An Experimental Investigation on Different Types of Slags in Partial Replacement in Cement

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ABSTRACT:

In India, the preparation of Portland bond was initiated around the year 1912. The startingwas not exceptionally encouraging and development of bond industry was moderate. At the season of freedom in 1947, the introduced limit of cement plants in India was roughly 4.5 million tons and real creation around 3.2 million tons for every year. The huge development movement attempted amid the different 5 years designs predominantly amid the required the development of concrete industry. However, the five-year plans envisaged for Multi-purpose projects and also for rapid industrial growth remained stinteddue to the complete control exercised by the Government over the cement industry. As the infra structure sector was developing during 1980's prompted the various industrial organizations were interested for setup new cement plants in the country. The full liberalization on cement industry in 1988 further provided rapid expansion for the growth.

Concrete is highly used construction material and, in that cement, plays a major role in bonding and due to its huge usage, the natural resources are getting depleted, hence it is time tosearchforalternativematerialforcement.In that direction, the current research involves multi-material combination i.e., copper slag, steel slag, and GGBS slag. Initially individual influence of material is elevated later the combination of material is done with different proportions. The optimum proportions will be considered for all mechanical properties.

I. INTRODUCTION

Concrete is the most commonly used construction material; its usage by the communitiesacrosstheglobeissecondonlyto water. Customarily, concrete is produced by using the Ordinary Portland Cement (OPC) as the binder. The usage of OPC is on theincrease to meet infrastructure developments. The world-wide demand for OPC would increasefurtherinthefuture.Itiswell-known that cement production depletes significant amount of natural resources and releases large volumesofcarbon-dioxide.Cementproduction is also highly energy-intensive, after steel and aluminium. On the other hand, coal burning power generation plants produce huge quantities of GGBS and some of the materials which are byproducts. The volume of fly ash would increase as the demand for power increases. Most of the fly ash is considered as waste and dumped in landfills. In order to address the issues mentioned above, it is essential that other forms of binders must be developed to make concrete.

The global use of concrete is second only to water. As the demand for concrete as a construction material increases, so also the demand for Portland cement. Concrete is a durable construction material produced by mixing Portland cement, water, aggregates and additives with special proportion. Revising the ingredients and production method of conventionalconcreteisimportantwithrespect to high consumption of concrete as a construction material. High consumption of concrete causes vast requirements of cement production. Production of every one tonne of OPC emits about one tonne of carbon dioxide (CO2) into the atmosphere, causing global warming. Statistics expose that the Cement industry constitutes about 5 % of the total emission of green house gases (GHG) in India. Every one tonne of OPC requires 1.2 to 1.5 tonnes of lime stone as raw material andaround 0.2 tonnes of coal as fuel for burning, causing depletion of natural resources. The energy requirements for manufacturing one kg cement are 750 Kcal (thermal) and 85 Kcal (electrical), which is exacting the energy sources. Therefore, an effective way to reduce the adverse environmental impacts of concrete without affecting its engineering properties isto reduce the amount of OPC in concrete. Use of mineral admixture with OPC in ternary blend cement system as a binder is an effective and practical way to achieve this objective.

On the other hand, the climate change due to global warming and environmental protection has become major concerns. The global warming is caused by the emission of greenhouse gases, such as carbon dioxide (CO_2), to the atmosphere by human activities. Among the greenhouse gases, CO_2 contributes about 65% of global warming. The cement industry is held responsible for some of the CO_2 emissions, because the production of one ton of Portland cement emits approximately one ton of CO_2 into the atmosphere. The environment must be protected by preventing dumping of waste/by-product materials in un- controlled manners.

NECESSITY OF ALTERNATIVE MATERIALS

Pozzolanic material that is defined as siliceous or siliceous and aluminous material which in itself possesses very little cementitious value, chemically react with Calcium Hydroxide (lime) in presence of water at normal temperature and form soluble compound includes cementitious property similar to cement. concrete is generally normal concrete or very conventional concrete is made up of cement plus water plus water, this two makes paste, sand which are, which we called as fine aggregate, could be sand or crushed stone powder. Then stones which forms are course aggregates. So, that is generally the concrete normal concrete. But a modern concrete is not only this four components, but it has definitely two more components. So, modern engineered concrete has additional ingredients other than the four components

