A STUDY ON MECHANICAL PROPERTIES OF ORDINARY CONCRETE AND STANDARD CONCRETE BY REPLACING CEMENT WITH GGBS

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Abstract: Concrete has become a vital part of our lives, the use of concrete is increasing at a very high rate. One of the main constituents of concrete is Portland cement. The manufacturing of cement results in the emission of large amounts of CO_2. Thus the researchers have started finding alternatives for the partial replacements for cement. This main study of this paper is on investigating the behavior of M20 and M40 concrete by partially replacing the cement by Ground granulated blast furnace slag (GGBS). Ground-granulated blast-furnace slag (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. GGBS is used to make durable concrete structures in combination with ordinary Portland-cement and/or other pozzalanic materials. Cubes and Cylinders are tested for its Compressive and split tensile strength after 7 and 28 days of curing. The replacement percentages of cement by GGBS used are 0% ,10% ,20% and 30% . Water cement ratio adopted in this work is 0.50(M20) and 0.40 (M40) .

Keywords : CO2, M20, M40 , GGBS, compressive strength, split tensile strength, flexural strength, durability test, etc,.

I.INTRODUCTION

In today's world, concrete has become a vital part of our lives. With each passing day, the use of concrete is increasing at a very high rate. One of the main constituents of concrete is Portland cement. With the increase in use of concrete, the manufacturing and consumption of cement has increased drastically. Although cement has exceptional binding properties and is very suitable for use in concrete, the manufacturing of cement results in emission of large amounts of CO_2. Due to this, researchers have started finding alternatives to cement that are economical as well as environment friendly. Among many alternatives, Ground granulated blast furnace slag is the industrial by-product which provide excellent binding properties to concrete and serve as a replacement of cement. This alternative is generally termed as Supplementary cementious materials (SCMs). The advancement of concrete technology can reduce the consumption of natural resources, which can be reused and find other alternatives. In India numbers of waste materials are produced by different manufacturing companies, thermal power plant, municipal solid wastes and other wastes. Solid as well as liquid waste management is one of the biggest problems of the whole world. Disposal of waste in to the land causes serious impact on environment. Now a day's large amount of GGBS powder is generated in furnace industries with an impact on environment and humans. By using the replacement materials offers cost reduction, energy savings and few hazards in the environment. The powder waste which is dumped in land filling and pit or vacant spaces causes the environmental pollution which is dangerous for human health. This waste is not recycled in any form at present. However, the tile waste is durable, hard and highly resistant to biological, chemical, and Ground Granulated Blast furnace Slag (GGBS)

Ground Granulated Blast Slag (GGBS)

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

APPLICATIONS OF GGBS

GGBS is used to make durable concrete structures in combination with ordinary Portland and/or other pozzolana materials. GGBS has been widely used in Europe, and increasingly in the United States and in Asia (particularly in Japan and Singapore) for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years

Two major uses of GGBS are in the production of quality-improved slag cement, namely Portland Blast furnace cement (PBFC) and high-slag blast-furnace cement (HSBFC), with GGBS content ranging typically from 30 to 70%; and in the production of ready-mixed or site-batched durable concrete.

Concrete made with GGBS cement sets more slowly than concrete made with ordinary Portland cement, depending on the amount of GGBS in the cementations material, but also continues to gain strength over a longer period in production conditions. This results in lower heat of hydration and lower temperature rises, and makes avoiding cold joints easier, but may also affect construction schedules where quick setting is required.

Use of GGBS significantly reduces the risk of damages caused by alkali silica reaction (ASR), provides higher resistance to chloride ingress reducing the risk of reinforcement corrosion and provides higher resistance to attacks by sulfate and other chemicals.

