

# Experimental Investigation of M35 Grade Self Compaction Concrete by Partial Replacement of Metakaolin in Place of Cement and Cuppola Slag with Coarse Aggregate

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**Abstract**— The simplest way of getting aggregate is from naturally available sources. Excavation of rocks from valley which is generally produces worst environmental impacts. Cutting and screening out of coarse aggregate makes the conventional concrete more costly and scarce due to small sized limited quantity of natural materials which is used. Cupola slag can be used in construction industry as replacement of coarse aggregate. Cupola slag is the by- product of cast iron manufacturing, produced when molten steel is separated from impurity in cupola furnace. Cupola slag is replaced with coarse aggregate and Metakaolin is replaced with cement with optimum percentage of replacement to check the suitability of concrete to Mechanical properties, Durability, Workability and Environmental feasibility.

In this project, Metakaolin is replaced with cement and Cupola slag is replaced with coarse aggregate are studied. The physical properties of cupola slag and coarse aggregates are similar and physical properties of Metakaolin and cement are similar. Both materials are eco- friendly building material. The problem of the disposal and maintenance problem of land filling is reduced. This study investigates the performance of concrete mixture in terms of Compressive strength, split tensile strength and flexural strength for 7, 28 and 56 days respectively of M-35 grade concrete. This project deals with the self- compacting concrete where the replacement OPC by Metakaolin were 5%, 10%, 15% and 20% by weight and Cupola slag by weight of Coarse Aggregates in various percentages such as 15%, 20 %,30%, 45%, 60%.

**Keywords:** Cupola slag, Metakaolin, Durability, Workability, Environmental feasibility, Compressive strength, Split tensile strength, Flexural strength.

## I. INTRODUCTION

At present, development in India is mainly by implementation of infrastructure projects. Due to that construction projects are executed at very rapid rate.

In the developing country like India, availability of natural resources is also an influencing factor apart from funding due to this rapid infra- structural growth it requires large amount of construction material like cement, aggregate ,wood etc. R.C.C. structures are preferred over steel structures in India which requires larger quantity of concrete. Since availability of natural resources of concrete is limited as we get it from natural deposits at present, there is a need to develop a new material that can effectively replace with conventional without compromising with strength and durability properties of concrete.

Concrete is the most widely used man made construction material in civil engineering world. As the demand for concrete as a construction material increased, the world production of cement has greatly increased since 1990. The global warming is caused by the emission of greenhouse gases such as CO<sub>2</sub> to the atmosphere by human activities. Among the greenhouse gases, CO<sub>2</sub> contributes about 65% to global warming. The cement industry is responsible for about 6% of all CO<sub>2</sub> emissions, because the production of one tonne of Portland cement emits approximately 0.9 tonne of CO<sub>2</sub> into the atmosphere. Although the use of Portland cement is still unavoidable until the anticipated future, many efforts are being made in order to reduce the use of Portland cement in concrete.

### 1.1 CUPOLA SLAG

Cupola furnaces were built in China as early as the Warring States period, although Donald Wagner writes that some iron ore melted in the blast furnace may have been cast directly into moulds' modern cupola furnace was made by French scientist and entomologist René- Antoine Ferchault de Reaumur around 1720.

Cupola slag is a by-product material which is gathered from cast iron, pig iron, and steel manufacturing unit. It is produced by action of various fluxes upon gangue materials within the iron ore during the process of pig iron making in blast furnace and steel manufacturing in steel melting shop and during melting of cast iron in cupola furnaces. The slag occurs as a molten liquid which solidifies upon cooling. Primarily, the slag consists of calcium, magnesium, manganese and aluminium silicates in various combinations and it is a complex solution of silicates and oxides.