OBJECTIVE

In order to achieve the scope of this study, the following aims have to be met:

- GGBS, Copper slag, Steel Slag are usedaspartialreplacementofcement.
- In the present experimental investigation, the cement is partially replaced by 0, 5, 10, 15, 20, 25 and 30% of GGBS, Copper slag, Steel Slag by weight.
- The influence of combinedapplication of GGBS, Copper slag, Steel Slag on compressive strength, Spilt tensile and flexure strength of M30gradeofconcreteisinvestigated.
- This work continues with testing of concrete specimens in addition with combined application of GGBS, Copper slag, Steel Slag formechanical properties
- Curing was done at the ages of 7, 14 and 28 days were tested i.e. compression,splittensilestrengthand flexural strength tests.Optimumproportionsareconsidered and combination will be done
- GGBS-5,10,15,20,25and30
- Copperslag-5,10,15,20,25and30
- STEELSlag-5,10,15,20,25and30
- GGBSSLAGARECONSTANT FOR 5%
- GGBS+COPPERSLAG,5+10,5+15,
  5+20,5+25and5+30
- GGBS+STEELSLAG,5+10,5+15,
  5+20,5+25and5+30

II. LITERATUREREVIEW

1. **Fruehan,.**The main concern related to the acceptance of steel slag for concreteproduction is the presence of free lime or free magnesia which undergoes chemical reactions with the water, causing volume deformations, hence leading to development of internal stress within the concrete. The steel slag before usein concrete structures should contain minimal possiblequantityoffreelimeormagnesia,also displaying volumetric stability. The reduction in the free lime or magnesia content in steel slag aggregates may be achieved by subjecting the aggregates to weathering for six months or more.
2. **Shoya et al.**reported because of the heavy specific weight and glass-like surfaceproperties with irregular grain shape, the more the volume fraction of copper slag as a fine aggregate, the greater the bleeding. Although the use of copper slag in concrete production has attracted considerable attentions in the past years, it is still not clear about the optimum content of copper slag to be used as a fine aggregate. The objective of this study is to determine the optimum content of copper slag replacementasafineaggregateinSingaporeto achieve a high strength concrete with performance similar to or surpassing that of conventional sand concrete. Mechanical properties such as workability, quasi-static and dynamic compressive strength, flexural and tensile splitting strength are evaluated by experimental studies. The microscopic view is also conducted to estimate the effect of copper slag as a substitution of sand on the Micro structure of theconcrete. Finally the optimum content of copper slag replacement in high strength concrete production is discussed and recommended.
3. **Gopalakrishnan S**It is well documented that the early strength of the GGBS-blended concrete is adversely affected; the strength development of the concrete improves at later ages, matching the compressive strength of OPC concrete at 56 days onwards.
4. **Maslehuddin, et al,** compared steel slag and crushed limestone aggregate. They studied the mechanical properties and durability characteristics of steel slag aggregate concrete in assessment with limestone aggregates. Abrasion resistance, specific gravity, water absorption, chemical soundness, alkalinity, concentration of chloride and sulfates were tested and compared with lime stone aggregates. Shrinkage and expansion characteristics of steel slag and sand cement mortar specimens were evaluated and length was measured at periodic intervals. Compressive strength of steel slag aggregates increased with the proportion of coarse aggregates from 31.4MPa with 45% coarse aggregates to 42.7MPa with 65% coarse aggregates. The flexural strength and split tensile strength also increased while the water absorption capacity was reduced. Shrinkage of steel slag exposed to a dry environment was similar to limestone aggregate.

III. METHODOLOGY

Inmakinganytypeofconcrete,selectionand type of materials is very important as all the properties depends on them. Thefollowingmaterialsarebeingusedandare listed below.

- Cement
- Fineaggregate(sand)
- Coarseaggregate
- Water
- GGBS
- Copperslag
- Steel Slag
- CONMIXSP

Cement

Themostwidelyrecognizedbondutilizedisan Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 53 review (OPC) fitting in with IS: 8112-1989 is utilized. Abondisafastener,asubstanceutilizedasapart of development that sets, solidifies and clings todifferentmaterials,restrictingthemtogether.

Fig.:.Cement

Table:PropertiesofCement.