USES OF GGBS

The major use of GGBS is in ready mixed concrete, and it is utilised in a third of all UK [2] „ready-mix" deliveries. Specifies are well aware of the technical benefits, which GGBS imparts to concrete, including:

- Better workability, making placing and compaction easier.
- Lower early age temperature rise, reducing the risk of thermal cracking in large pours.
- Elimination of the risk of damaging internal reactions such as ASR
- High resistance to chloride ingress, reducing the risk of reinforcement corrosion
- High resistance to attack by sulphate and other chemicals
- Considerable sustainability benefits

OBJECTIVE OF THE STUDY

- To determine the performance of concrete by partial replacement of cement by Ground granulated blast furnace slag in 10%, 20%, 30% variants.
- To use pozzolana material such as GGBS in concrete by partial replacement of cement.
- To conduct compressive strength test, split tensile strength test, flexural test.
- To provide economical construction material
- Provide safeguard to the environment by utilizing waste properly.

- To determine the most optimized mix of GGBS- based concrete.

II. LITERATURE REVIEW

Er. Kimmi Garg, Er. Kshipra Kapoor et all,.(2014) They studied and experimented, it is proved that GGBS can be used as an alternative material for cement, reducing cement consumption and reducing the cost of construction. Use of industrial waste products saves the environment and conserves natural resources

.**Vinayak Awasare, Prof. M. V. Nagendra et all,.(2015)** they made a study work to analyse strength properties of partially replaced GGBS concrete. The flexural strengths achieved are 3.01Mpa, 3.45Mpa, 3.58Mpa, 3.44Mpa and 3.12Mpa at 0%, 20%, 30%, 40%, and 50% for GGBS concrete respectively for M20 grade concrete of OPC cement and crushed sand. This report shows that tensile strength also gives good performance for 20%, 30 % and 40% replacement which is more than normal plain concrete.

Yasutaka SAGAWA, Daisuke Yamamoto and Yoshikazu HENZAN in a study concluded that the specimens which include normal-strength concrete and high-strength concrete by changing W/B from 65% to 35% were examined. The effectiveness of GGBS on chloride ion diffusion coefficient was investigated by migration test. Moreover, the application of GGBS which has the surface area of 6000 cm2/g for bridge superstructures was presented.

D. Suresh and K. Nagaraju the review concluded that the movement of moisture of GGBS mixes, probably due to the dense and strong microstructure of the interfacial aggregate/binder transition zone is probably responsible for the high resistance of GGBS mix to attack in aggressive environments such as silage pits. GGBS is a good replacement for cement in some cases and serves effectively but it can't replace cement completely. But even though it replaces partially it gives very good results and a greener approach to construction and sustainable development which we are engineers are keen about today.

III. MATERIALS AND MIX DESIGN

CEMENT : Cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete- which is a combination of cement and an aggregate to form a strong building material.

The ordinary Portland cement of 53 Grade is used in accordance with IS: 12269-1987 Properties of this cement were tested and listed here. Fineness of cement = 5 Specific gravity if cement = 3.15 Standard Consistency of cement = 33% Initial setting time = 30 minutes Final setting time = Not more than 10 hours.

FINE AGGREGATE : Locally available fresh sand, free from organic matter is used. The result of sieve analysis confirms it to Zone-II (according to IS: 383-1970).The tests conducted and results plotted below. Specific gravity = 2.3 Fineness modulus = 3.06.

WATER: Generally potable water should be used. This is to ensure that the water is reasonable free from such impurities as suspended solids, organic matter and dissolved salts, which may adversely affect the properties of the concrete, especially the setting, hardening, strength, durability, pit value, etc

Super plastizers (perma super plast 220) **:**Perma Plast Super- 220 is a high range, low dosage, super plasticizing admixture for slump retention. It is a product based on refined naphthalene formaldehyde and ligno sulfonate blends. Color: Dark Brown/Black Liquid ,Specific Gravity :1.20 ± 0.1 at 25° C ,Air Entrainment :1% Maximum, Chloride Content : Free from added chloride, Nitrate Content : Nil, Freezing Point : can withstand any number of freezing and thawing cycles

