

# Study on Utilization of Copper Slag in Sustainable Construction of Rigid Pavements

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**ABSTRACT:-** Copper slag is an industrial by-product generated during extraction and refining of copper metal from copper ore. Presently there are limited uses of copper slag and unused quantity is dumped unattended in the landfills, which create pollution in the environment. Particle size analysis of copper slag shows that it can be a substitute for fine aggregate in the concrete during construction of rigid pavements. The principal objective of this research is to assess the possibility of using copper slag in the construction of rigid pavements.

In this study, characterization of copper slag was carried out to evaluate its engineering properties. The fine aggregates were replaced partially by copper slag in two grades of concrete i.e. M25 and M30 by 0%, 10%, 20%, 30% and 40% copper slag, by weight. The compressive strength and flexural strength tests were conducted on the cement mixes and results were analyzed in dissertation phase ii.

Concrete is the universal construction material having the properties of high compressive strength and durability. The strength, durability and other characteristics depend upon the properties of its ingredients, on the proportions of mix, the method of compaction and other controls during placing, compaction and curing. Concrete making is not just a matter of mixing the ingredients, but good concrete has to satisfy performance requirements in the plastic or green state and so in the hardened state. Among the various properties of concrete, its general compressive strength is considered to be the most important but in case of rigid pavement, flexural strength becomes more important.

Use of copper slag in concrete mix has been harnessed by various researchers and they gave way to use this concrete in rural roads, low traffic street in municipal areas, cross drainage works, drainage lines, deck floors for low volume traffic culverts, medians, and precast interlocking tiles etc. This study explores the possibility of partially replacing fine aggregate by copper slag in the concrete.

## Green Highways

Green highways may be described as those which are environmental friendly and sustainable in all aspects including design, construction and maintenance. The Green Highways approach is a revolutionary approach to resource protection and environmental compliance. The natural environment is the most precious resource we have as it sustains all forms of life on the earth. Recycling of waste material is the major environmental sustainability concept and leads to sustainable development especially for huge utilization of waste in highway construction. With the growing awareness of sustainability and global climate change, highway controlling agencies are taking essential steps to reduce carbon emissions from highway infrastructure on a life cycle basis. A rigid pavement, due to its long life is an economic and cost effective pavement solution as compared to flexible pavements. It consumes minimal materials, energy and other resources for construction and maintenance over its lifetime. The other feature that makes concrete pavements as green highways areas follows:

1. Using industrial by-products such as copper slag in concrete reduces the need for landfill area for disposal and saves the environment from pollution.
2. The rigidity of concrete pavements makes lower vehicle fuel consumption and emissions.
3. The less fuel intensive construction operations results in less CO<sub>2</sub> emissions.
4. Concrete pavements are 100 percent recyclable.
5. The light colored and cool surface of concrete pavements leads to improved visibility and reduced heat island effects.
6. Concrete pavement's overall lower energy foot print means tremendous savings in energy over the life of the pavement facility.

## Need of the Study

Copper slag is generated during extraction and refining of copper metal from its ore or concentrate. Presently in India only 10 to 20% of its production is being utilized in various purposes such as in the manufacture of cement, in the manufacture of ready mix concrete, as abrasive material in shot blasting and as embankment material in the construction of roads (Havanagi et al. (2012a)). The remaining part is dumped unattended in the landfills. If stockpiling is continued then it might be a threat to the future generation. Therefore in the present study, fine aggregates are replaced by copper slag in different proportions in the concrete.

## Objectives of the Research

The prime objective of the research is to study the possible application of copper slag in cement concrete for utilization in various components of low volume road construction. In more detail; the objectives of this dissertation are as follows:

- ☐ To study the characterization of copper slag in order to contribute to a better knowledge of its properties.
- ☐ To investigate the potential use of copper slag as fine aggregate in cement concrete by partial replacement of sand.

Previous studies by various researchers have established that copper slag can be used in different component layers such as embankment, sub base course, base course and bituminous mixes of the flexible pavements. In the present research, an experimental work has been carried out for the characterization and utilization of copper slag in the cement concrete with the partial replacement of fine aggregates by copper slag. The cement concrete so investigated can be utilized as the wearing course of rigid pavements on the low volume roads. Also concrete containing copper slag can be utilized for flooring of causeway, construction of median strip etc.

## Methodology

In the present study, two grades of concrete mixes i.e. M-25 and M-30 were selected which are most commonly used in the rigid pavements. The materials such as copper slag, coarse aggregates, fine aggregates and cement were tested as per relevant Indian standards. Copper slag which was procured from Birla Copper plant was investigated for various physical properties such as gradation, specific gravity and water absorption. The physical properties of coarse and fine aggregates such as gradation, specific gravity and water absorption were determined in the laboratory. The normal consistency, initial setting time and final setting time tests for cement were carried out as per relevant Indian standard. The mix design as per IS : 10262-2009 for concrete of grade M-25 and M-30 was done by using conventional materials for a design slump of 100-125 mm. After that fine aggregates were replaced by copper slag with 10, 20, 30 and 40%, by weight of aggregates in the both mixes. The compressive strength at 7 days and 28 days were determined in the laboratory. The beam specimens were prepared and flexural strength at 28 days was determined for all the mixes as per relevant Indian standards (IS). Hence, total ten concrete mixes as shown in Table 3.1 were prepared and tested.

Table 3.1 Details of Concrete Mixes Prepared

Grade of Concrete	Variation in Copper Slag (% weight of fine aggregates)	Number of Mixes
M-25	0, 10, 20, 30 and 40	5
M-30	0, 10, 20, 30 and 40	5

## Material for Experimental Investigation

- (a) Copper Slag: It was procured from Birla Copper (Riyansh Enterprise.), Dahej (Gujrat).
- (b) Coarse Aggregates: Well graded coarse aggregates (20 mm and 10 mm) were procured from local crusher situated at lonsara (Barwani).
- (c) Fine Aggregate (river sand): It was procured from Narmada River, Barwani.

- (d) Cement: Ordinary Portland Cement of 43 Grade (Ultra tech Cement) was procured.
- (e) Chemical Admixture: Naphthalene Formaldehyde and PCE Mix base (SHALIPLAST HPRACS-2)

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**AUTHOR**

I **Vikas Dhangar**, student of "Master of Engineering" in "Transportation Engineering" discipline(CE),2017-2019, here by declare that the work presented in this dissertation entitled "**Study on Utilization of Copper Slag in Sustainable Construction of Rigid Pavements**" is the outcome of my own work, is bonfire and correct the best of my knowledge and this work has been carried out taking care of Engineering Ethics. My respected guide **Mr Jitendra Chouhan**, Assistant Professor Civil Engineering Department for his valuable guidance, complete technical assistance, critical interruption sand offering many innovative idea sand helpful suggestions, which led to the

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