

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 6, June 2019

An Experimental Study on Mechanical & Durability Properties of Blended Concrete with M₃₀ Grade

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ABSTRACT: In present scenario in the world, the cost and environmental pollution of cement is very high. To reduce the cost of cement, this is obtained from the cement industries. Alternately we want reduce the cost and environmental pollution by adding waste industrial materials. Among the many types of admixtures we are adding the perlite powder (PP) & GGBS. Perlite powder is a material which is made from the volcanic rocks & it can be reduce the very low thermal conductivity. Adding of GGBS is to get the more strength. Here we are mainly focusing that to control the thermal conductivity. Replacing perlite powder 2%, 4%, 6% & GGBS 20% constantly because as the reference papers studied. We are getting the high strength at 4% PP + 20% GGBS compressive test flexural test are performed on this project for M30 grade of concrete. The Present work some test are also performed on this project they are XRD, SEM, EDS describes the structure life time and the structural compositions and the chemical compositions of the structure. Here we can easily analyze the structure because of these studies. The XRD studies shows the life time of the structure it can be shows like a graphical shape and the SEM analysis can shows that inner part of the structure and how it can be formed jells because of the reactions between the cement and add mixtures. The EDS studies show the chemical composition of the structure which type of molecules are presented highly. The durability studies are also done on this project. The durability studies can show that how the structure will react for the acid rains. Here the project will be done for two type of acids alkaline acid (H₂SO₄) and nitric acid (HNO₃). The durability studies are done for 4 cycles. By partial replacement of cement by perlite powder & GGBS we are getting the good results. It can resist the structure form the environmental reactions like acid rains.

KEYWORDS: GGBS, Perlite Powder, Compressive Strength, Split tensile Strength, Flexural strength and Durability

I. INTRODUCTION

Concrete is the most versatile building materials being utilized all around the world. For construction materials, concrete has high resistant to elevated temperature when compared to other building materials like steel and wood etc., However, it is pertinent up to a possible temperature level in a given period of time. Concrete materials are highly susceptible to high temperatures due to fire accident or when it is nearest to reactors or furnaces. When it surpasses its time under high exposures, it leads to severe changes resulting in collapse of structure such as swelling, causing cracks, forming large pores and deplete the bond between aggregate – cementations materials. The characteristics properties such as modulus of elasticity, volume deformation, structural integrity, strength of the structural elements are notably reduced during these exposures. This may finally end up with severe structural changes and failures. And so, the behavior of concrete elements remains after such an accident are still crucial for detecting load carrying capability and for restoring the destructive structures. The physical structure and chemical composition of the materials transforms considerably when rising to high. The durability studies are also accomplished for this undertaking to acknowledge the behavior of the structure when acid rains are happened. In this project the use of the alkaline (H₂SO₄), nitric acid

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(HNO₃). The acids suggest the weight reduction of the cubes. The weight reduction can be the result of acid reaction on the structure.

