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INVESTIGATION OF DURABILITY OF CONCRETE BY INCORPORATING GGBS AND ALCCOFINE

Srushti P. Rukmangad[1], Dr. Sudhir P. Patil[2]

[1]M.Tech Student, Dept. of Civil Engineering, Dr.Vishwanath Karad MIT-World Peace University, Pune
[2]Professor, Dept. of Civil Engineering, Dr.Vishwanath Karad MIT-World Peace University, Pune

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Abstract - *In the development of infrastructure concrete plays a vital role, it is widely used as a building material. Concrete is a mixture of cement, water, coarse aggregate and fine aggregate. Over the last few years, the environment is greatly affected due to the amount of energy consumed and CO_2 emitted during production of cement, these environmental and economical issues related to materials production and use have stimulated interest in the development of alternative materials which would partially replace cement and improve the performance of concrete. The materials which can used for partial replacement could be naturally occurring, industrial wastes or by-products that are less energy intensive. These pozzolanic materials when combined with calcium hydroxide, exhibits cementetious properties. This work focuses on investigation of durability characteristics of M30 grade concrete with partial replacement of cement with ground granulated blast slag (GGBS) by 20%, 40%, 60% and alccofine by 10%, 12%, 14%. The cubes and cylinders are tested for compressive strength, water permeability and rapid chloride penetration test.*

Key Words: GGBS, alccofine, compressive strength, water permeabilty, RCPT

1. INTRODUCTION

Cement is the most important construction material and it is most likely that it will have same importance in the future. The construction materials should meet the new and higher demands and to fulfil these demands the materials should not only have good strength property but should also be durable to sustain for a longer life span, thus improving the durability of the concrete and producing a greener concrete are now becoming one of the main criteria in obtaining a good quality concrete. The efforts are made for improving the performance and durability of concrete by partially replacing cement with naturally occurring, industrial wastes or by-products that are less energy intensive. Recently some attention has been given to the use of some of these chemical and industrial by-products like alccofine and ggbs. The use of these supplementary products to achieve high performance concrete is a relatively new approach. The present paper focuses on investigating durability characteristics of M30 grade concrete with partial replacement of cement with different percentages of alccofine and ggbs.

2. OBJECTIVE

- To find the effect on durability of concrete by adding various dosage of ggbs and alccofine in concrete.
- Comparative study of cement based materials, alccofine and GGBS in improving the durability of concrete.
- To find the optimum dosage of alccofine and GGBS at which appreciable results will be obtained.
- To perform compressive strength test, water permeability test, RCPT and concrete specimens with different dosage of ggbs and alccofine.

3. LITERATURE REVIEW

(Balamuralikrishnan 2019)In this work nine different percentage combination of alccofine (A), GGBS (G) and cement (C) were used (C100, C70A0G30, C90A10G0, C60A10G30, C30A10G30, C40A0G60,C85A15G0, C55A15G30, C25A15G60). It is intended to study the compressive strength, and its durability properties like acid attack test, sulphate attack test and rapid chloride permeability test (RCPT). For the nine different combination the maximum compressive strength results of concrete were achieved by using AL10% and GGBS 30% is 38.08 N/mm2. C60A10G30 is 28.76% higher than the control mix. This paper concludes that concrete incorporating alccofine and GGBS have higher compressive strength and alccofine enhanced the durability of concrete also.

(Vijaya 2017)In the present work cement has been replaced by 10% GGBS and varying percentage of alccofine i.e., 5%, 10%, and 15% for M30 grade of concrete. It is observed from this work that there is a gradual increase in the compressive and flexural strength of concrete when cement is substituted by alccofine and ggbs. Alccofine and ggbs has witnessed to improve the mechanical characteristics of concrete.

(Gupta 2014)In this experimental work is carried out to find mechanical strength development of high strength concrete (M50) with partial replacement of cement by ultra fine slag (alccofine). Comparative study is done between cubical strength and cylindrical strength of M50 grade concrete using alccofine. From experimental investigation it is found that hardened properties of concrete with alccofine are enhanced. It is seen that cylindrical strength of concrete

increases after replacement of cement by alccofine but is always less than its cubical counterpart.

(Karri2015)This paper focuses on investigating characteristics of M20 and M40 grade concrete with partial replacement of cement with ggbs by 30%, 40%, 50%. The cubes, cylinders and prisms are the specimens which were tested for compressive strength, split tensile strength, flexural strength. Durability studies for sulphuric acid and hydrochloric acid were also carried out. The results showed increase in compressive strength, split tensile strength and flexural strength due to ggbs replacement, also the resistance of concrete to acid attack is increased due to increase in ggbs amount.