Fig -1: 20mm Lump sized of Cupola Slag aggregate

## 1.2 METAKAOLIN

General the raw material in the manufacture of Metakaoline is kaolin clay. Kaolin is a fine, white, clay mineral that has been traditionally used in the manufacture of porcelain. Kaolins are classifications of clay minerals, which like all clays, are phyllosilicates, i.e. a layer silicate mineral. The Meta prefix in the term is used to denote change. In case of Metakaolin, the change that is taking place is dehydroxylation, brought on by the application of heat over a defined period of time. Dehydroxylation is a reaction of decomposition of kaolinite crystals to a partially disordered structure. The results of isothermal firing show that the dehydroxylation begins at 420°C. At about 100 - 200°C clay minerals lose most of their adsorbed water. The temperature at which kaolite loses water by dehydroxylation is in the range 500-800°C.

This thermal activation of a mineral is also referred to as calcining. Beyond the temperature of dehydroxylation, kaolinite retains two dimensional orders in the crystal structure and the product is termed Metakaolin. Metakaolin is neither the by-product of an industrial process nor is it entirely natural. It is derived from naturally occurring mineral and is manufactured specially for cementing applications. Metakaolin is produced under carefully

controlled conditions to refine its colour, remove inert impurities, and tailor particle size such, a much high degree of purity and pozzolanic reactivity can be obtained. Metakaolin is white, amorphous, highly reactive aluminium silicate pozzolan forming stable hydrates after mixing with lime stone in water and providing mortar with hydraulic properties.

Heating up of clay with kaolinite  $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$  as the basic mineral component to the temperature of 500 - 600°C causes loss of structural water with the result of deformation of crystalline structure of kaolinite and formation of an unhydrated reactive form so called metakaolinite.



Fig -5: Metakaolin

## II. LITERATURE REVIEW

1. Pranita Bhandari, K. M. Tajne et al. (2016) they research was carried out to produce a low-cost concrete. An experimental investigation was carried out on a concrete containing waste foundry sand in the range of 0%, 10%, 20%, 30%, 40%, 60%, 80% and 100% by weight for M25 grade concrete. The concrete containing foundry sand was tested and compared with conventional concrete in terms of workability, compressive strength and acid attack. Cubes were casted and compression test was performed on 3rd, 7th and 28th day for mix of 1:1.01:2.5 at a w/c of 0.4. Through experimental result they conclude that after 20% partial replacement of foundry sand the compressive strength decreases with increase in partial replacement of waste foundry sand. The aim of this research is to know the mechanical properties of concrete after adding optimum quantity of waste Foundry sand in different proportion.

2. Sarita Chandrakanth, Ajay. A. Hamane et al. (2016) they identifies a potential use of wastes from foundry industry and construction industry for utilization in construction industry and represents the experimental investigation on utilization of foundry

waste as a partial replacement of natural sand by 0%, 20%, 40%, 60% and recycled aggregate as a partial replacement of natural coarse aggregate by 0%, 20%, 40% and 60%. Concrete mixtures were produced, tested and compared in terms of strength with the conventional

concrete. These tests were carried out to evaluate the strength for 7 and 28 days. It is found that compressive strength of concrete mix is increases with increase in percentage of waste foundry sand and recycled aggregate as compare to normal concrete. It was maximum for 40% replacement after that it reduces.

It is also found that split tensile strength increases with increase in percentage of waste foundry sand and recycled aggregate up to 40% replacement after that it reduces. It is also found that flexural strength increases with increase in percentage of waste foundry sand and recycled aggregate up to 40% replacement after that it reduces. Average compressive strength at 28days increased by 3.96%, 8.857% & 5.37% at as compared to conventional concrete. Average split tensile strength at 28days increased by 9.3088%, 22.07% & 7.048% at 28 days as compared to conventional concrete. Average flexural strength at 28days increased by 21.29%, 28.07% & 15.93% as compared to conventional concrete.

3.Amitkumar D. Raval, Arti Pamnani, Alefiya I. Kachwala et al. (2015) they research was carried out in this study, effect of foundry sand as fine aggregate replacement on the compressive strength of concrete with a M25 mix proportion investigated at different limited curing periods (7 days, 14 days and 28 days). The percentage of foundry sand used for replacement were 10%, 20%, 30%, 40% and 50% by weight of fine aggregate. Test showed impressive results, showing capability of foundry sand for being a component in concrete for imparting strength. Making concrete from recycled materials saves energy and conserves resources which lead to a safe sustainable environment.