S.No.	CHARACTERISTICS	VALUE
1	SPECIFICGRAVITY	3.15
2	NORMAL CONSISTENCY	31%

Aggregates

Aggregates are idle granular materials, for example, sand, rock or squashed stone that are a finished result in their own right

- CoarseAggregate
- FineAggregate

- **Coarse**aggregatesareparticulates that are greater than 4.75mm. The usual range employed is between 9.5mmand37.5mmindiameter.

- **Fine**aggregatesareusuallysandor crushed stone that are less than 9.45mmindiameter

Table:PropertiesofFineAggregate.

S.No.	CHARACTERISTICS	VALUE
1	ZONE	II
2	SPECIFICGRAVITY	2.64
3	DENSITY	$14KN/m^3$
4	WATERABSORPTION	2.1%

Table:.PropertiesofCoarseAggregate.

S.No.	CHARACTERISTICS	VALUE
1	NOMINALSIZE	10mm
2	SPECIFICGRAVITY	2.84
3	DENSITY	$1625.83Kg/m^3$
4	WATER ABSORPTION	2.4%

Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helpsto from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully.

Slagin Cement:

In India around 2,069,738 a large number of metric huge amounts of CO2 is produced inthe time of 2010. The concrete business contributes around 5% of aggregate worldwide carbon dioxide emanations.

GroundGranulatedBlastFurnaces(GGBS)

Ground-granulated impact heater slag (GGBS orGGBFS)isgottenbyextinguishingliquid

iron slag (a side-effect of iron and steel- production) from a shoot heater in water or steam, to deliver a lustrous, granular item that is then dried and ground into a fine powder. These work at a temperature of around 1500 degrees centigrade and are encouraged with a deliberately controlled blend of iron mineral, coke and limestone. The iron metal is lessened to press and the rest of the materials from aslag that buoys over the iron.

Fig.:GGBS

Table..Physicalpropertiesof GGBS

PROPERTIES	VALUES
Particlesize	0.1to microns
Specificsurface area	400-600m^2/kg
Relativedensity	2.85-2.95
pH(T=20 ºC)	1.0-1.1 tonnes/m^3
Specificgravity	2.9

Copperslag

The slag is a black glassy and granular innature and has a similar particle size range of sand which indicates that it could be tried as replacement with sand in cementationsmixture. The other main advantage of using Copper slag (a waste material) is to reduce the cost of construction. (Al-Jabri et al 2009).

Fig.:Copperslag

Table:PhysicalPropertiesofcopperslag

S.NO	PARTICULARS	RESULTS
1	Type	Aircooled
2	Appearance	Blackandglassy
3	Particleshape	Irregular
4	Specificgravity	2.82
5	Finenessmodulus	3.18

Steel slag

Inthepresentinvestigation,crushed steel slag aggregate of 20mm size was used. Thespecificgravityofsteelslagis3.45.The physicalpropertiesofsteelslagareshownin table

Table:PhysicalPropertiesofsteelslag

S.NO	PARTICULARS	RESULTS
1	Type	powder
2	Specificgravity	3.25
3	Waterabsorption	1.87

FigSteelSlag

IV. EXPERIMENTALRESULTS

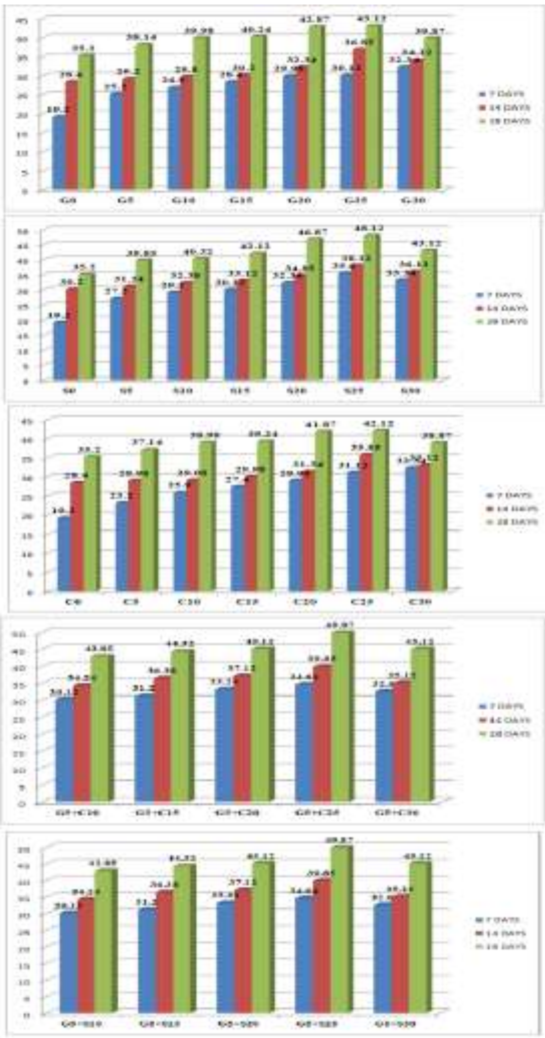
The following are the strength tests which was conducted in the project:

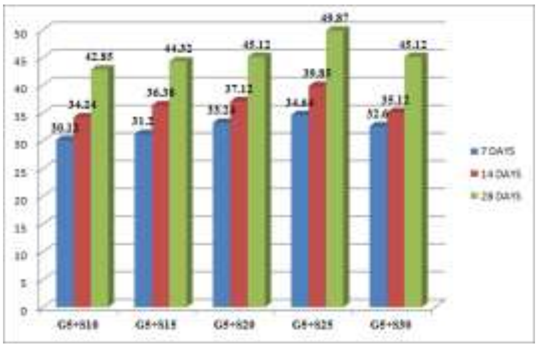
- Compressivestrengthtest
- Splittensilestrengthtest
- Flexuralstrengthtest
- The results completed in the present investigation are reported in the form of Tables and Graphs for various percentages, in the present experimental investigation, thecement is partially replaced by 0, 5, 10,15,20,25and30%ofGGBS, Copper slag, Steel Slag and byweight**.**

COMPRESSIONTESTRESULTS

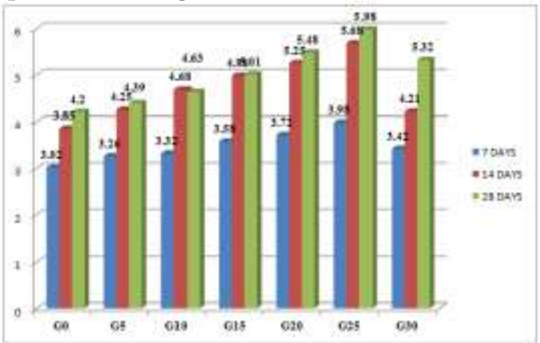
The cubes were casted in the concrete technologylaboratoryandweretestedon7,14 and 28 days and the results obtained were as follows

