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Experimental Study on Concrete using Copper Slag as Fine Aggregate with Bacterial Admixture

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Abstract:
This study deals with the replacement of fine aggregate partially by copper slag and bacteria is added as admixture. The bacteria added to the concrete heal the micro crack present in the concrete. Copper slag is used as a substitute for sand; it reduces the cost of fine aggregate. The compressive test is done on hardened concrete after curing to find out the strength of concrete. Slump cone test is made on fresh concrete to determine the workability of the concrete. Bacteria were added to cement in different percentage. Compression test was carried out to evaluate the strength properties of concrete at the age of 7 and 14 days. From the results we conclude that expected strength was obtained

I. INTRODUCTION

In the present scenario carbon emission and sand mining are major concern due to its hazardous effect to environment and making serious imbalance to the ecosystem. Copper slag is one of the materials that can be considered as a waste material which could have a promising future in construction industry as partial or full substitute of any two either cement or aggregates. Copper slag is a by-product of copper extraction by smelting. During smelting, impurities become slag which floats on the molten metal. Sterlite Industries India Ltd (SIIL) is planning to convert a waste product of its copper smelting plant at Tuticorin – copper slag — into an alternative material for concrete applications. The company has already started supplying the material to cement manufacturers and now wants to focus on road, abrasives and other industries. The Tuticorin plant of Sterlite has a capacity of 400,000 tonnes per annum and the company plans to double it with an investment of Rs 2,500 crore. The key raw material for copper smelter is copper concentrate which mainly consists of copper, iron and sulphur. During the smelting operation, iron is removed as iron silicate, which is known commonly known as copper slag (Ferro sand).As per scientific estimate, for every ton of copper metal produced, around 1.8-2.2 tonnes of slag is generated, Sterlite Industries India Ltd."With increasing scarcity of river sand and natural aggregates across the country, construction sector is under tremendous pressure to explore alternative to these basic construction material to meeting growing demand of infrastructure demands," he said.In states like Kerala, Maharashtra and Gujarat, sand mining in rivers has already been banned owing to its disastrous impact ecology. "Therefore, slag has a big potential of getting developed as a suitable alternative material to these resources. It is a new business avenue for us and we are going to make revenue out of waste," At present, across the world around 33 ton of slag is generated while in India three copper producers Sterlite, Birla Copper and Hindustan Copper produce around 6-6.5 tonnes of slag at different sites.

A. Advantages of Bacterial Concrete

- Self-repairing of cracks without any external aide.
- Significant increase in compressive strength and flexural strength when compared to normal concrete.
- Resistance towards freeze-thaw attacks.
- Reduction in permeability of concrete.
- Reduces the corrosion of steel due to the cracks formation and improves the durability of steel reinforced concrete.
- Bacillus bacteria are harmless to human life and hence it can be used effectively.

B. Disadvantages of Bacterial Concrete

- Cost of bacterial concrete is double than conventional concrete.
- Growth of bacteria is not good in any atmosphere and media.
- The clay pellets holding the self-healing agent comprise 20% of the volume of the concrete. This may become a shear zone or fault zone in the concrete.
- Design of mix concrete with bacteria here is not available any IS code or other code.
- Investigation of calcite precipitate is costly.

II. FRESH CONCRETE TESTING

Fresh concete is a freshly mixed material which can be mould into any shape. The relative quantity of cement, fine aggregate, coarse aggregate and water mixed together control the properties of concrete in wet state. In this the properties of concrete deals this called workablity. Workability is the ability of a fresh concrete mix to fill the form/mould properly with the desired vibration and without reducing the concrete quality. Workability depends on water content, aggregate (shape and size distribution), cementitious content and age. Raising the water content or adding chemical increases concrete workability. Excessive water leads to increase bleeding (surface water) and/or segragation (when the cement and aggregates start to separate), with the resulting concrete having reduced quality. The use of an aggregate with an undesirable gradation can result in a very low slump, which cannot be readily made more workable by addition of resonable amounts of water. Workability can be measured by the concrete slump test. Slump is normally measured by filling an "Abrams cone" with a sample from a fresh batch of concrete. The cone is placed with the wide end down onto level, non-absorptive surface. It is then filled in three layers of equal volume, with

each layer being tampes with a steel rod to consolidate the layer. When the cone is carefully lifted off, the enclosed material slumps very little, having a slump value of one or two inches (25 or 50mm) out of one foot (305mm). A relatively wet concrete sample may slump may slump as much as eight inches.