II. LITERATURE REVIEW

- **M.PRATHAP KUMAR, VADDI SRINIVAS AND M,ZOHEB NAWAZ (2017)**, “ Experimental Investigation on High Strength Concrete using GGBS, Fly ash & SP-430 Super Plasticizer,” International of Civil Engineering and Technology. They opined that alkali activated slag such as blast furnace slag, steel slag, copper slag and phosphorus slag should be a prime topic for construction materials researchers.
- **S.TANER YILDIRIM, FATMA SEYMA KESKIN (2016)**. The study titled by Investigation of utilization of Perlite Powder and Bottom Ash for the Insulaton Mortar by using design of experimental via taguchi method this paper reports an experimental study to determine high temperature effect on concrete containing pelite powder as a sustainable admixture material. In this study, two control factors were used for statistical analysis.
- **M.SUTAR, RAMESHWARI, TARANNUM, SHURUTI, (2015)** “Experimental Studies on Pozzolanic Acton of GGBS and Strength Properties of GGBS Concrete,” International journal for Innovative Research in Science & Technology. A strong relationship between thermal conductivity and unit weight was obtained. Compressive strength and modulus of elasticity of concretes are reduced as the content of the expanded perlite increases.
- **ATILA GURHAN CELIK, AHMET MAHMUT KILIC, AND GAYE OZGUR CAKAL (2013)**, “Expanded Perlite Aggregate Characterization for Use as a Lightweight Construction Raw Material”.
- **T.K.ERDEM, C.MERAL, M. TOKYAY, T.Y. ERDOGAN (2012)**. In the study conducted by them published in cement and concrete composites (Middle East Technical University) titled as Use Of Perlite As Pozzolanic Addition In Producing Blended Cements gives the result that for a perlite type, perlite amount and Blaine fineness, blended cements produced by inter-grinding gave slightly higher compressive strength values as compared to those produced by combining separately ground materials.
- **OZKAN SENGULA, SENEM AZIZIB, FILIZ KARAOSMANOGLUB, MEHMET ALI, TASDEMIRA (2011)**. In the study by them titled as Effect of expanded Perlite on the mechanical properties and thermal conductivity of light weight concrete gives the result that when expanded perlite is used in concrete then the thermal conductivity of the mixtures is substantially reduced by replacing normal aggregate with expanded perlite. A strong relationship between thermal conductivity and unit weight was obtained. Compressive strength and modulus of elasticity of concretes are reduced as the content of the expanded perlite increases.
- **ULKER BEKIR, TOPUCA BURAK, IU, KADAU (2010)**. In the study conducted by them titled as manufacture of high heat conductivity resistant clay bricks containing Perlite gives the result concluding compressive strength decreases, heat conductivity resistance and shrinkage of perlite bricks increase as the replacement ratio of perlite increases.
- **HOSAM (2010)**: investigated the seawater resistance of concrete incorporating silica fume (SF), ground granulated blast furnace slag (GGBS) and metakaolin (MK) as an addition to cement in binary and ternary combinations. Permeability of different mixtures was measured. Strength deterioration ratios (SDR) were determined after 3, 6 and 12 months of exposure to synthetic seawater. The results indicate that the binary combination of cement-SF proves to be the most effective pozzolana to resist seawater attack.
- **WANG LING et al. (2004)** Analyzed the performance of ggbs and the effect of ggbs on fresh concrete and hardened concrete. GGBS concrete is characterized by high strength, lower heat of hydration and resistance to chemical corrosion.
- **ONER and AKYUR (2003)**. Studied on optimum level of Ggbs on compressive strength of concrete and concluded that the optimum level of GGBS content for maximizing strength is at about 55-59% of the total binder content.
- **QIAN JUESHI and SHI CAIJUM (2002)**. Studied on high performance cementing materials from industrial slag and reviewed the recent progress in the activation of latent cementinious properties of different slag. They

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opined that alkali activated slag such as blast furnace slag, steel slag, copper slag and phosphorus slag should be a prime topic for construction materials researchers.

III. EXPERIMENTAL INVESTIGATION

Experimental investigation consists of casting and testing of 18 sets along with control mix. Each set comprises of 9 cubes, 9 cylinders and 9 beams for determining compressive, tensile and flexural strengths respectively. hooked Perlite powder & GGBS is used to study with The mineral admixtures like GGBS (20%) & Perlite powder content varies from (2%, 4% and 6%) by volume of cement is used in concrete. All specimens are water cured and tested at the age of 7, 28 and 56-days. Ductility and bond of concrete is to found to increase with mineral admixtures in reinforced concrete. In this study optimum percentage perlite powder arrived at the keeping optimum percentage addition of GGBS constant. Cube section dimension is of 15cmx15cmx15cm, cylinder section dimension is 15cmx30cm and prism dimension is 50cmx10cmx10cm. The moulds are applied with a lubricant before placing the concrete. After a day of casting, the moulds are removed. The cubes, cylinders and prisms are moved to the curing tank carefully.

MATERIALS:

The constituent materials used in these studies are given below:

- 1) Cement
- 2) Fine aggregate
- 3) Water
- 4) Perlite powder
- 5) GGBS
- 6) Coarse aggregate

CEMENT:

The cement used was Ordinary Portland cement (OPC) of 53-grade conforming to IS 12269 is used in experimental work.

Table 1: cement test result

s.no	Property	Experimental value	Requirements As Is codes
1	Normal consistency	34%	IS 4301-1988(part-4)
2	Specific gravity	3.12	3.15
3	Initial setting time Final setting time	44 min 460 min	As per 12269 30 min 600 min (max)
4	Soundness test	7 mm expansion	

AGGREGATE: It should be passed through IS Sieve. As fine aggregate (F.A) natural sand from river is used conforming to IS383-1970. Which comes under zone II. As a coarse aggregate hard granite chips passing 20mm down where used conforming to IS383-1970. Various tests such as specific gravity water absorption and sieve analysis have been conducted on (F.A) and (C.A) to know the good quality and grading.