The increase in strength parameters may be due to fineness of the foundry sand. The foundry sand fineness is higher than fine aggregate and reduces the porous nature in concrete thereby increasing density and strength. But reduction in compressive strength of concrete specimen with replacement percentage beyond 30 % is attributed to binders present in foundry sand, composed of very fine powder of clay and carbon, which results in a weak bond between

cement paste and aggregate. Making concrete using recycled materials (foundry sand) saves energy and conserve primary resources and it is concluded that the more material was reused, the fewer resources were consumed which leads to a safe, sustainable environment.

### III. EXPERIMENTAL WORK ON SCC

#### 3.0 GENERAL

The present chapter deals with the materials properties and the results obtained from the various tests conducted on the material used for the development of M35 grade of concrete mix with various percentages of Metakaolin as partial replacement of cement and cupola furnace slag as partial replacement of coarse aggregates. The inherent high pozzolanic reactivity of Metakaolin adds to the strength factor when mixed with cement concrete partially replacing cement even at higher strengths. In order to achieve the objective of the present study, an experiment was conducted to determine the compressive strength, split tensile strength and flexural strength of concrete specimens made by using the prescribed materials in designed proportions. Experimental study is carried out to investigate the strength variations in concrete. The experimental procedure has been planned to determine the effect of metakaolin and cupola slag on the compressive, split tensile and flexural strength of concrete. The experimental program has been planned and carried out in three stages.

Stage I: Procurement of materials and its testing  
Stage II: Moulding of specimens and curing  
Stage III: Testing of specimens

#### 3.1 PROCUREMENT OF MATERIALS & ITS TESTING

The materials used in the experimental investigation are locally available cement, sand, coarse aggregate, mineral and chemical admixtures. The chemicals used in the present investigation are of commercial grade. 3.1.1 Cement Ordinary Portland cement of 53 grade [IS: 12269-1987, Specifications for 53 Grade Ordinary Portland cement] has been used in the study. It was procured from a single source and stored as per IS: 4032 - 1977. Care has been taken to ensure that the cement of same company and same grade is used throughout the investigation. The cement thus obtained was tested for physical properties in accordance with the IS: 12269 - 1987.

3.1.1.CEMENT

Selection of the type of cement will depend on the overall requirements for the concrete, such as strength, durability, etc. C3 content higher than 10% may cause problems of poor workability retention.

- The typical content of cement is 350-450 Kg/m<sup>3</sup>.
- More than 500 Kg/m<sup>3</sup> cement can be dangerous and increase the shrinkage.
- Less than 350 Kg/m<sup>3</sup> May only is suitable with the inclusion of other fine filler, such as fly ash, pozzolana, Metakaolin, silica fuma etc.

Table 3.1 shows the physical characteristics of Ultra-Tech (53 Grade) cement used, tested in accordance with IS:4031-1988 [Methods of physical tests for hydraulic cement].

S. No	Property	Test Method	Test Results	Specificati on in IS 12269-2013
1.	Normal Consistency	Vicat Apparatus (IS:4031 Part-4)	28.5%	26%-32%
2.	Specific Gravity	Sp. Gr Bottle (IS:4031 Part-4)	3.15	
3.	Initial Setting Time	Vicat Apparatus (IS:4031 Part-4)	53 minutes	Not less than 30 minutes
	Final Setting Time		493 Minutes	Not less than 10 hours
4.	Fineness	Sieve test on sieve no.9 (IS: 4031 Part -1)	5%	10%
5.	Soundness	Le-Chatlier method (IS: 4031 Part-3)	3mm	Not more than 10mm

3.1.2. FINE AGGREGATES

All normal concreting sands are suitable for SCC, both crushed or rounded sands can be used. Siliceous or calcareous sands can be used. The amount of fines less than 0.125 mm is to be considered as powder and is very important for the rheology of the SCC. A

minimum amount of fines (arising from the binders and the sand) must be achieved to avoid segregation. The fine aggregate used was locally available river sand without any organic impurities and conforming to IS: 383 - 1970 [Methods of physical tests for hydraulic cement]. The fine aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386 - 1963 [Methods of test for aggregate for concrete] and is shown in Table 3.2. The sand was surface dried before use.