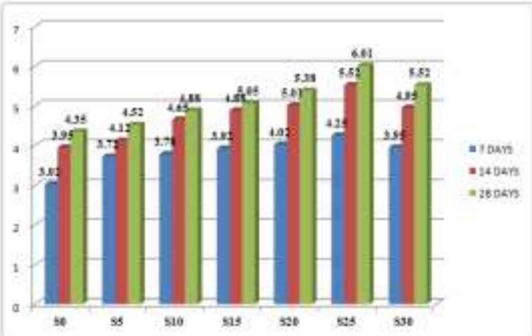
CompressiveStrengthTestResults

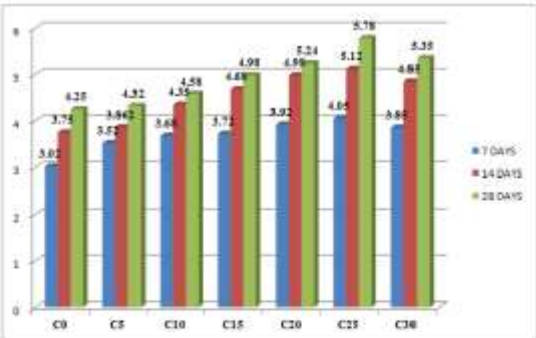


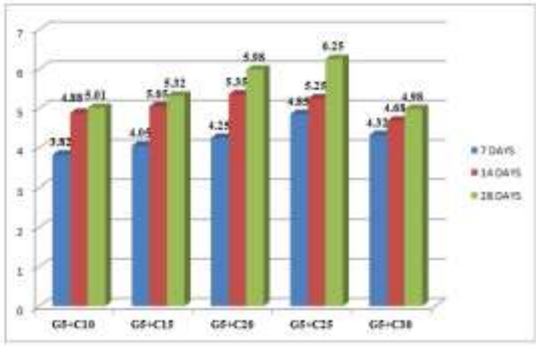


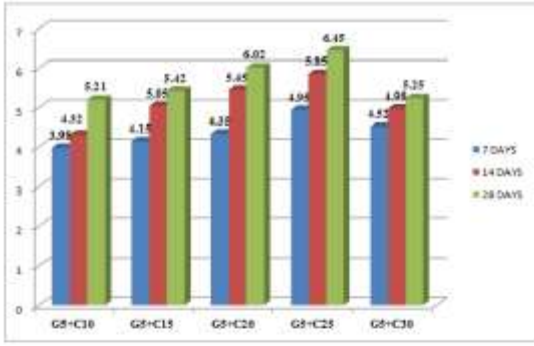
Splittensilestrengthtestresults

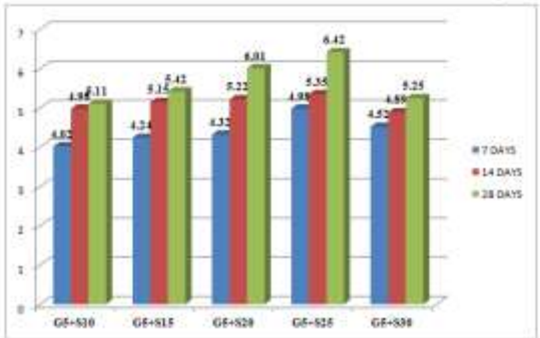


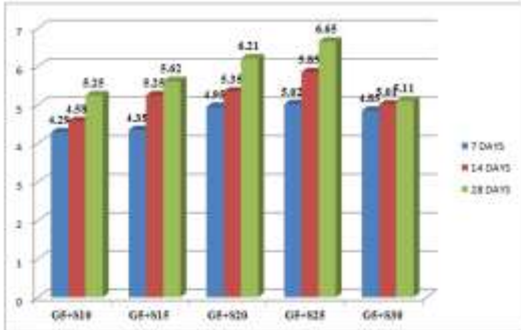




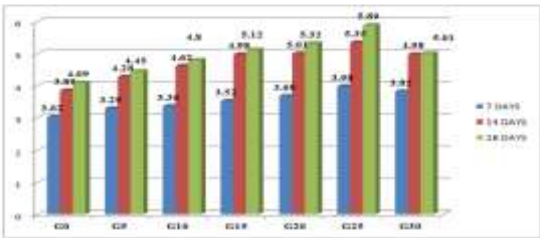


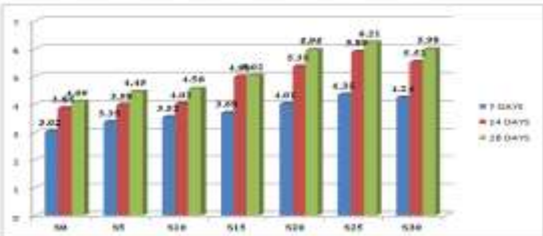


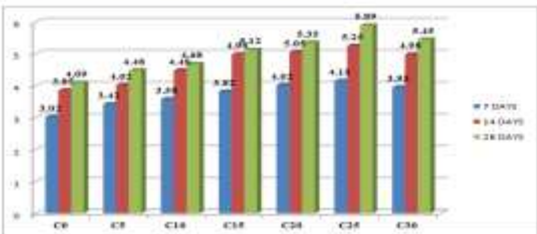




FlexureStrengthTestResults







V. CONCLUSIONS

In order to achieve the scope of this study, the following are the conclusions we drawn:

- In the present experimental investigation, the cement is partially replaced by 0, 5, 10, 15, 20, 25 and 30% of GGBS, Copper slag, Steel Slag by weight.
- The influence of combinedapplication of GGBS, Copper slag, Steel Slag on compressive strength, Spilt tensile and flexure strength of M30gradeofconcreteisinvestigated.
- This work continues with testing of concrete specimens in addition with combined application of GGBS, Copper slag, Steel Slag formechanical properties
- Curing was done at the ages of 7, 14 and 28 days were tested i.e. compression, 28 days for split tensile strength and flexural strength tests.
- The proportions are considered with cement replacement as GGBS- 5,10,15,20,25 and 30% optimum compressive strength

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