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Techno Economic Study of Use of Alccofine and GGBS in Concrete by using Crushed Sand

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Abstract - *Conservation of natural resources and preservation of environment is the necessary for sustainable development. Depletion of natural resources is a common phenomenon in developing countries like India due to rapid urbanization and industrialization, involving the infrastructure developments. India being second largest populated country in the world it has become very difficult to prepare a concrete by using natural resources to construct various structures such as Roads, buildings, bridges etc. Availability of natural sand in that is getting depleted and also it is becoming costly. To prevent exhaustion of natural resources such as natural stone, natural sand etc. an attempt is made to replace the natural materials by using waste crushed material along with Alccofine powder and Ground granulated blast furnace slag (GGBS).By using the waste and chemical compound with different proportions along with cement and with proper water cement ratio the suitability and performance of the above said materials is measured in this project*.

Key Words: **Alccofine, Ground granulated blast furnace slag, Crushed Sand, Compressive strength.**

1. INTRODUCTION

The construction industry is the second largest industry in India after agriculture. It provides employment to large number of people and makes significant contributions to the national economy. For the construction of any structure the more important material required is concrete. Concrete is the second most used material in the world after water. The main ingredients required for preparation of concrete are cement, sand, aggregate and water. Pollution and Global Warming are the two most important problems the world is facing today. The excess use of natural resources such as Natural sand, aggregates and cement for the construction of any structure is affecting the Environment. In 2018 India was the second largest country for the production of cement in the world. The consumption of cement was around 270 Million metric tons per annum. India has emitted about 2,299 million tons of carbon dioxide in 2018 with increase of 4.8% compared to last year. The manufacture of cement contributes to 7% of global CO2 emissions. The raw materials used for production of cement are Lime stone and Clay, these materials are extracted from quarries, which also results in environmental degradation In the last few years it has been observed that availability of good natural sand for the construction is decreasing, excess use of natural sand is leading to environmental degradation which affects the environment, also the cost of the Natural sand is increasing day by day due to its scarcity. To overcome these problems, use of waste materials like Ground Granulated Blast Furnace Slag (GGBS), crushed sand and Alccofine can be used in Concrete.

1.1 Alccofine

Alccofine 1203 which is supplementary cementious material is used in production of high performance concrete. It has low calcium silicate. Alccofine 1200 has different series like 1201, 1202, and 1203 which represents fine, micro fine and ultra fine particles. The percentage of water for the given workability in concrete can be reduced even up to 70% by use of Alccofine 1203.It can also be used as water reducer to increase the compressive strength and also the workability of concrete.

Fig No-1 Alccofine 1203

Table -1: Chemical Composition of Alccofine 1203

C2O	SIO2	SO3	AL2O3	FE2O3	MGO
61-64%	21-23%	2-2.4%	5-5.6%	3.8-4.4%	0.8-1.4%

Table -2: Physical properties of Alccofine 1203

Fineness cm^2/gm	Specific Gravity	Bulk Density (Kg/m3)	Particle Size Distribution		
			D10	D50	D90
>12000	2.9	700-900	1.5 mic.	5 Mic.	9 Mic.

1.2 Ground Granulated Blast Furnace Slag

Ground Granulated Blast furnace slag is by product obtained from Iron manufacturing industry. It is obtained by quenching molten iron slag which is a byproduct of iron and steel making from a blast furnace in water. This molten slag has chemical composition of 10% to 20% of silicon dioxide (Sio2) and about 40 % of calcium oxide (CaO) which is nearly equal to the chemical composition of ordinary Portland cement. Iron ore, coke and limestone are fed into the furnace, when these two materials melt into the furnace two products are produced 1) The molten Iron 2) The molten slag. This molten slag consists mostly silicates and alumina from the original iron ore, combined with some oxides from limestone. The molten slag has less weight as compared to molten iron and hence floats on water. After the molten iron is tapped off the molten slag is cooled through high pressure water jet. This results in the formation of glassy granulate, this glassy granulate is then dried and ground to very fine powder which is known as GGBS. The use of GGBS in concrete will help to reduce CO2 emissions. It can be replaced partially up to 50 % to cement in concrete. The calcium content in GGBS is very small as compared to cement and hence it will take time for setting as well as attaining early strength. This extended setting time will be an advantage while doing concrete in hot weather. The concrete will remain workable for a long period of time.

Fig No-2 GGBS

Table -3: Chemical Composition of GGBS

Calcium Oxide	Silica	Alumina	Magnesia
40%	35%	13%	8%

Table -4: Physical Properties of GGBS

Colour	Off white
Specific Gravity	2.9
Bulk Density	1200 Kg/m^3
Fineness	350m^2/kg

1.3 Crushed Sand

Crushed sand which is a waste material obtained from stone crushing plant which is available in large quantity. Around 200 Million tons of crushed sand is generated per year in crushing plant industry. This sand is treated as waste material and has land disposal problems which create health and environmental hazard. The physical and chemical properties of crushed sand depend upon the type of rock and its source. The cost of crushed sand is less as compared to Natural sand and hence it becomes important factor to prepare economical concrete.