I.S. Sieve (mm)	Percentage Passing I.S. Sieve as per IS 383-1970	Percentage Passing through I.S. Sieve
10	100	100
4.75	90-100	99.6
2.36	75-100	99
1.18	55-90	92.6
600 micron	35-50	48.6
300 micron	8-30	8.2
150 micron	0-10	2
Zone	II	
Fineness modulus	2.2	
Specific Gravity	2.50	
Bulk Density	1625 Kg/m <sup>3</sup>	
Bulking of Sand	23%	
Silt Content	0.25 %	

3.1.3. COARSE AGGREGATE

All types of aggregates are suitable. The normal maximum size is generally 16-20 mm; however particle sizes up to 40 mm or more have been used in SCC. Consistency of grading is of vital importance. Regarding the characteristics of different types of aggregate, crushed aggregates tend to improve the strength because of the interlocking of the angular particles, whilst rounded aggregates improve the flow because of lower internal friction.

Sieve size (mm)	20 mm		12 mm	
	Requirement as per IS: 383-1970	Percentage passing	Requirement as per IS:383-1970	Percentage passing
80.00	----	----	----	----
63.00	----	----	----	----
40.00	100 %	100 %	----	----
20.00	85 - 100 %	94.60 %	----	----
16.00	----	----	100 %	100 %
12.50	----	----	85 -100 %	93.4 %
10.00	0 - 20 %	14.30 %	0 - 45 %	39.23 %
4.75	0 - 05 %	2.85 %	0 - 10 %	6 %
2.36	----	----	----	----
Specific gravity	2.82		2.79	
Water Absorption %	0.40		0.48	
Aggregate Impact Value	12 %		13 %	
Bulk Density (kg/m <sup>3</sup> )	1660		1655	
Flakiness	14 %		15 %	
Elongation	15 %		16 %	

3.1.4. METAKAOLIN

Metakaolin is neither the by-product of an industrial process nor is it entirely natural. It is derived from naturally occurring mineral and is manufactured specially for cementing applications. Metakaolin is produced under carefully controlled conditions to refine its colour, remove inert impurities, and tailor

particle size such, a much high degree of purity and pozzolanic reactivity can be obtained. The Metakaolin is obtained From the Mahaveer ceramic and Mineral industry at sarpavaram in Kakinada. The chemical composition and physical characteristics of Metakaolin used in the present investigation were given in Tables 3.4 and Table 3.5.

Oxides	Percentages
SiO <sub>2</sub>	52.24
Al <sub>2</sub> O <sub>3</sub>	43.18
CaO	1.03
MgO	0.61
Fe <sub>2</sub> O <sub>3</sub>	0.60

Table: 3.4 Chemical requirements of fly ash

Property	Values
Colour	Pink / Off-white
Pozzolan Reactivity mg Ca (OH) <sup>2</sup> /gm	900
Average Particle size	1.4 micron
Brightness (ISO)	75 ± 2
Bulk Density (Gms / Ltr)	320 to 370
Specific Gravity	2.5

Table: 3.5 Physical properties of Metakaolin.

### 3.1.5. CUPOLA SLAG

Cupola slag is a by-product material which is gathered from cast iron, pig iron, and steel manufacturing unit. It is produced by action of various fluxes upon gangue materials within the iron ore during the process of pig iron making in blast furnace and steel manufacturing in steel melting shop and during melting of cast iron in cupola furnaces. The slag occurs as a molten liquid which solidifies upon cooling. Primarily, the slag consists of calcium, magnesium, manganese and aluminum silicates in various combinations and it is a complex solution of silicates and oxides. Cupola furnace is cylindrical shaped melting device which is used in steel industries for melting of cast iron ranging from 0.5 to 4 m in diameter. Lumps size varied from 100 mm to 450 mm. Cupola slag is tends to be dense solid material that varies in color from Grey to black.