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FINE AGGREGATES

The material which passes by means of 4.75 mm sieve is termed as fine aggregate. Mainly common sand is used as a first-rate aggregate at places the place ordinary sand will not be to be had crushed stone is used as a satisfactory combination. The sand used for the experimental works is in the neighborhood procured and conformed to grading zone III.

NATURAL COARSE AGGREGATE:

The broken stone is generally used as a coarse combination. The character of work decides the maximum size of the coarse aggregate. In the community on hand coarse mixture having the highest dimension of 20 mm was once used within the reward work. The properties of average mixture are provided below

Table 2: Properties of coarse aggregate

S.no	Properties	Values
1	Specific gravity	2.74
2	Water absorption	1%
3	Fineness modulus	5.78
4	Maximum size of aggregates	20 mm

Water

Water plays a prominent role in making of the concrete after cement. The major functions of water are as follows.

- This spreads the cement uniformly.
- The reaction of cement with water transforms to calcium silicate hydrate (C-S-H) gel (Strongest component of the concrete)
- It lubricates the mixes (thus enhances workability)

Two sources of water in concrete

1. Mix water (water added to the concrete) and
2. Aggregate moisture (either sucks water from mix or add water to the mix).

Perlite Powder : Perlite is a pozzolanic material formed naturally by hydration of obsidian and expands when heated. As the curing period increases the strength of perlite increases. Perlite expands nearly 15-17 times the original size of it when heated up to 900-1100°C. When perlite is blended along with concrete it offers very high thermal insulation to the concrete and also perlite is a waste material which is a volcanic glass which is relatively cheaper and makes the mix economical. Today's competitive world is growing so fast and construction works are also getting developed by using admixtures and blended concrete, durability of the structures are being increased considerably. There are number of important buildings and there is a chance of getting fire accidents. Fire accidents sometimes completely destroy the building and strength of the concrete relatively decreases and it will be hard for the building to survive.

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Table3 : properties of perlite powder

S.No	Properties	Value
1	Colour	white
2	Bulk density	40-50kg/m ³
3	Ph	Neutral
4	Thermal conductivity	0.40 w/mk@ 0°
5	Moisture content	0.5% max.
6	Organic content	0.1% max.

Ground-granulated-blast-furnace slag (GGBS or GGBFS)

GGBS is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder.

IV. RESULTS AND ANALYSIS

Results for various percentages of mineral admixtures

Table 4 : Compressive strength results

S.no	Replacement of perlite powder and GGBS	Compressive strength(N/mm ²)		
		7 days	28 days	
1	Conventional Concrete	15.99	38.51	38.4
2	20% GGBS+2% PP	20.70	36.41	36.9
3	20% GGBS+4% PP	23.90	39.72	40.8
4	20% GGBS+6% PP	14.60	30.10	32.7

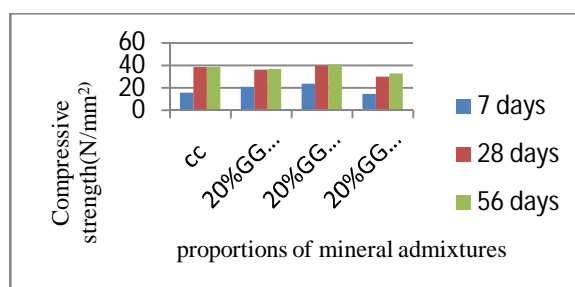


Fig 1: Overall results of compressive strength

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SPLIT TENSILE TEST RESULTS

When silica fume percentage increases from 0% to 20%, the normal consistency is increases about 40%. Increase in split tensile strength beyond 10% silica fume replacement was almost unsatisfactory. I this study M60 grade concrete and it was found that maximum split tensile strength of 6.07 N/mm².

Table5 : Split tensile strength results

S.no	Replacement of perlite powder and GGBS	Tensile strength (Mpa)	
		7 days	28 days
1	ConventionalConcrete	1.16	2.47
2	20%GGBS+2%PP	1.38	2.16
3	20%GGBS+4%PP	2.30	2.51
4	20%GGBS+6%PP	2.15	2.38