(Patankar 2018)In this study alccofine and microsilica are used as cement replacement by 5%, 10% and 15%. The present experimental investigation cocsist of detailed comparative study using microsilica and alccofine on hardened properties of High Performance concrete. The test carried out in this work include compressive strength, water permeability, rapid chloride penetration test and modulus of elasticity. From the experimental result it is found that performance of microsilica is better than that of alccofine in concrete mix.

Based on the literature review it is seen that the use of alccofine and ggbs as the partial replacement for cement has improved durability and strength characteristics of concrete. In most of the research both the supplementary materials are used in combination or with some other admixture. In this study comparison of both these materials on compressibility and durability is done and their individual effect on concrete is found out.

4. MATERIALS AND METHODOLOGY

In the present investigation ordinary portland cement(OPC) of 53 grade is used throughout the work. The specific gravity of cement is 3.11. The fine aggregate used in the present work is locally available clean and well dried. Fine aggregate passing through IS sieve 2.36 mm is used. Specific gravity of fine aggregate(sand) is 2.70. The coarse aggregate used were locally available crushed aggregate of maximum size 20mm. The coarse aggregates used confirmed to IS 383:1970. The maximum size and grading of the aggregates depends on the special applications. The specific gravity of coarse aggregate is 2.80. M30 grade concrete was designed as per IS code. The water used for the purpose of mixing should be free from harmful chemicals. In this work total 7 mixes were prepared, initial M30 concrete mix was designed without replacement of cement by any supplementary material. alccofine and ggbs are used as supplementary materials.

Alccofine is a special type of material which is produced based on the content of slag which almost contain the maximum quantity of glass which is formed from the high reactivity and granulation process. This material is formed by the composition of fewer silicates of calcium. The distribution of particle size is based on the ingredients present in it. Due to accurate particle size distribution this alccofine gives greater results and reduces quantity of water required. So alccofine is mainly called as a water reducing agent. Alccofine thus increases the particle packing and this increases concrete strength and fine aggregate improves long term strength of concrete.

Table 1- Property of Alccofine

Chemical property	Percentage%	Physical property	Range
CaO	30- 34	Bulk Density	600 -700 kg/m3
Al2O3	18 -25	Surface Area	12000 cm²/gm
Fe2O3	0.8 3.0	Particle Shape	Irregular
SO3	0.1-0.4	Particle Size,d10	<2mm
MgO	6-10	d50	<5mm
SiO2	30-36	d90	<9mm

Fig 1: Alccofine

GGBS is a by-product of steel and iron industries. The main objective of this supplementary material is to sav the cement. GGBS is mainly composed of 30 % to 40%% of Silicon di-oxide (SiO) and also 40% CaO which is also similar to the chemical composition of cement. This material's heat of hydration may be less, it could withstand chemical attack, it gives good workability & durability characteristics in nature and is also a cost effective constructional material.

Fig 2. Ground granulated blast slag

Table 2 – Property of GGBS

Chemical Property	Percentage %	Physical property	Range
Calcium oxide	40%	Colour	Off white
Silica	35%	Specific gravity	2.9
Alumina	13%	Bulk density	1200kg/m^3
Magnesia	8%	Fineness	350m^2/kg

4.1 Mix Design

M30 grade concrete mix design is done as per the IS code specification. The properties of all materials are discussed above. The properties of all materials required for mix are discussed above. The water cement ratio considered for the design mix is 0.43.
Mix design details for M30 grade concrete is,

- M0 (0% Alccofine, 0% GGBS)
  Cement = 407 Kg/cu.m
  Coarse aggregate = 1169.98 Kg/ cu.m
  Fine aggregate = 748.02 Kg/ cu.m
  Water = 175 Litre

From above quantities the mix ratio obtained was
1: 1.83: 2.8 (cement: fine aggregate: coarse aggregate).
Mix design details for 6 different mixes incorporating different percentage of cement replacement materials is as follows,

- S1 (10% Alccofine)
  Cement = 366.3 Kg/ cu.m
  Alccofine = 40.7 Kg/ cu.m
  Coarse aggregate = 1169.98 Kg/ cu.m
  Fine aggregate = 748.02 Kg/ cu.m
  Water = 175 Litre