MIX DESIGN OF M20 AND M 40

M20 : Trial mix for M20 is 1: 1.81:2.82

S.no	Cement Kgs	GGBS Kgs	Fine aggregates Kgs	Coarse aggregates kgs	Water liters
1	175.176	37.824	384	599	92
10 % addition	192.70	41.61	422.40	658.90	101.20

M40 : Final trial mix for M40 grade concrete is 1:2.29:3.56 at w/c of 0.40

S.NO	Cement Kgs	GGBS Kgs	Fine aggregates Kgs	Coarse aggregate Kgs	Water Litters	Admixture kgs
1	137	24.732	378	587	68.22	3.265
10 % addition	150.70	27.2052	415.80	645.70	75.042	3.60

IV.RESULTS AND ANALYSIS

MATERIAL PROPERTIES:

CEMENT:

Sl.no	Test	Results	IS code used	Acceptable limit
1	Specific gravity of cement	3.160	IS:2386:1963	3 to 3.2
2	Standard consistency of cement	6mm at 34% w/c	IS:4031:1996	w/c ratio 28%-35%
3	Initial and final setting time	45 mins and 10 hours	IS:4031:1988	Minimum 30mins and should not more than 10 hours
4	Fineness of cement	3.00%	IS:4031:1988	<10%

COARSE AGGREGATES:

Sl.no	Test	Results	Is code used	Acceptable limit
1	Fineness modulus	6.5	IS:2386:1963	6.0 to 8.0mm
2	Specific gravity	2.90	IS:2386:1963	2 to 3.1mm
3	Porosity	46.83%	IS:2386:1963	Not greater than 100%
4	Voids ratio	0.8855	IS:2386:1963	Any value
5	Bulk density	1.50g/cc	IS:2386:1963	-
6	Aggregate impact value	37.5	IS:2386:1963	Less than 45%
7	Aggregate crushing value	26.6%	IS:2386:1963	Less than 45%

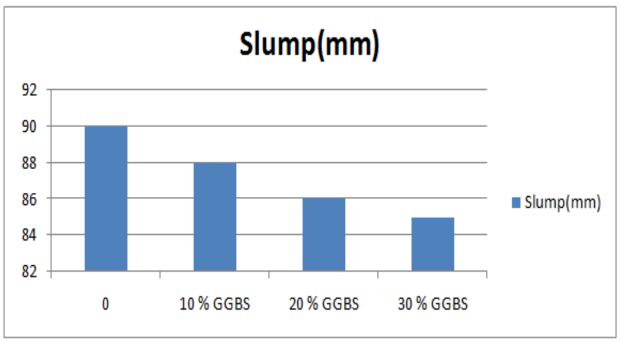
FINE AGGREGATES:

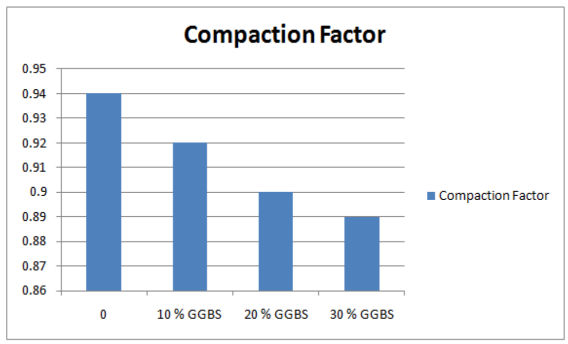
Sl.no	Test	Result	Is code used	Acceptable limits
1	Fineness modulus	4.305	IS:2386:1963	Not more than 3.2 mm
2	Specific gravity	2.43	IS:2386:1963	2.0 to 3.1
3	Porosity	36.6%	IS:2386:1963	Not greater than 100%
4	Voids ratio	0.577	IS:2386:1963	Any value
5	Bulk density	1.5424	IS:2386:1963	-
6	Bulking of sand	3.0%	IS:2386:1963	Less than 10%