Cupola slag was obtained from Meta Therm Furnace Private Limited is a leading manufacturing of melting furnace in Kakinada. The chemical composition and physical characteristics of cupola slag used in the present investigation were given in Tables 3.6 and Table 3.7.

Element	Percentage
Al <sub>2</sub> O <sub>3</sub>	9.5
MnO	2.9
SiO <sub>2</sub>	45.0
MgO	2.35
TiO <sub>2</sub>	1.00
CaO	14.250
Fe <sub>2</sub> O <sub>3</sub>	23.500
Cr <sub>2</sub> O <sub>3</sub>	0.300
Na <sub>2</sub> O	0.500
K <sub>2</sub> O	0.200

Table: 3.6 Chemical composition of Cupola slag

Property	Results	IS Requirements
Fineness Modulus	4.60	-
Crushing Value	27%	Concrete < 45 Road < 30
Impact Value	26%	Concrete < 45 Road < 30
Flakiness Index	11%	< 15%
Elongation Index	14%	< 15%
Specific Gravity	2.50	-
Bulk density	1640	-
Moisture Content	0.004	-
Water Absorption	0.4	< 2

Table: 3.7 Physical composition of Cupola slag

### 3.2. WORKABILITY CRITERIA FOR THE FRESH SCC

Filling ability, passing ability and segregation resistance are the requirements for judging the workability criteria of fresh SCC. These requirements are to be fulfilled at the time of placing of concrete. Typical acceptance criteria for Self-compacting Concrete with a maximum aggregate size up to 20 mm are shown in Table 3.11.

Table: 3.11 Acceptance criteria for Self-compacting Concrete.

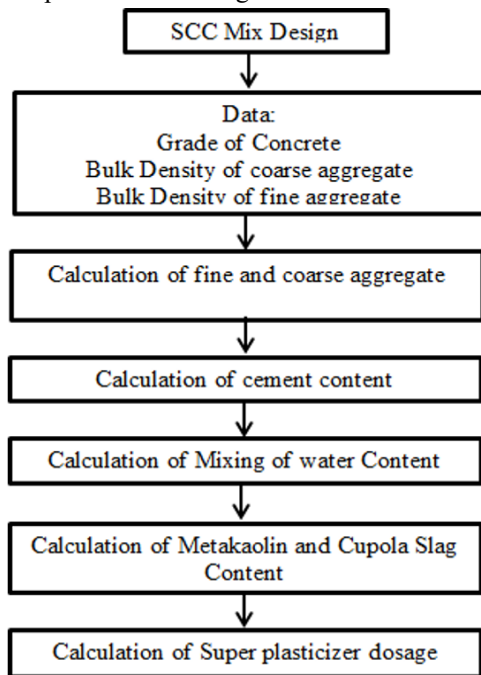
S.No	Method	Property	Typical range of values	
			Minimum	Maximum
1.	Slump flow test	mm	650	800
2.	T50cm Slump flow	sec	2	5
3.	V-funnel test	sec	6	12
4.	V-Funnel at T5 minutes	sec	6	15
5.	L-Box test	H2/H1	0.8	1.0
6.	U - Box test	(H2-H1) mm	0	30
7.	Fill box apparatus test	%	90	100
8.	J-Ring	mm	0	10
9.	Orimet test	sec	0	5
10.	GTM screen stability test	%	0	15

## IV. SCC - MIX DESIGN PROCEDURE

### 4.0. Development of a Rational Mix Design Procedure

As per Nan Su's method of mix design of Self-Compacting Concrete, the parameters that influence the mix proportions are packing factor, fine aggregate - total aggregate ratio and powder content. However, as per Nan Su's method assumptions in lieu of

packing factor, cement content, fly ash content and fine aggregate - total aggregate ratio were made. From the strength and workability studies conducted on SCC in the present investigation, it was noted that there is a significant change in the mix proportions with respect to packing factor, effective size of aggregate, fine aggregate - total aggregate ratio, fly ash content, cement content and water content. It was hence felt that these three parameters, which were otherwise assumed, are of reasonable importance. Hence, a rational mix design methodology modifying the existing Nan Su method has been proposed. The flow chart given in Fig.6.1 explains the SCC mix design. The following is a stepwise procedure for rational mix design, based on the values obtained from experimental investigations.