- S2 (12% Alccofine)
  Cement = 358.16 Kg/ cu.m
  Alccofine = 48.84 Kg/ cu.m
  Coarse aggregate = 1169.98 Kg/ cu.m
  Fine aggregate = 748.02 Kg/ cu.m
  Water = 175 Litre

- S3 (14% Alccofine)
  Cement = 350.02 Kg/ cu.m
  Alccofine = 56.98 Kg/ cu.m
  Coarse aggregate = 1169.98 Kg/ cu.m
  Fine aggregate = 748.02 Kg/ cu.m
  Water = 175 Litre

- G1(20% GGBS)
  Cement = 325.6 Kg/ cu.m
  Ggbs = 81.4 Kg/ cu.m
  Coarse aggregate = 1169.98 Kg/ cu.m
  Fine aggregate = 748.02 Kg/ cu.m
  Water = 175 Litre

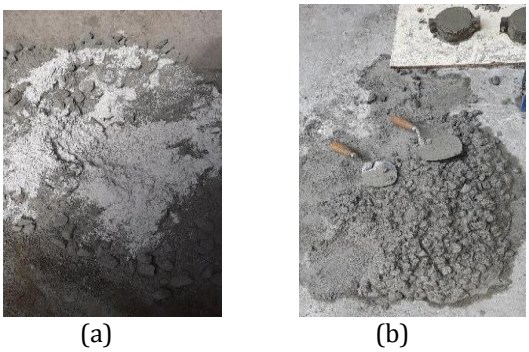
- G2(40% GGBS)
  Cement = 244.2 Kg/ cu.m
  Ggbs = 162.8 Kg/ cu.m
  Coarse aggregate = 1169.98 Kg/ cu.m
  Fine aggregate = 748.02 Kg/ cu.m
  Water = 175 Litre

- G3(60% GGBS)
  Cement = 162.8 Kg/ cu.m
  Ggbs = 244.2 Kg/ cu.m
  Coarse aggregate = 1169.98 Kg/ cu.m
  Fine aggregate = 748.02 Kg/ cu.m
  Water = 175 Litre

Note: M0, S1, S2, S3, G1, G2, G3 are notations for mix proportions as per % of alccofine and ggbs replacement for cement.

4.2 Experimental work

The M30 concrete mix was prepared as per the IS code mix design. Firstly, the dry mix was prepared using tools trowels and horizontal pans. The materials required for dry mix are cement, sand, coarse aggregate and required percentage of admixture. After dry mixing of required constituents water is added to the mix to prepare final concrete of M30 grade. The cubes of dimension 150 x 150 x 150mm and cylinders of height 50mm and diameter 100mm were casted. The cubes were casted for compressive strength test and water permeability test. The cylinders were used for rapid chloride penetration test. After 24 hours from casting of specimen, mould are removed and specimen are placed in water tank for curing. Total cubes for compressive strength are 21 for28 days and 21 cubes for 56 days, same number of cubes are casted for water permeability test. The cylinders casted for RCPT test are 14 each for 28 days and 56 days.



(a) (b)

Fig 3. Preparation of concrete mix(a) Dry mix (b) Wet mix

Fig 4- Casting of specimen

Fig 5-Curing

7. RESULT

7.1 Compressive strength

The average compressive strength of 3 cubes(150 x 150 x 150mm) after 28 days and 56 days is considered as final compressive strength.

Concrete Type	Compressive strength (N/mm^2) 28 days	Compressive strength (N/mm^2) 56 days
M0	41.65	49.54
S1	44.56	52.16
S2	47.12	55.72
S3	45.82	53.81

Table 3- Compressive strength for Alccofine

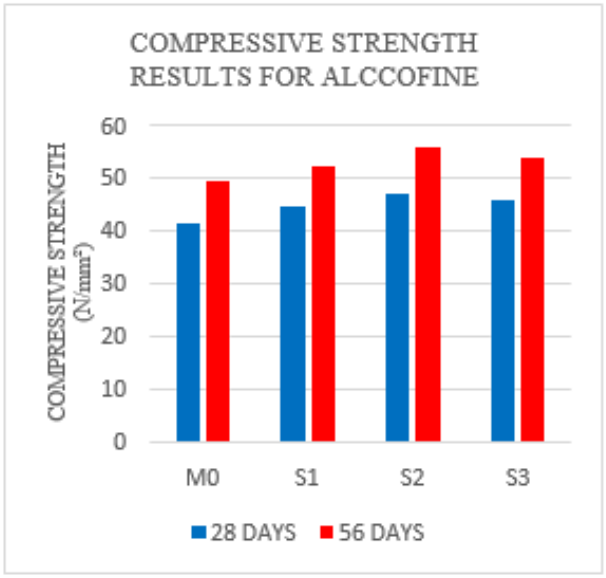


Chart -1: Compressive Strength Result

Table 4- Compressive strength for GGBS

Concrete Type	Compressive strength (N/mm^2) 28 days	Compressive strength (N/mm^2) 56 days
M0	41.65	49.54
G1	43.06	51.07
G2	45.01	53.18
G3	42.16	50.36