Factors affecting workability:

- Water content
- Mix proportion
- Size of aggregate
- Shape of aggregate
- Grade of aggregate
- Use od admixture

Measurement of workability

- Slump test
- J-ring test
- V-funnel test

A. SLUMP VALUE

Table.1. Slump value result for 20% copper slag

SI.NO	PERECNTAGE OF BACTERIA	BACTERIA IN ml	SLUMP VALUE AT 20% OF COPPER SLAG AS FINE AGGREGATE IN mm
1	0%	0 ml	75
2	1%	60 ml	87
3	3%	180ml	98

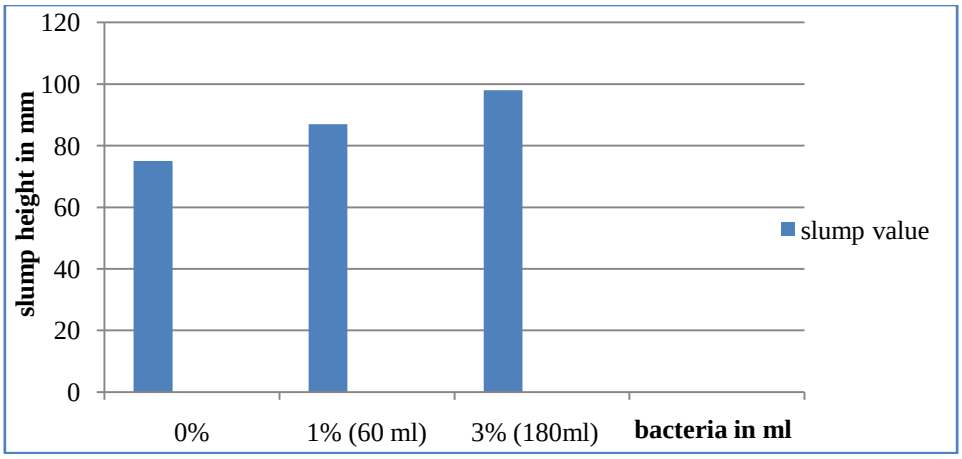

Figure.1. Shows the slump value result 20% copper slag

Table.2. Slump value result for 40% copper slag

S.NO	PERECNTAGE OF BACTERIA	BACTERIA IN ml	SLUMP VALUE AT 40% OF COPPER SLAG AS FINE AGGREGATE IN mm
1	0%	0 ml	70
2	1%	60 ml	80
3	3%	180ml	86

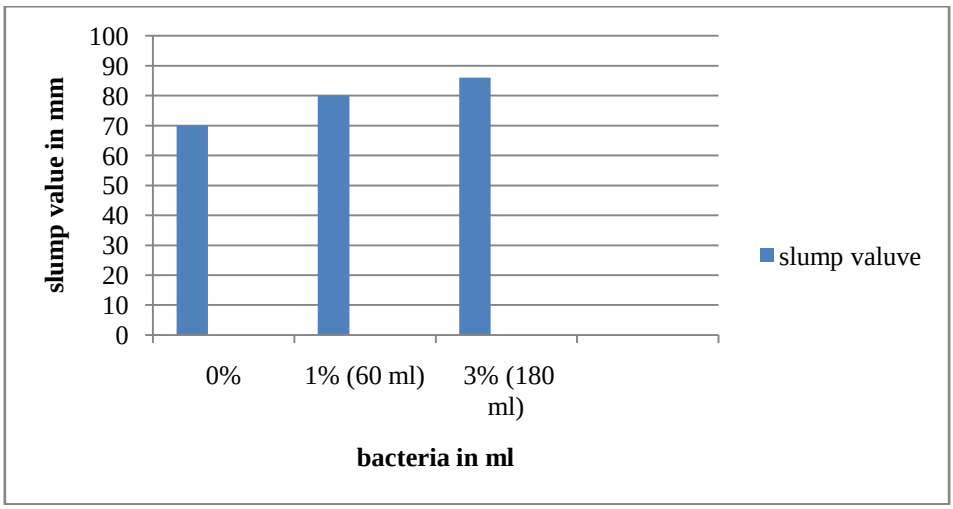

Figure.2. Shows the slump value result for 40% copper slag

Table.3. Compressive strength of concrete with 20% copper slag after 7 days curing

S.NO	BACTERIA		REPLACEMENT OF COPPER SLAG	7 DAYS CURING	
	%	ml		LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)
1	0	0	20%	200	8.88
2	1	60	20%	295	13.11
3	3	180	20%	325	14.44