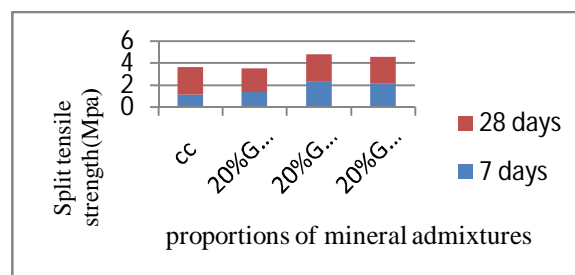


Fig 2: Split tensile testing of cylinder

Flexural Strength: The steel mould of size 500x100x100 is well tighten and oiled thoroughly . They were allowed for curing in a tank After 28 days curing, prismatic specimens are placed on flexural testing machine having a maximum of 100 KN and a constant rate of loading of 40 kg/m² per minute is applied on the test specimen by placing the specimen in such a way that the two point loading should be placed at a distance of 13.3 cm from both the ends. Ultimate load at which the prismatic specimen fails is noted down from dial gauge reading.

Table 6: Flexural strength results

S.NO	Replacement of perlite powder and GGBS	Flexural strength(Mpa)	
		7 days	28 days
1	ConventionalConcrete	3.89	5.17
2	20%GGBS+2%PP	3.64	7.9
3	20%GGBS+4%PP	8.84	11.92
4	20%GGBS+6%PP	6.96	8.6

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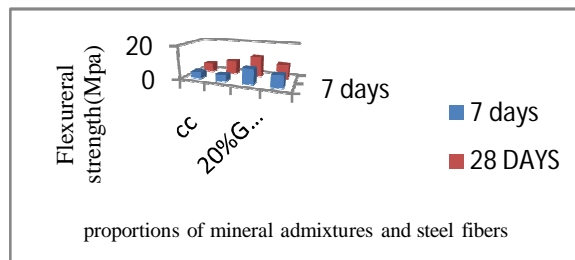


Fig 3: Overall flexural strength by mineral admixtures

SEM ANALYSIS:

A normal scanning electron microscope operates at a high vacuum, the basic principle field emission gun. The electron beam is accelerated through a high voltage and passed through system of apertures and electromagnetic lenses to produce thin beam of electrons, then the beam scans the surfaces of the specimens by means of scan coil. Electrons are the emitted from the specimen by the action of the scanning beam and collected by a suitably- positioned detector.

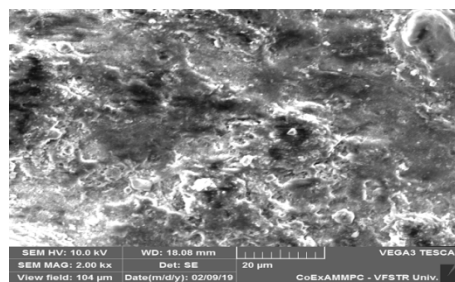


Fig 4: Pictorial view of SEM analy

XRD Analysis:

It is a scientific technique using x-ray on powder on microcrystalline samples or structural characterization of materials. A diffractometer produces waves at a known frequency, which is determined by their source. The source is often X-rays, because there is the only kind of light with the correct frequency for inter-atomic-scale diffraction. When these waves reach the sample, the atoms of the sample act just like a diffraction grating, producing bright spots at particular angles. By measuring the angles where these bright spots occur, the spacing of the diffraction grating can be determined by Bragg's law. Because the sample itself is the diffraction grating, these spacing is the atomic spacing.

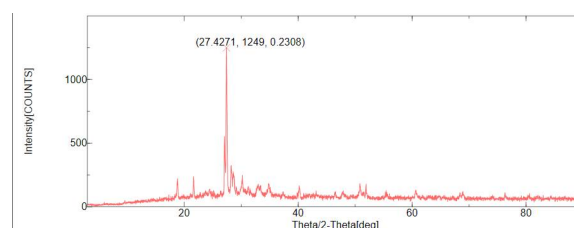


Fig 5 : Graphical representation of XRD Analysis

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EDS Analysis:

X-ray spectroscopy is a chemical microanalysis technique used in conjunction with scanning electron microscopy (SEM). It can be used to determine chemical elements present in a sample, and can be used to estimate their relative abundance. The technique detects X-rays emitted from the sample during bombardment by an electron beam to characterize the elemental composition of the analysed volume. Features or phases as small as one micrometer or less can be analysed.