2. EXPERIMENTAL INVESTIGATION

2.1 Materials Used

Cement – OPC 53 Grade, Alccofine 1203, GGBS, Crushed Sand and Natural Sand is used in this study

2.1.1 Cement- Ordinary Portland cement of 53 Grade conforming to IS 12269-2013 is used.

2.1.2 Fine Aggregate- The fine aggregate is as per IS 383-1970 conforming under Zone- II.

2.1.3 Crushed Sand-Crushed sand was available from local stone crusher situated at Toap, District- Kolhapur.

Table -5: Properties of Sand

Property	Crushed Sand	Natural Sand
Specific Gravity	2.54-2.60	2.60
Bulk Density Kg/m3	1720-1810	1460
Water Absorption	1.30%	Nil
Sieve Analysis	Zone II	Zone II

2.1.4 Alccofine- Alccofine 1203 is used in this study.

2.1.5 GGBS- GGBS was available from Kagal MIDC Kolhapur.

2.1.6 Coarse Aggregate- The coarse aggregate conforming to IS 383-1970 was used. The maximum size of aggregate is 20mm.

Table -6: Properties of Coarse Aggregate

Specific Gravity	2.87
Bulk Density Kg/m3	1534
Water Absorption	0.31%
Fineness Modulus	8.14

2.2 Mix Design

The Mix design was done for M25 Grade concrete with reference to IS 10262-2009 and IS 456-2000.

Table -7: Mix proportions for 1m³ Concrete -M25 grade

Cement	**410 Kg/m³**
Alccofine	**82 Kg/m³**
GGBS	**123 Kg/m³**
Coarse Aggregate	**985.46 Kg/m³**
Fine Aggregate	**673.48 Kg/m³**
Water	**197.16 kg**
Water Cement Ratio	**0.48**
Mix Proportion by weight	**1:1.64:2.40**

Table -8: Percentage of Mix Proportions

Mix No	Cement (%)	Alccofine (%)	GGBS (%)	CS (%)	NS (%)
M1	100	00	00	00	100
M2	80	5	15	100	00
M3	70	10	20	100	00
M4	60	15	25	100	00
M5	50	20	30	100	00

*-CA- Crushed Sand, NS- Natural Sand, M1- Conventional Mix

2.3 Preparation of Concrete Cubes, Beams and Cylinders

According to mix proportions, Cubes, beams and Cylinders are casted for different Mixes. Cubes of Sizes 150mm x 150mm x 150mm are casted for 7 days and 28 days. Beams of size 100mm x 100mm x 400mm are casted for flexural strength. Cylinders of Diameter 150mm and height 300mm is casted for split tensile strength

Fig No-3 Mixing of Ingredients

Fig No-4 Compaction Using Table Vibrator

Fig No-5 Cubes, Beams and Cylinders

Fig No-6 Curing of Specimens

3. RESULTS AND DISCUSSIONS

3.1 Compressive Strength

Compressive strength may be defined as the ratio of Failure Load and cross sectional area of the specimen. Compressive strength test is taken for 7 days and 28 days.

$$Fck=Pc/A$$

Where

Fck= Compressive strength in N/mm²

Pc= Failure load in Newton

A= Cross sectional Area of the specimen in mm²

Table -9: Compressive Strength at 7 and 28 days

Mix No	Cement (%)	Alccofine (%)	GGBS (%)	Average Compressive Strength in N/mm2	
				7 days	28 days
M1	100	00	00	**16.60**	**25.20**
M2	80	5	15	**17.28**	**26.23**
M3	70	10	20	**17.30**	**26.95**
M4	60	15	25	**18.05**	**26.60**
M5	50	20	30	**18.09**	**28.11**

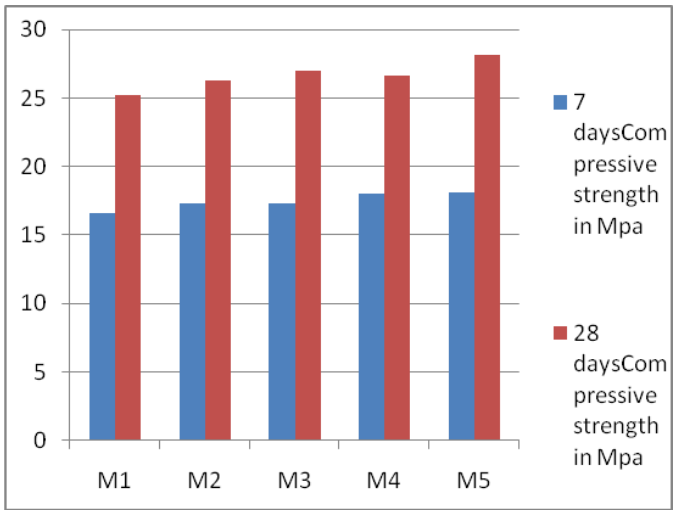

Chart -1: Average Compressive Strength

3.2 Flexural Strength

Flexural strength is the measure of resistance of beam to failure in bending.