V.RESULTS AND DISCUSSIONS

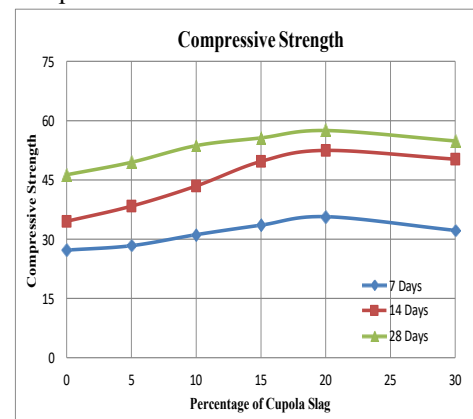
5.1. COMPRESSIVE STRENGTH

Test specimens (3 each) of 150mm x 150mm x 150mm were cast for testing the compressive strength of concrete at different percentages. The concrete mix with varying quantity of Metakaolin i.e. 20% as partial replacement to cement and cupola slag i.e. 5%, 10%, 15%, 20%, and 30% as partial replacement to coarse aggregate were cast and tested after curing period of 7,14 and 28 days. The results obtained after curing period of 7, 14 and 28 days for are mentioned in Table 5.3.

MIX	METAKAOLIN (%)	CUPOLA SLAG (%)	COMPRESSIVE STRENGTH (MPa)		
			7 Days	14 Days	28 Days
M35	20	0	27.25	34.52	46.28
	20	5	28.36	38.35	49.45
	20	10	31.14	43.45	55.68
	20	15	32.54	49.68	58.65
	20	20	33.68	52.47	60.52
	20	30	32.21	50.24	54.87

Table: 5.3 Compressive strength of M35 grade SCC

It can be observed from the above results that the compressive strength of the concrete increases by incorporating metakaolin 15% as a partial replacement to cement and cupola slag up to 30% as partial replacement to coarse aggregate in all the concrete mixes and subsequently increase on further decrease in the cupola slag concentration in the concrete specimen. The results are plotted graphically for curing period of 7, 14 and 28 days as shown in Graph 5.1.



Graph: 5.1 Compressive strength of M35 grade SCC

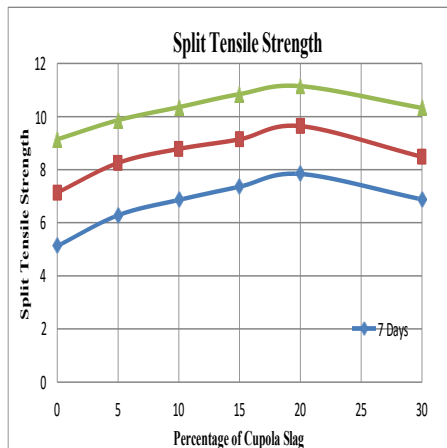
5.2. SPLIT TENSILE STRENGTH

The split tensile strength of concrete is tested by casting cylinders of size 150mm x 300mm were cast for testing the split tensile strength of concrete at different percentages. The concrete mix with varying quantity of Metakaolin i.e. 20% as partial replacement to cement and cupola slag i.e. 5%, 10%, 20%, and 30% as partial replacement to coarse aggregate were cast and tested after curing period of 7,14 and 28 days. The results obtained after curing period of 7, 14 and 28 days for are mentioned in Table 5.4.

MIX	METAKAOLIN (%)	CUPOLA SLAG (%)	SPLIT TENSILE STRENGTH (MPa)		
			7 Days	14 Days	28 Days
M35	20	0	2.24	3.12	3.92
	20	5	2.35	3.56	4.32
	20	10	2.56	4.12	4.72
	20	15	2.65	4.54	4.95
	20	20	2.80	4.94	5.25
	20	30	2.52	4.21	4.46

Table: 5.4 Split Tensile strength of M35 grade SCC

It can be observed from the above results that the split tensile strength of the blocks is increased by incorporating cupola slag up to 30% as partial replacement to coarse aggregate in all the concrete mixes and this value declines further by increasing the cupola slag concentration in the concrete specimen. The results are plotted graphically by considering average reading of split tensile strength for curing period of 7, 14 and 28 days as shown in Graph 5.2.



