MANTECH Publications

International Journal of Advance Civil Engineering and Technology
Volume 7, Issue 1, January-June, 2022

An Investigation into the Possibility of Extending Geotechnical Bearing Capacity by Using Industrial Waste

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Abstract

In India, the usage of industrial waste in different engineering projects has become popular. This is required because of the disposal issues involved. Copper slag and silica fume are two of the most often used waste products in the building sector today. Large amounts of these wastes are gathered and deposited on expensive land, resulting in the waste of good cultivable land. Mixing these wastes with existing soil types without entirely removing and replenishing with another soil type can be an inexpensive option for cement mixing and soil stabilization. This study presents a review of existing research studies on the effective use of copper slag and silica fume conducted by various scholars.

Keywords: *Copper Slag, Properties, Soil Stabilization, Waste Utilization, Silica Fume*

INTRODUCTION

In India, the usage of industrial waste in different engineering projects has become popular. This is required because of the disposal issues involved. Copper slag and silica fume are two of the most often used waste products in the building sector today. Large amounts of these wastes are gathered and deposited on expensive land, resulting in the waste of good cultivable land. Mixing these wastes with existing soil types without entirely removing and replenishing with another soil type can be an inexpensive option for cement mixing and soil stabilization. This study presents a review of existing research studies on the

effective use of copper slag and silica fume conducted by various scholars.

Copper Slag

Copper slag (CS) is a waste product produced during the copper smelting process. The extraction of copper slag differs depending on the kind of ore and the purity of the final product. Unwanted elements are physically or chemically removed to get the required slag concentration.

Copper ore is combined with powdered coke and sand in a blast furnace and heated to a high temperature. The furnace is made of steel plates that are coated on the interior with fire clay bricks. Hot air is delivered into the furnace via tuyers at the furnace's base. The upper layer is slag, which is removed, and the lower layer is matte, which is a combination of cuprous sulphide and unaltered ferrous sulphide [1].

Each tonne of copper produced yields around 2-3 tones of copper slag the use of copper slag in soil stabilization can help to alleviate a potentially harmful environmental condition. Copper slag is also commonly used for embankment and structural fill [2].

Fig. 1 Copper slag

Silica Fume

Silica fume is mostly made up of amorphous (non-crystalline) silicon dioxide. It is made in an electric furnace. Quartz, coal, and woodchips are the basic resources. This procedure generates ash, which is collected and sold as silica fume. It is often used in concrete as a mineral additive. It's a grey powder that looks like Portland cement or flies ash.

After environmental concerns forced the collection and disposal of silica fume, it became commercially viable to employ in a variety of geotechnical applications Silica fume concrete flatwork takes less finishing labor than regular concrete. Silica fume concrete with low water content is resistant to chloride ion penetration [3].

Fig. 2 Silica Fume

REVIEW OF RESULTS

By substituting a portion of the cement in concrete, the effect of copper slag may be seen. According to research done by CRRI in New Delhi, fine sand with up to 40% copper slag may be utilized as fine aggregate in both pavement grade concrete and dry lean concrete [4]. In varying quantities, copper slag combined with flash and clayey soil offers efficient results suitable for embankment, sub-base, and base of a road pavement [5]. When copper slag was combined with locally available soil in a proportion of 30% CS and 70% soil, the plasticity index of the soil was lowered by 40% [6]. Table 1 shows the physical parameters of copper slag collected from the Birla Copper Unit, Hindalco's Industries Ltd, Dahej, and Gujarat, India.

TABLE I: Physical Properties of Copper Slag

Property	Value
Specific gravity	3.51
Plasticity index	Non-plastic
Swelling index	Non-swelling
Hardness, Moh’s scale	6-7
Granular shape	Angular, sharp edges
Gravel (%)	1.00
Sand (%)	98.9
Silt + clay	0.05
Colour	Black

The siliceous and silica-aluminous compounds found in copper slag are pozzolanic. They react chemically with calcium hydroxide in the presence of water at room temperature to generate cementitious gels. The addition of copper slag to lime or cement results in calcium-alumina-silicates with outstanding binding properties [7]. A number of studies have been conducted in India and internationally to investigate the impact of copper slag and silica fume as partial substitutes for cement and soil stabilizers, with good findings. Mroueh et al. conducted a life-cycle study for the utilization of industrial waste slag in road building, yielding useful results for the reuse of waste by-products [8]. Enhanced soil containing 35% Cu slag may be utilized as a sub grade material, and the tensile and compressive properties can be significantly improved. The value of the California Bearing Ratio (CBR) can be raised by more than 50% [9].

Copper slag is often utilized in sand drains and sand heaps to substitute sand. The mixing of copper slag with expansive soil has a high potential and is cost-effective [10]. According to studies, copper slag behaves similarly to medium sands and can be utilized as a building material in place of sands, such as retaining wall backfill and landfill for the construction of shallow foundations [11]. Table 2 shows the chemical composition of copper slag.

TABLE II: Chemical Composition of Copper Slag

Property	**(% wt)**
Iron oxide	42-48
Silica	26-30
Aluminium Oxide	1-3
Magnesium Oxide	0.8-1.5

TABLE III: Chemical Composition of Silica Fume

Parameter	Value
Silica	89.9
Total Sulphur Content	0.58
Lime	7.85
Magnesia	4.03
Alumina	-
Iron Oxide	-

The addition of silica fume decreases the development of cracks on the surface of compacted clay samples which reduces the width of crack by 75%. The permeability of soil is increased with an increase in silica fume content [12]. Silica fume can also be used as a non-traditional stabilizer for black cotton soil, which is highly expansive in nature. The chemical composition of silica fume as collected from Shishir Export House, Raipur, Chhattisgarh is presented in table-3.

Increasing the cement percentage of silica fume to 10% raised the unconfined compressive strength of the samples substantially. The optimal proportion of nano silica for cemented sand stabilization was 10% cement content. The optimal moisture content of cemented sand rose as the nano silica concentration increased.

CONCLUSIONS

Copper slag might be used as an additive to improve the qualities of problematic soils. Copper slag is advised for sub grade, sub-base, and bitumen mixtures. Waste of excellent cultivable land may be prevented by using and repurposing industrial waste products such as copper slag and silica fume. Backfilling retaining walls and embankments can be done with soil stabilized by silica fume and copper slag.

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