CONCRETE TESTS

SLUMP TESTAND COMPACTION TEST FOR M20 GRADE OF CONCRETE

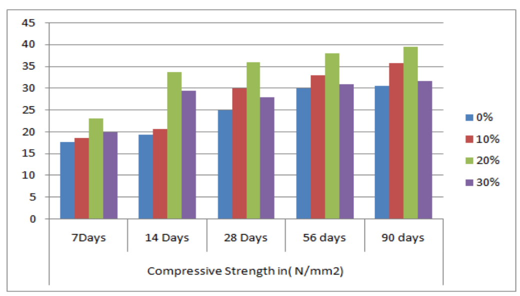
Type of Mix	Slump(mm)	Compaction Factor
0 %	90	0.94
10 % GGBS	88	0.92
20 % GGBS	86	0.9
30 % GGBS	85	0.89





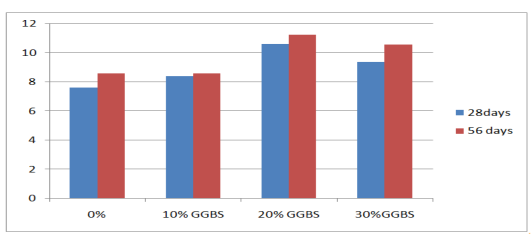
COMPRESSIVE STRENGTH

Type of Mix	Compressive Strength in(N/mm^2)				
	7Days	14 Days	28 Days	56 days	90 days
0%	17.56	19.26	24.8	29.82	30.52
10% GGBS	18.5	20.56	29.8	32.8	35.6
20% GGBS	23	33.7	35.9	37.89	39.4
30% GGBS	19.8	29.32	27.84	30.85	31.5



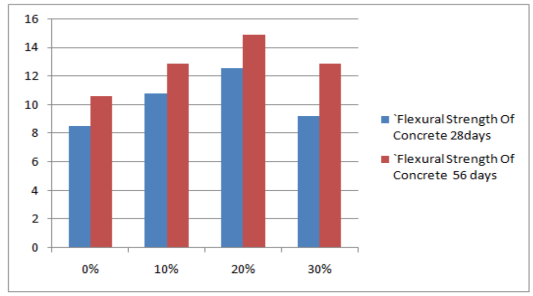
SPLIT TENSILE STRENGTH

S.no	Type of Mix	Split Tensile Strength Of Concrete	
		28days	56 days
1	0%	7.62	8.6
2	10% GGBS	8.4	8.6
3	20% GGBS	10.62	11.25
4	30%GGBS	9.4	10.58



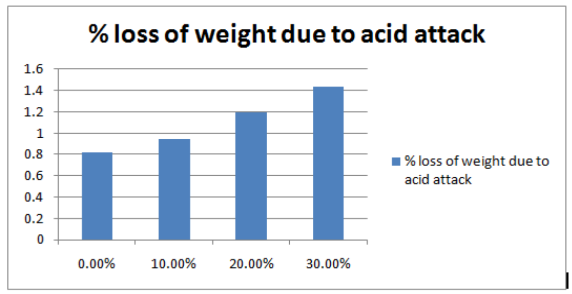
FLEXURAL STRENGTH

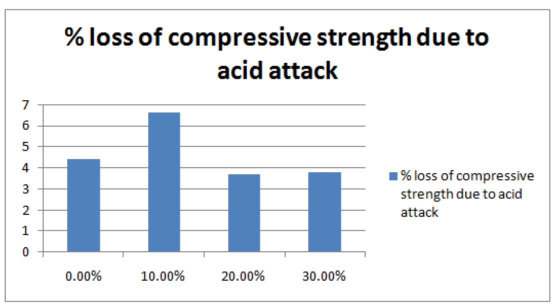
S.no	Type of Mix	`Flexural Strength Of Concrete	
		28days	56 days
1	0%	8.52	10.56
2	10%	10.8	12.85
3	20%	12.56	14.86
4	30%	9.2	12.86