Graph: 5.2 Split Tensile strength of M35 grade SCC

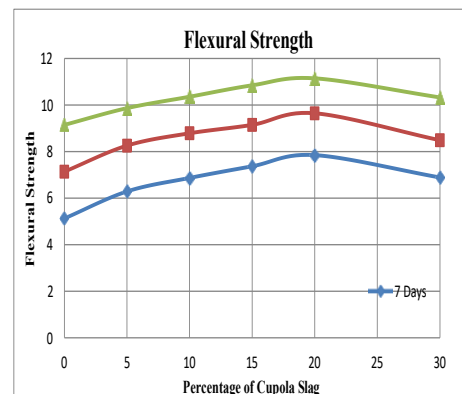
### 5.3. FLEXURAL STRENGTH

The flexural strength of concrete is tested by casting beam of size 150mm x 150mm x 750mm were cast for testing the flexural strength of concrete at different percentages. The concrete mix with varying quantity of Metakaolin i.e. 20% as partial replacement to cement and cupola slag i.e. 5%, 10%, 20%, and 30% as partial replacement to coarse aggregate were cast and tested after curing period of 7, 14 and 28 days. The results obtained after curing period of 7, 14 and 28 days for are mentioned in Table 5.5.

MIX	METAKAOLIN (%)	CUPOLA SLAG (%)	FLEXURAL STRENGTH (MPa)		
			7 Days	14 Days	28 Days
M35	20	0	5.12	7.13	9.14
	20	5	5.38	8.25	9.96
	20	10	5.56	8.78	10.35
	20	15	6.36	9.14	10.84
	20	20	6.54	9.64	12.34
	20	30	6.21	8.48	11.32

Table: 5.5 Flexural strength of M35 grade of SCC

It can be observed from the above results that the flexural strength of the blocks is increased by incorporating cupola slag up to 30% as partial replacement to coarse aggregate in all the concrete mixes and this value declines further by increasing the cupola slag concentration in the concrete specimen. The results are plotted graphically by considering average reading of split tensile strength for curing period of 7, 14 and 28 days as shown in Graph 5.3.



Graph: 5.3 Flexural strength of M35 grade SCC

## VI. CONCLUSIONS

The conclusions based on the limited observations from the present investigation on properties of fresh and hardened metakaolin and cupola slag based concrete are:

1. The addition of metakaolin and cupola slag in SCC mixes increases the self-compatibility characteristics like filling ability, passing ability and segregation resistance.
2. The flow value increase by an average of 5.36% for metakaolin in cement replacements of 15% and cupola slag in coarse aggregate replacement of 5%, 10% and 15% respectively.

3.The mechanical properties of SCC follow the inverse relations with the metakaolin and cupola slag contents for all grades of concrete.

4.The compressive strength of the mixes was observed that gradual increase with level of increase in cupola slag contents. The compressive strength for Concrete mix of (20% MK and 20% CS) achieved an increase of 26.84 MPa and 44.87% at the age of 7 and 28 days respectively, when compared with 7 days compressive strength (32.21MPa).

5.The Split Tensile strength of the mixes was observed that gradual increase with level of increase in cupola slag contents. The Split Tensile strength for Concrete mix of (20% MK and 20% CS) achieved an increase of 2.45 MPa and 46.66% at the age of 7 and 28 days respectively, when compared with 7 days Split Tensile strength (2.80MPa).

6.The flexural strength of the mixes was observed that gradual increase with level of increase in cupola slag contents. The flexural strength for Concrete mix of (20% MK and 20% CS) achieved an increase of 5.8 MPa and 47% at the age of 7 and 28 days respectively, when compared with 7 days flexural strength (6.54MPa).

7.The optimum Percentage of M35 Grade SCC with 20% Metakaolin and 20% of Cupola Slag offers maximum increases in percentage of strength results such as 44.87% for compressive strength, 46.66% for split tensile strength and 47% for flexural strength.