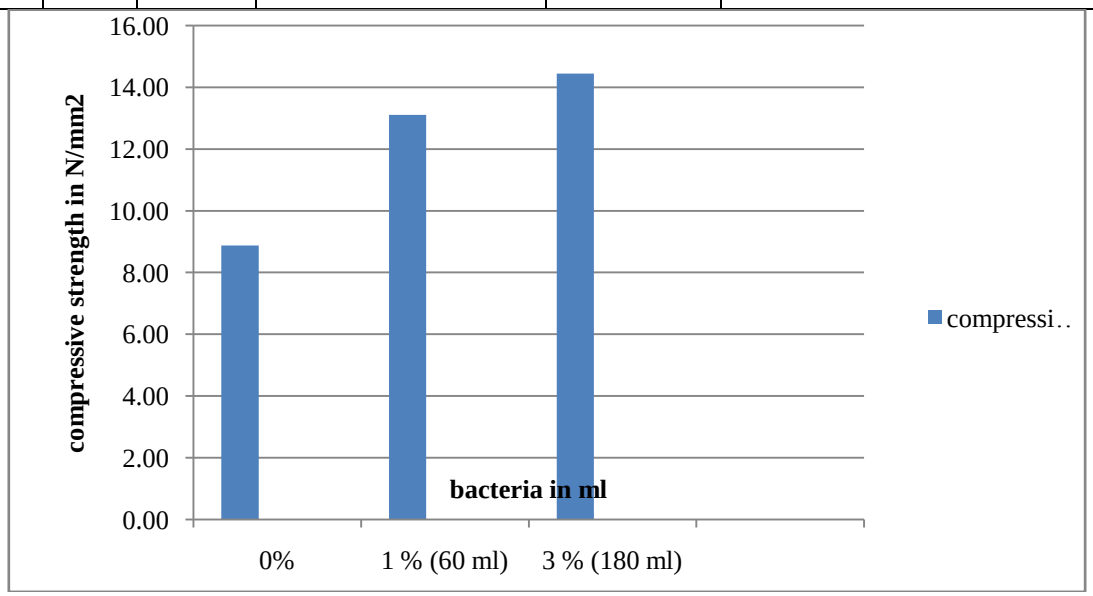

Figure.3. Shows the compressive strength of concrete with 20% copper slag after 7 days curing

Table .4. Compressive strength of concrete with 40% copper slag after 7 days curing

S.NO	BACTERIA		REPLACEMENT OF COPPER SLAG	7 DAYS CURING	
	%	ml		LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)
1	0	0	40%	395	17.55
2	1	60	40%	425	18.88
3	3	180	40%	475	21.11

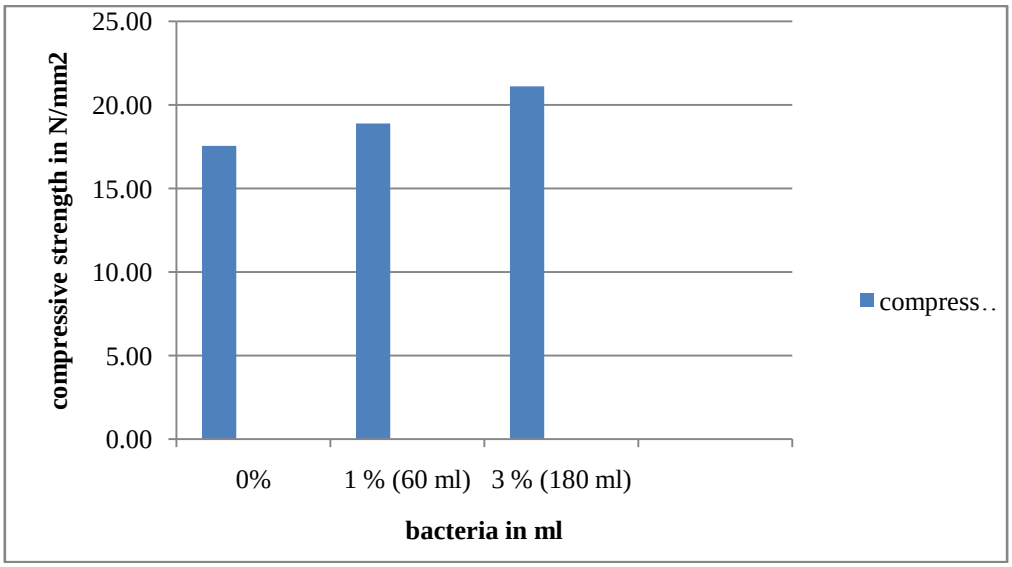

Figure.4. Shows the compressive strength of concrete with 40% copper slag after 7 days curing

Table .5. Compressive strength of concrete with 20% copper slag after 14 days curing

S.NO	BACTERIA		REPLACEMENT OF COPPER SLAG	14 DAYS CURING	
	%	ml		LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)
1	0	0	20%	450	20
2	1	60	20%	480	21.33
3	3	180	20%	550	24.44