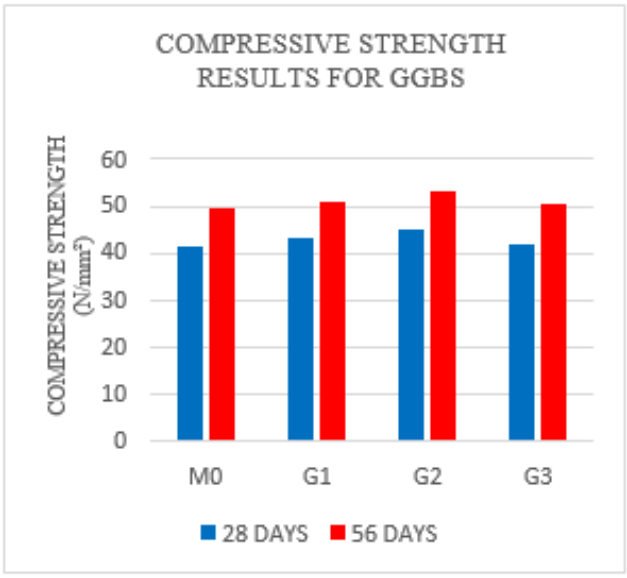


Chart -2: Compressive Strength Result

7.2 Rapid Chloride Penetration Test

In this test cylinders of dimension 50mm height and 100mm diameter are used for obtaining result. The result after 28 days and 56 days curing are given below.

Following are the results for alccofine and ggbs replacement,

Table 5- RCPT for Alccofine

Concrete mix type	Total charge passed(Coulomb) at 28days	Total charge passed(Coulomb) at 56days
M0	2019.28	838.27
S1	1507.05	451.12
S2	980.32	406.05
S3	720.89	320.07

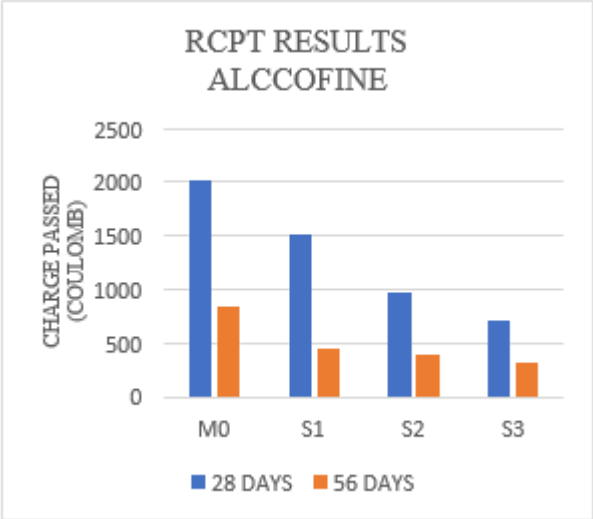


Chart -3: RCPT Result

Concrete mix type	Total charge passed(Coulomb) at 28days	Total charge passed(Coulomb) at 56days
M0	2019.28	838.27
G1	1725.83	468.07
G2	1343.56	428.07
G3	920.67	391.28

Table 6- RCPT for GGBS

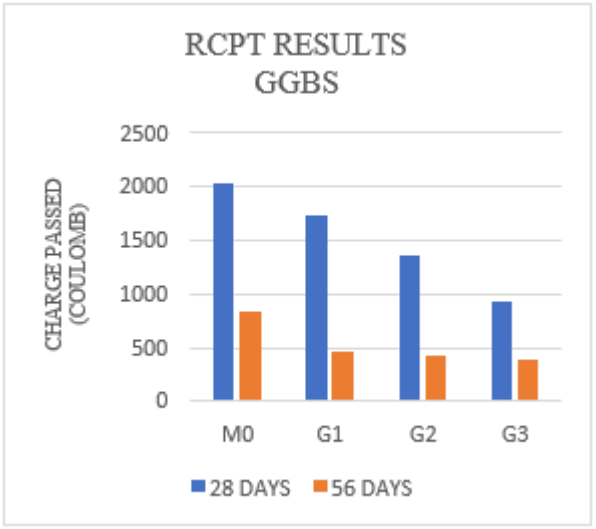


Chart -4: RCPT Result

7.3 Water Permeability Test

In this 150 x 150 x 150mm cubes of various mix proportion are tested and results obtained after 28 days and 56 days of curing are tabulated below. In this test depth of water penetration in cm is found out.

