulfill certain requirements as stipulated in the standards. Hence, it is important to economize in construction with proper selection of materials, optimum input of technology and adoption of appropriate design methodology by conducting extensive research in order to attain sustainability in the highways sector.
1.3 SCENARIO OF INDUSTRIAL WASTE GENERATION IN INDIA

India is a developing country, having a variety of industries. The wastes generated from petrochemical, chemical and mineral processing industries, etc., account for nearly 150 mt per annum (RHPCHW 2006). Out of the listed industries above, the mining and metallurgical industries generate more hazardous waste than the other industries.

Indian non-ferrous industry has been registering considerable growth during the past decades. The present economic scenario in the country is highly conducive to all-round growth and development of non-ferrous industry. The solid waste generated and recoveries of metals from selected non-ferrous industries are shown in Table 1.1.

Table 1.1 Waste Generations and Recovery of Metals

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Non-Ferrous Metal Industries</th>
<th>Solid Waste Generated</th>
<th>Waste as % of Ore Extracted</th>
<th>Recovery of Metals in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aluminum</td>
<td>Red mud sludge and Spent pot lining</td>
<td>77</td>
<td>23</td>
</tr>
<tr>
<td>2</td>
<td>Copper</td>
<td>Smelter and converter slag, Leach residues</td>
<td>99</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Lead</td>
<td>Smelter slag, Drosses and scrap</td>
<td>96</td>
<td>4</td>
</tr>
</tbody>
</table>


From the above table, it may be inferred that to generate a little quantity of usable metals, the waste generated is very high. Especially in the copper industry, wastage is higher than the other industries. Hence, the waste
generated from the copper industry must be examined for its effective utilization.

1.4 INDIAN COPPER INDUSTRY - A REVIEW

The copper industry is one of the major developing industries in India. The domestic production of copper is about 0.50 mt per annum whereas the demand is about 2.50 mt (Sinha et al. 1998). From this, it is evident that a huge deficit of about 2 mt per annum has induced the industries to enhance the capacity of production. The major primary copper production industries in India are shown in Figure 1.1. The domestic production capacity along with annual production of copper in the industries is presented in Table 1.2.

![Figure 1.1 Primary Copper Production Industries in India](Source: www.icsg.org)
Table 1.2 Copper Production in India

<table>
<thead>
<tr>
<th>S. No</th>
<th>Name of the Company</th>
<th>Name of the State</th>
<th>Location of the Plant</th>
<th>Annual Production Capacity in mt</th>
<th>Annual Production in mt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hindustan Copper Limited</td>
<td>Rajasthan</td>
<td>Ketri</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>2</td>
<td>Birla Copper Limited</td>
<td>Gujarat</td>
<td>Dahej</td>
<td>0.50</td>
<td>0.27</td>
</tr>
<tr>
<td>3</td>
<td>Sterlite Copper Limited</td>
<td>Tamil Nadu</td>
<td>Thoothukudi</td>
<td>0.40</td>
<td>0.28</td>
</tr>
</tbody>
</table>


Such a tremendous growth of copper industries has resulted in substantial production of waste materials. It is estimated that for every tonne of copper produced, about 2.2 tonnes of copper slag is generated as a waste (Gorai et al. 2003). Even though a few studies carried out with various metal industrial wastes, studies available on copper slag utilization are very limited, especially for highways construction works.

1.5 STUDY AREA DESCRIPTION

The Granulated Copper Slag (GCS) produced in the copper industry situated in the Thoothukudi District of Tamil Nadu has been taken for conducting this research. The industry produces about 0.44mt of GCS annually. Out of this total production, only 3% to 5% of slag is used for the purpose of sand blasting works. Since the ratio of demand and supply is very low, the material is dumped in open land and left unattended. The aggregate dust, which is also an essential component material in the analysis, has been taken from a quarry near Thoothukudi.
1.6 **OBJECTIVES OF THE RESEARCH STUDY**

The objectives of the research study are:

- to identify environmental considerations and technical characteristics of GCS as an aggregate in bituminous base.
- to evolve a methodology for arriving at specification for Copper Slag Dust Base (CSDB) with an objective of high volume utilization.

1.7 **THESIS OUTLINE**

The thesis of this research project is organized into seven chapters. The first chapter discusses the need for the research program, including objectives. Chapter 2 describes the literature review on material utilization, bituminous mix design considerations and Fine Aggregate Bituminous Bases (FABB). Chapter 3 describes the methodology of the research work. Chapter 4 deals with the chemical and physical characterization of the material. Chapter 5 discusses the formulation of mix design constraints for optimization process. Chapter 6 deals with the experimental mix design of CSDB and the process of optimization using Multi-Objective Three Dimensional Non-Linear Optimization Program (MONLOP) technique. Chapter 7 presents the conclusions, the limitations, and scope for further study.

1.8 **SUMMARY**

The need and objectives of the research study have been discussed in this chapter. The thesis outline has also been presented. In the next chapter, the detailed literature review of the research is discussed and summarized.