DURABILITY TEST

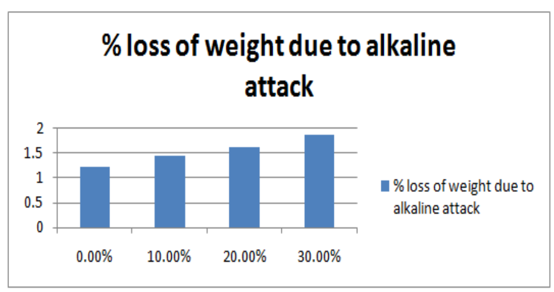
Sl.no	% replacement	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to acid attack
1	0.00%	2261	2242	0.82	26.8	22.4	4.4
2	10.00%	2340	2318	0.94	28.2	21.6	6.6
3	20.00%	2351	2323	1.2	29.3	25.6	3.7
4	30.00%	2234	2202	1.44	27.6	23.8	3.8

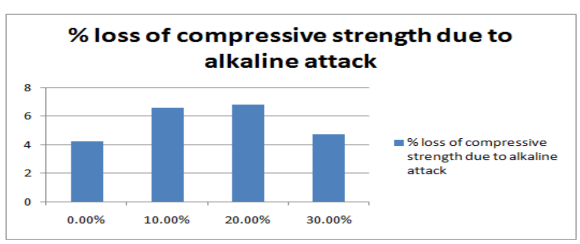




ALKALINE ATTACK

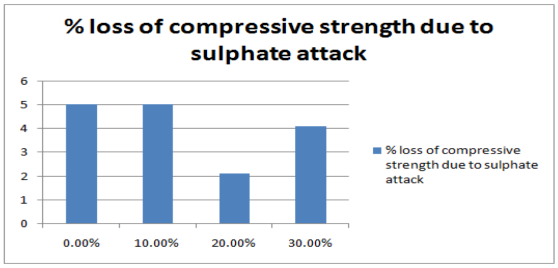
Sl. No	% replacement	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to alkaline attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to alkaline attack
1	0.00%	2286	2259	1.2	26.8	22.6	4.2
2	10.00%	2340	2306	1.44	28.2	21.6	6.6
3	20.00%	2280	2244	1.6	29.3	22.5	6.8
4	30.00%	2310	2268	1.84	27.6	22.9	4.7





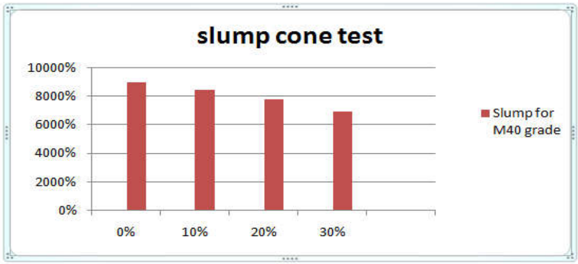
SULPHATE ATTACK

Sl.no	% replacement	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to sulphate attack
1	0.00%	26.5	21.5	5
2	10.00%	27.5	22.5	5
3	20.00%	28.6	26.5	2.1
4	30.00%	24.6	20.5	4.1



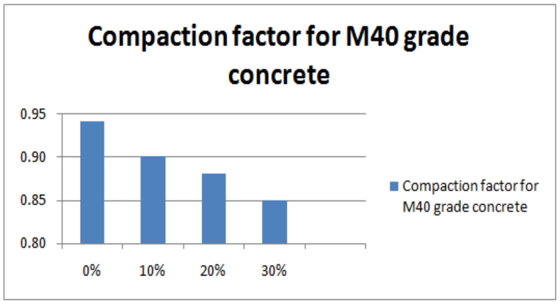
M40 GRADE OF CONCRETE

S.NO	% Replacement of GGBS	Slump for M40 grade
1	0%	90
2	10%	85
3	20%	78
4	30%	69