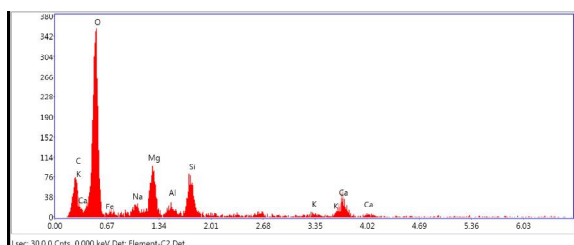


Fig 6: Graph showing EDS analysis

Durability studies of blended concrete:

The concentrations of acids in water are 1% HNO_3 and 1% H_2SO_4 . Durability studies of weight loss of blended concrete are effected with chemicals as follow

Table 7: weight loss of concrete cubes after immersion of H_2SO_4

Sl. No	Immersion in days	Weight loss(%)			
		GGBS & Perlite powder			
		0%	20%g+2%pp	20%g+4%pp	20%g+6%pp
1	30	0.48	0.54	0.21	0.41
2	60	0.76	0.58	0.84	0.65
3	90	1.07	1.83	1.61	0.97
4	120	1.91	3.05	1.91	1.54
5	150	2.91	4.54	2.00	2.52

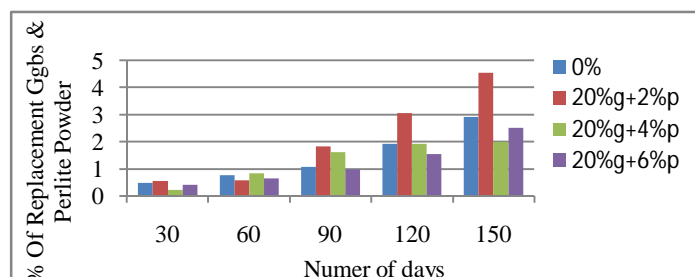


Fig 7 : weight loss of blended concrete(H_2SO_4)

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Table 8 : Durability of blened concrete with presence of HNO_3

Sl. No	Immersion in days	Weight loss(%)			
		GGBS & Perlite powder			
		0%	20% g+2% pp	20% g+4% pp	20% g+6% pp
1	30	0.45	0.79	0.72	0.75
2	60	0.62	1.08	0.83	0.85
3	90	0.89	2.42	1.41	0.90
4	120	1.23	3.3	1.02	1.97
5	150	1.98	3.92	1.62	2.00

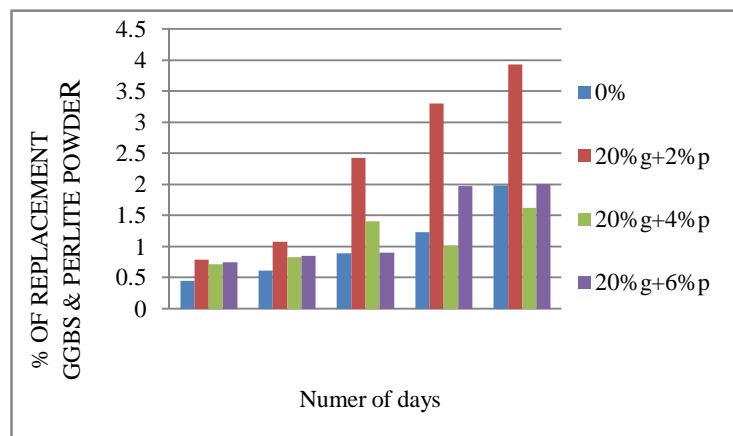


Fig 8: Weight Loss of Blended Concrete(HNO_3)

V. CONCLUSIONS

- We concluded that, on 7, 28 and 56 days strength of the specimen at 105°C has maximum compressive strength obtained for the mix having 4% PP and 20% GGBS shows 39.44 MPa and 40.80 MPa respectively.
- As the percentage of perlite powder increases at 4%, both the compressive strength and tensile strength values increased by 0.54% and 1.68% respectively as compared to conventional concrete.
- Surface cracks observed at temperature 600°C and it gets more pronounced to further temperature and change of color also seen at this temperature.
- Increasing the target temperature lowers the strength of the concrete in all mixes.
- However, increase in the temperature suppresses the concrete strength, blends of GGBS and PP makes the concrete more resistant to heat.
- The blends of GGBS and PP show excellent compressive strength than the conventional concrete.
- From all the mixes, mix of 4% PP and 20% GGBS proven to be better at elevated temperatures than the others.
- Up to 1-30, 30-60, 60-90, 90-120 and 120-150 days, in sulphuric acid 22% of GGBFS concretes shows more weight loss with compared to 0%, 24%, and 26% of GGBFS concretes acid attack using 1% H_2SO_4
- Nitric acid solution HNO_3 was found to be more weight loss when compared to acid solution HNO_3

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