$$F= PL/bd^2$$

Where F= Flexural strength in N/mm²

Pc= Failure load in Newton

b= Width of beam in mm

d= Depth of beam in mm

Table -10: Flexural Strength at 7 and 28 days

Mix No	Cement (%)	Alccofine (%)	GGBS (%)	Average Flexural Strength in N/mm2	
				7 days	28 days
M1	100	00	00	**3.24**	**4.03**
M2	80	5	15	**3.55**	**4.34**
M3	70	10	20	**3.91**	**4.52**
M4	60	15	25	**3.48**	**4.51**
M5	50	20	30	**3.18**	**4.46**

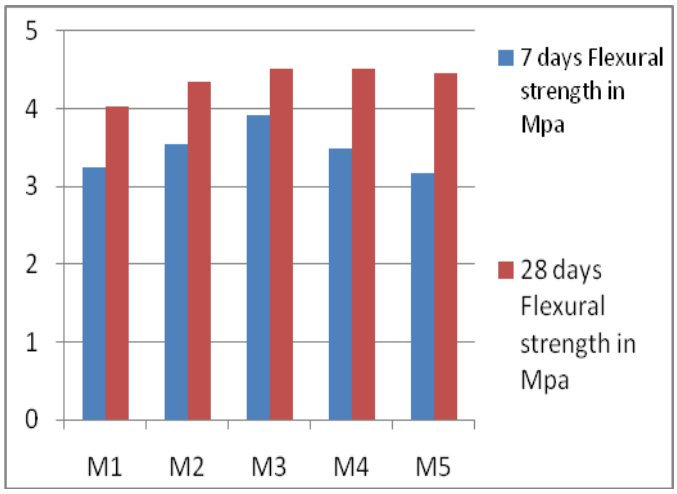

Chart -2: Average Flexural Strength

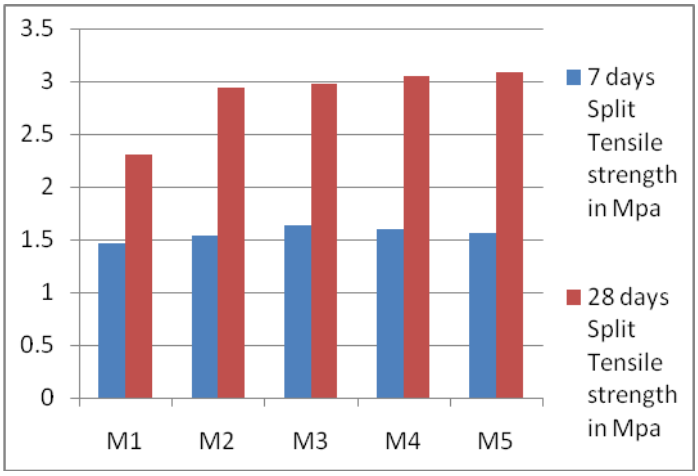

Chart -3: Average Split Tensile Strength

3.3 Split Tensile Strength

Split tensile strength is a method of determining the tensile strength of concrete.

$$T = 2P/3.142\ L\ D$$

Where F= Split tensile strength in N/mm^2

P= Failure load in Newton

L= Length of cylinder in mm

D= Diameter of cylinder in mm

Fig No-7 Testing of Specimen

Table -11: Split Tensile Strength at 7 and 28 days

Mix No	Cement (%)	Alccofine (%)	GGBS (%)	Average Split Tensile Strength in N/mm2	
				7 days	28 days
M1	100	00	00	**1.46**	**2.30**
M2	80	5	15	**1.54**	**2.94**
M3	70	10	20	**1.63**	**2.98**
M4	60	15	25	**1.60**	**3.05**
M5	50	20	30	**1.56**	**3.09**

3.4 COST OF MATERIALS USED PER KG

The cost of the materials are taken as per the current prices available in local market

Table -12: Cost of Materials per Kg

Materials	Unit	Rate in Rs
Cement	**kg**	**7**
Alccofine	**kg**	**10**
GGBS	**kg**	**2.5**
Crushed Sand	**kg**	**0.6**
Natural Sand	**kg**	**1.2**
Coarse Aggregate	**kg**	**0.5**
Water	**Lit**	**-**

3.5 COST COMPARISON PER CUBIC METER

The cost of the Mix required for one cubic meter of concrete is calculated.