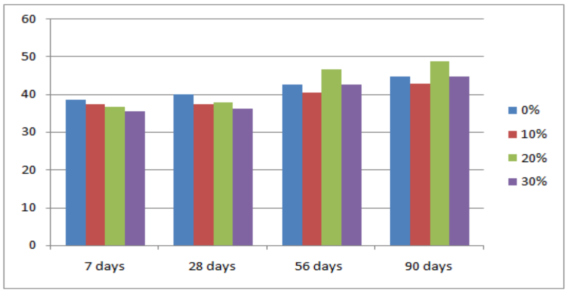
compaction test

S.NO	% Replacement of GGBS	Compaction factor for M40 grade concrete
1	0%	0.94
2	10%	0.90
3	20%	0.88
4	30%	0.85



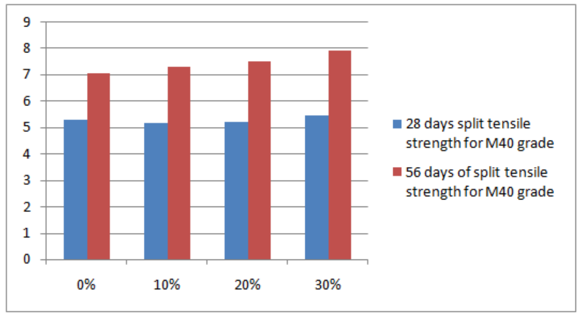
Compressive Strength

s.no	% replacement of GGBS	Compressive strength of concrete M40 grade concrete			
		7 days	28 days	56 days	90 days
1	0%	38.6	39.86	42.5	44.6
2	10%	37.24	37.44	40.5	42.8
3	20%	36.6	37.9	46.5	48.6
4	30%	35.4	36.2	42.5	44.6



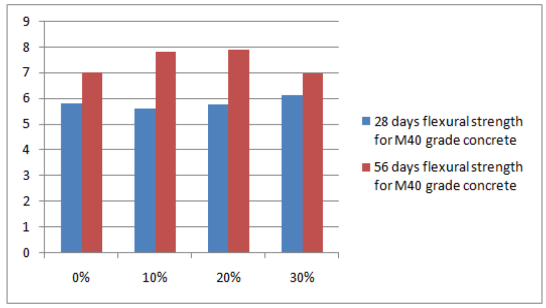
SPLIT TENSILE STRENGTH

S.no	% Replacement of GGBS	28 days split tensile strength for M40 grade	56 days of split tensile strength for M40 grade
1	0%	5.28	7.05
2	10%	5.16	7.29
3	20%	5.2	7.5
4	30%	5.46	7.88



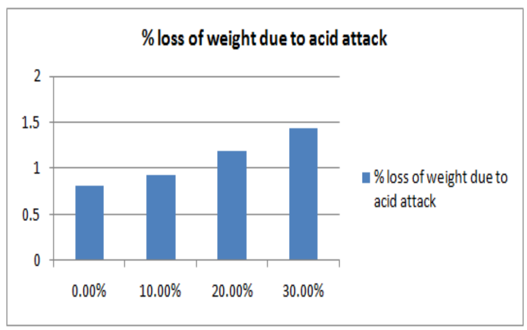
FLEXURAL STRENGTH

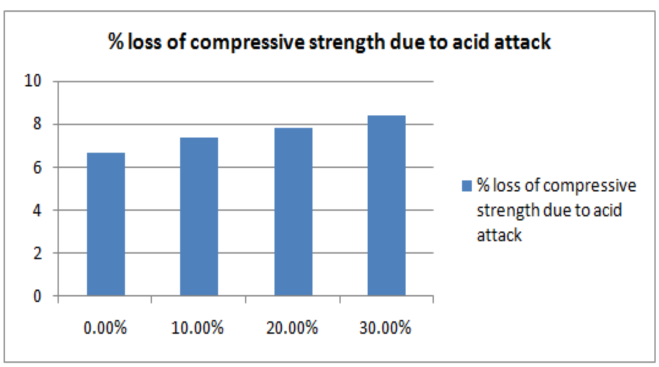
S.no	% Replacement of GGBS	28 days flexural strength for M40 grade concrete	56 days flexural strength for M40 grade concrete
1	0%	5.8	7.02
2	10%	5.6	7.8
3	20%	5.74	7.9
4	30%	6.1	6.95