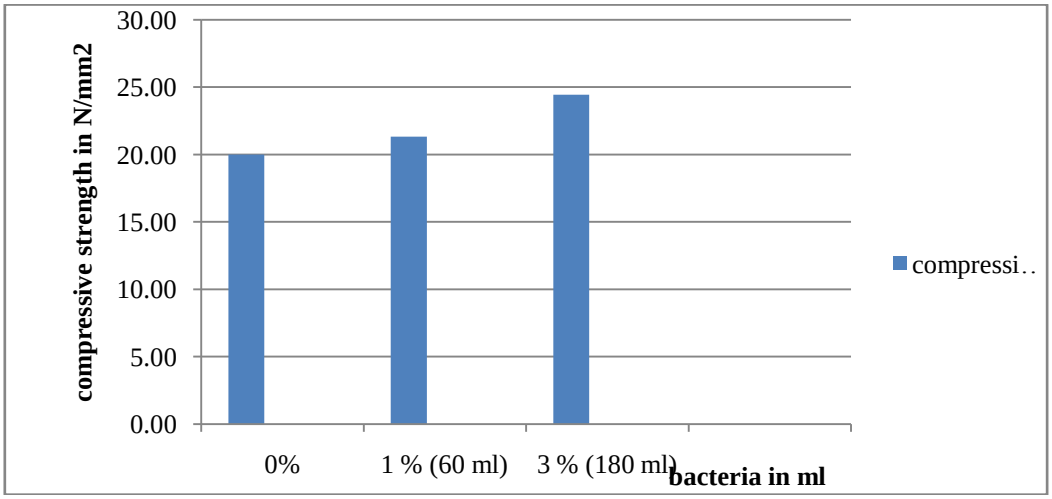

Figure.5. Shows the compressive strength of concrete with 20% copper slag after 14 days curing

Table .6. Compressive strength of concrete with 40% copper slag after 14 days curing

S.NO	BACTERIA		REPLACEMENT OF COPPER SLAG	14 DAYS CURING	
	%	ml		LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)
1	0	0	40%	520	23.11
2	1	60	40%	550	24.44
3	3	180	40%	580	25.77

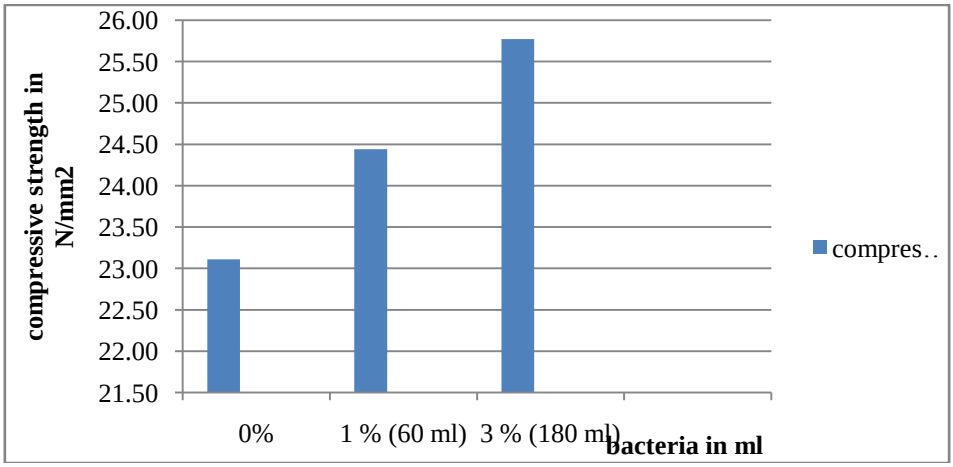

Figure.6. Shows the compressive strength of concrete with 40% copper slag after 14 days curing

III. CONCLUSION

Based on the investigations, the following conclusions were drawn. The utilization of copper slag in concrete provides additional environmental as well as technical benefits for all related industries. Partial replacement of copper slag in fine aggregate and cement reduces the cost of making concrete. The initial and final setting time of copper slag admixed concrete is higher than control concrete. Water absorption of copper slag was 0.16% compared with1.25%for sand. This was attributed to the low water absorption and glassy surface of copper slag. The results of compressive strength test have indicated that the strength of concrete increases with respect to the percentage of copper slag added by the weight of fine aggregate. The addition of bacteria also results in the increase of compressive strength the more amount of bacteria added it increases the value of compressive strength to more extent. In this study we added the bacteria at rate of 0%, 1% and 3% to the weight of

the cement and we conclude that by addition of copper slag and bacteria in concrete we can increase the compressive strength of the concrete. More amount of bacteria addition increases the workability of the concrete.

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