Table -13: Cost Comparison Per cubic Meter

	Mix				
Materials	**M1**	**M2**	**M3**	**M4**	**M5**
Cement	2870	2296	2009	1722	1435
Alccofine	-	205	410	615	820
GGBS	-	154	205	256	308
Crushed Sand	-	404	404	404	404
Natural Sand	808	-	-	-	-
Coarse Aggregate	493	493	493	493	493
Water	-	-	-	-	-
Total Cost in Rs	**4171**	**3552**	**3521**	**3490**	**3460**

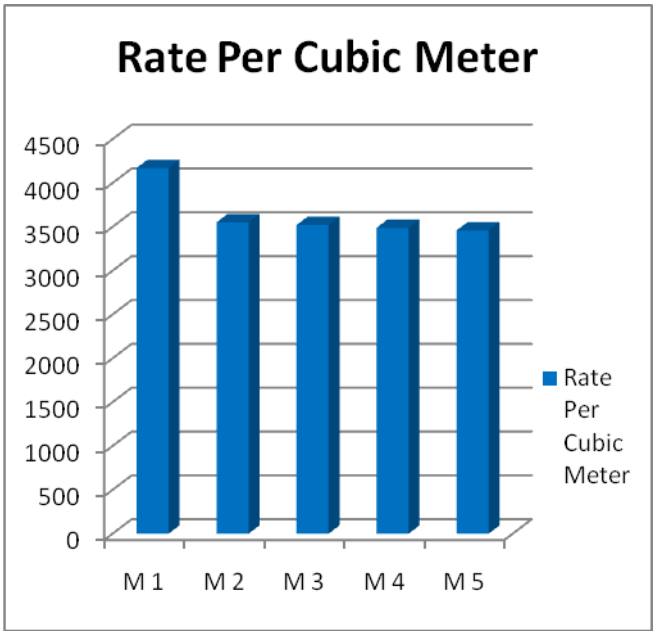

Chart -4: Rate of Mix per Cubic Meter

3.6 COST COMPARISON AS PER MIX

Table -14: Cost Comparison as per mix

Mix No	Cement (%)	Alccofine (%)	GGBS (%)	CS (%)	NS (%)	Rate in Rs
M1	100	00	00	00	100	**4171**
M2	80	5	15	100	00	**3552**
M3	70	10	20	100	00	**3521**
M4	60	15	25	100	00	**3490**
M5	50	20	30	100	00	**3460**

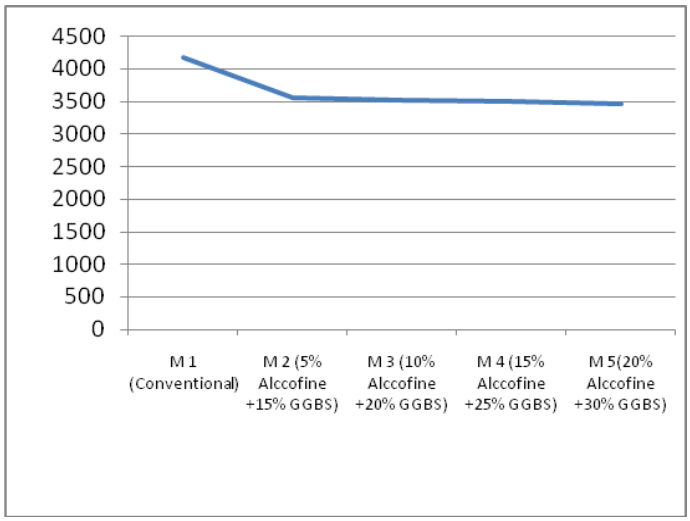

Chart -5: Cost Comparison

4. CONCLUSIONS

The following conclusions were drawn based on the experimental work done.

- The compressive strength of concrete using Alccofine, GGBS and crushed sand is found more than that of conventional concrete.
- The 28 days compressive strength of the mix using Alccofine and GGBS goes on increasing with increase percentage of Alccofine and GGBS.
- The use of Crushed sand in concrete showed better results than use of natural sand in conventional concrete. Hence Crushed sand can be fully replaced by natural sand.
- The use of crushed sand in concrete affects the workability of concrete, to attain good workability admixtures may be used for higher grades of concrete.

- Flexural strength and Split tensile strength of concrete using Alccofine, GGBS and crushed sand is found more than that of conventional concrete.
- Cost of the concrete goes on decreasing with increase percentage of GGBS and Alccofine. Hence the use of GGBS with Alccofine may be promoted in construction industry.
- From the results it may be concluded that replacement of cement with 10% Alccofine and 20 % GGBS (Mix M3) gives better results with Minimum cost of concrete. Hence these proportions may be used in construction site to achieve economy and better results.

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