DURABILITY TESTS

Sl.no	% replacement	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to acid attack
1	0.00%	2261	2242	0.82	99.55	92.94	6.64
2	10.00%	2340	2318	0.94	100.19	92.78	7.4
3	20.00%	2351	2323	1.2	102.016	94.06	7.8
4	30.00%	2234	2202	1.44	100.47	92.03	8.4





ALKALINE ATTACK

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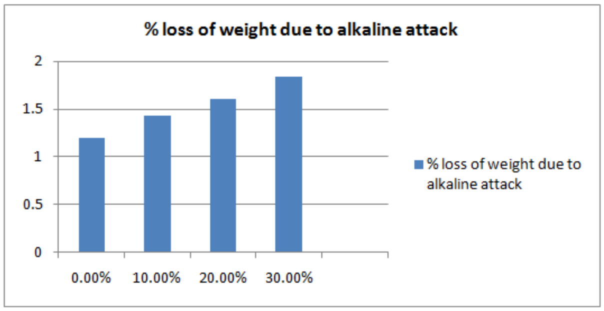
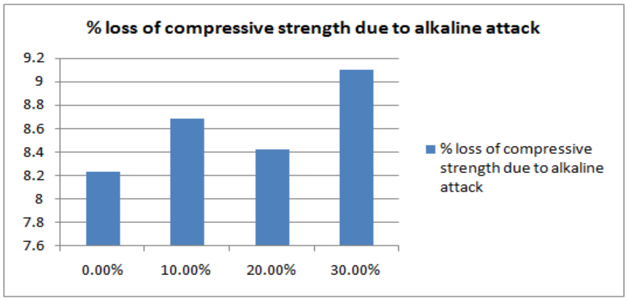
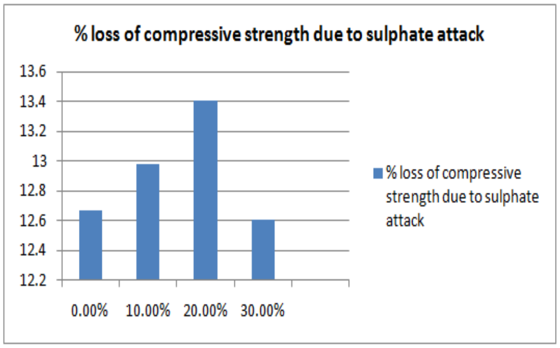
1	0.00%	2286	2259	1.2	99.55	91.36	8.23
2	10.00%	2340	2306	1.44	100.19	91.5	8.68
3	20.00%	2280	2244	1.6	102.016	93.43	8.42
4	30.00%	2310	2268	1.84	100.47	91.33	9.1





SULPHATE ATTACK

Sl.no	% replacement	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to sulphate attack
1	0.00%	99.55	86.95	12.66
2	10.00%	100.19	87.18	12.98
3	20.00%	102.016	88.35	13.4
4	30.00%	100.47	87.81	12.6



V.CONCLUSIONS

1. The material properties of the cement, fine aggregates and coarse aggregates are within the acceptable limits as per IS code recommendations so we will use the materials for research.
2. Slump cone value for the GGBS concrete decreases with increasing in the percentage of GGBS so the concrete was workable up to 20 %.
3. Compaction factor value of GGBS concrete decreases with increase in the percentage of GGBS
4. The compressive strength of concrete is maximum at 20% replacement of GGBS is the optimum value for 7days curing and 28days curing
5. Split tensile strength for the cylindrical specimens is maximum at 20% of replacement of GGBS for 28days curing.

6. The flexural strength of GGBS concrete is also maximum at 20% replacement of GGBS for 28 days of curing.
7. The optimum percentage of GGBS in both normal and standard concrete is 20%.

So the replacement of 10% to 20% of GGBS is generally useful for better strength values in M 20 and M40 grade of concrete.

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