Concrete mix type	Depth of water penetration(cm) at 28 days	Depth of water penetration(cm) at 56 days
M0	2.01	1.85
S1	1.80	1.72
S2	1.82	1.68
S3	1.78	1.66
G1	1.95	1.83
G2	1.93	1.82
G3	1.89	1.79

Table 7-Water Permeability test for GGBS

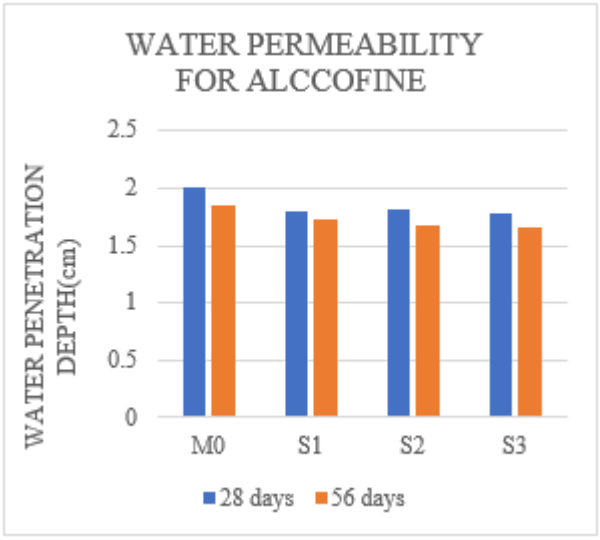


Chart -5: Water Permeability Result

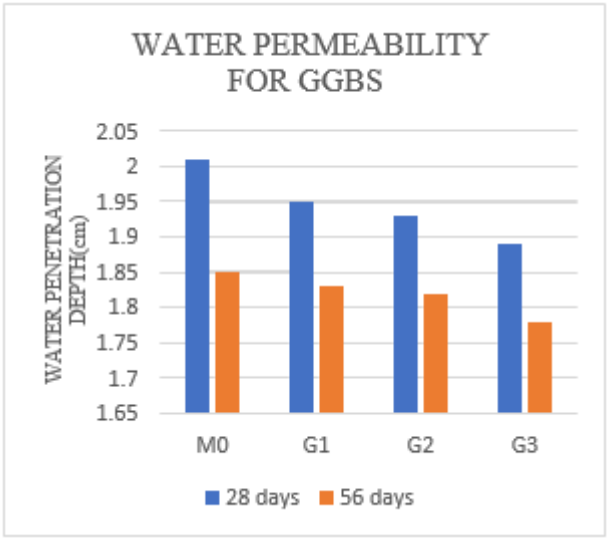


Chart -6: Water Permeability Result

8. CONCLUSIONS

Following conclusion can be drawn from this experimental investigation –

- The average compressive strength of concrete increased with increase in curing period, the partial replacement of ggbs and alccofine improved the compressive strength of concrete.
- The compressive strength of concrete increases as the ggbs and alccofine content is increased up to an optimum point, after this the compressive strength of concrete decreases.
- The optimum point for compressive strength is achieved at 40% ggbs replacement and 12% alccofine replacement for cement.
- The RCPT results shows that with increase in curing period and with increase in amount of ggbs and alccofine, the chloride ion penetration has decreased to an appreciable amount.
- To resist chloride ion penetration in concrete, replacement of alccofine showed much better results than ggbs. The amount of charge passed through concrete was much less for alccofine replacement than for ggbs.
- The water permeability also reduced with increase in the amount of ggbs and alccofine replacement in concrete.
- The replacement of cement by alccofine showed much better resistance to permeation of water in concrete than ggbs.
- The depth of water penetrated in specimen containing alccofine is less than that with ggbs.
- This investigation found that the performance of alccofine is much better than ggbs.
- The amount of alccofine used for replacement is less than ggbs but the improvement in strength and durability of concrete is more for mix using alccofine than mix with ggbs.
- The study shows that alccofine and ggbs replacement for cement improves the strength and durability characteristics of concrete.
- The Addition of these supplementary materials in concrete leads to eco- friendly and sustainable concrete.

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