8.From the above experimental results on mechanical properties for M35 grade of SCC mix, it is clear that the percentage of replacement of metakaolin and cupola slag is increases the strength is also increases gradually.

9.From the above mentioned work of various researchers and our present experimental work, it is clear that metakaolin and cupola slag can be used as a replacement of cement and coarse aggregate in concrete because of its increased workability, strength parameters.

10.Considering the strength criteria, the replacement of metakaolin in cement and cupola slag in coarse aggregate is feasible.

11.Therefore we can conclude that the utilization of waste by product like metakaolin and cupola slag in concrete as cement and coarse aggregate replacement is possible.

#### REFERENCES

- [1] R.Balaraman and S. Anne Ligoria “Utilization of cupola slag in concrete as fine and coarse aggregate” International Journal of Civil Engineering and Technology (IJCIET)-Aug 2015, Volume 6, pp. 06-14.
- [2] Joseph O. Afolayan, Stephan A. Alabi “Investigation on the potentials of cupola furnace slag in concrete” International Journal of Integrated Engineering– 2013, Volume 5, pp. 59-62.
- [3] Mohammed Nadeem and Arun D. Pofale “Experimental investigation of using slag as an alternative to normal aggregate (coarse and fine) in concrete” International Journal of Civil And Structural Engineering– 2012, Volume 3, pp. 117-127.
- [4] Mr. T. Yuvraj “Environment feasibility in utilization of foundry solid waste for M20 concrete mix” IOSR Journal of Environment Science and Toxicology and Food Technology-Jan. 2015, Volume 9, pp. 16-23.
- [5] D.Baricova, Pribulova and P. Demeter “Comparison of possibilities the blast furnace and cupola slag utilization by concrete production” Archives of Foundry Engineering, June-2010, Volume 10, pp. 15-18.
- [6] Christina Mary V. and Kishore CH “Experimental investigation on strength and durability characteristics of high performance concrete using GGBS and MSAND” ARPN Journal of Engineering and applied science, June-2015, Volume 10, pp. 4852- 4856.
- [7] Vema Reddy Chevuri, S.Sridhar “Usage of waste foundry sand in concrete” SSRG International Journal of Civil Engineering (SSRG-IJCE), December-2015, Volume 2,pp. 5-12.
- [8] Pranita Bhandari, Dr. K. M. Tajne “Use of foundry sand in conventional concrete” International Journal of Latest Trends in Engineering and Technology (IJLTET), January-2016, Volume 6, pp. 249-254.
- [9] Amitkumar D. Raval, Arti Pamnani, Alefiya I. Kachwala “Foundry sand: Utilisation as a partial replacement of fine aggregate for establishing

- sustainable concrete” International Journal of Engineering Sciences and Research Technology (IJESRT), January-2015, pp. 308-311.
- [10] Sarita Chandrakanth, Ajay.A.Hamane “Partial replacement of waste foundry sand and recycled aggregate in concrete” International Journal of Modern Trends in Engineering Research, May-2016, Volume 3, pp. 173-181.
- [11] M. Nazeer, R. Arun Kumar. 2014. Strength Studies on Metakaolin Blended High- Volume Fly Ash Concrete, International Journal of Engineering and Advanced Technology (IJEAT), ISSN: 2249-8958, 3(6).
- [12] Sanjay N. Patil, Anil K. Gupta, Subhash S. Deshpande, Metakaolin- Pozzolanic Material For Cement in High Strength Concrete. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) ISSN: 2278-1684, pp. 46-49.
- [13] Davidovits J. 1988. Soft Mineralogy and Geopolymer. Proceedings of the Geopolymer 88 International Conference, the University de Technologie, Compiègne, France.
- [14] Molhotra V.M., Fly Ash, Slag, Silica Fume, and Rice Husk Ash in Concrete: A review, Concrete International, 15(4): 2-28, 1993.
- [15] Wainwright PJ, Ait-Aider H. 1995. The influence of cement source and slag additions on the bleeding of concrete. Cement and Concrete. Research. 25(7): 1445-1456.