Effect of Incorporation of Iron Blast Furnace Slag, Barytes Powder as Replacement to Sand and Cement and Addition of Glass Fiber on The Durability Properties of M_{30} Grade Concrete

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Abstract: *Ordinary Portland cement is a leading material used in construction industry. Cement concrete is an universal material and the second largest material consumed after water. However, cement concrete is brittle, weak in tension and flexure. Many studies have been conducted to improve the mechanical and durability properties of opc concrete. Sand is naturally available material and iron blast furnace slag is a waste product generated from the manufacture of steel. Barytes is a mineral and it is available at cheaper cost locally. Glass fibers improve the mechanical properties of concrete. In the present investigation, an attempt is made to study the durability properties of M_{30} grade concrete incorporated with iron blast furnace slag as replacement to sand from 20% to 100% at 20% increment and barytes powder as replacement to cement 5%, 7.5% and 10%. Studies were also conducted on the durability properties of M_{30} grade concrete with 1% glass fiber, cement replaced by barytes powder at 5%, 7.5% and 10% and sand replaced with iron blast furnace slag at 60% acid resistance, alkaline resistance, chloride permeability and water permeability tests were conducted to find the durability of concrete. It is observed that the durability properties of M_{30} grade concrete can be improved by incorporation of iron blast furnace slag fine aggregate as partial replacement to sand and barytes powder as replacement to cement up to 7.5% and addition of glass fiber 1%. Further the experimental results show that sand can be replaced with locally available iron blast furnace slag as fine aggregate in M_{30} grade concrete.*

Keywords: Barites powder, Iron Blast Furnace Slag, Glass fiber Reinforced concrete

1. INTRODUCTION

Cement is a widely used material in the construction. Cement is a chief material in the concrete which acts as a binding material in presence of water and produces concrete which gives strength and can resist weathering actions. Natural river sand is widely used as fine aggregate in OPC concrete in India and across the world at large. Sand is uniqutous in construction and industrial production because it is cheap, versatile and easy to acquire yet all indications are that we are approaching a future where access to this resource is a critical barrier to sustainability and the full costs of uncontrolled sand extraction rates are exceeding natural sand replenishment rates [1]. The environmental and social impacts of sand extraction is an issue of global significance [2]. Blast furnace slag has been used extensively as a successful material for replacement material for Portland cement in concrete materials to

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improve durability [3]. Barytes is a mineral form of barium sulphate Baso4. Mangampet deposit in kadapa dist of A.P is the single largest barytes deposit in the world [4].The baryte group consists of baryte, Celestine, anglesite, and an hydrite. Baryte and Celestine form a solid solution SO_4. Barite powder can occur in numerous colors, white, brown, yellow, red and gray are most common. Barytes is an inert material and can resist chloride effect on concrete. Similarly due to its heavy weight, the barytes particles fill the voids and improve the micro structure of cement concrete leading to imparting durability to concrete. The replacement of barites powder up to 7.5% showed good resistance to chloride permeability, water permeability. The electrical resistivity improves up to 10% of replacement of cement with barites powder[5]. The blast furnace (BF) is charged with iron ore, fluxing material and coke as gasoline and the lowering agent inside the manufacturing of iron. Blast furnace slag is a broach from the furnace as a liquid that contains gases control in solution. Air-cooled blast-furnace slag is allowable to solidify underneath the prevailing part conditions, either during a pit adjacent to the chamber, or in one a long way away to that it's transported in giant ladles. Glass Fiber Reinforced concrete (GFRC) or (GRC) is a form of fiber strengthened concrete. This concrete is excellent for fabricating shapes at the front of buildings and it's less dense than steel. GFRC is a form of concrete that uses sand, cement, polymer (normally an acrylic polymer), water, other admixtures and alkali- resistant glass fiber[6].Iron blast furnace slag was proved to be a good replacement to fine aggregate. Its physical properties are similar to that of the fine aggregate [7]. The replacement of 15% of wt. silica sand with barite aggregate showed the best performance. Barite aggregates can be used in GFRC mixes for specific purposes such as radiation protection[8]. 10% of $MGSO_4$ solution has been used to find out sulphate attack. For 10% of palm oil fuel ash residual compressive strength had slightly increased. Beyond that residual compressive strength has been reduced [9]. Hydrochloric acid (HCL), solution was prepared by mixing 5% of concentrated HCL with one liter of distilled water. The test was conducted at 60 days of normal curing and was concluded [10] that durability characteristics gradually increased based on the addition of glass fiber.

2. Materials and methods

Mix proportions: M30 grade concrete is used in the present investigation. The mix proportions of M30 grade concrete are shown in table 1

Table 1.

S. No	Material	Quantity
1	Cement	380kg/m^3
2	Sand	715kg/m^3
3	Coarse aggregate	1166kg/mm^3
4	Water	182lit

Concrete Mixture IS: In this mix the sand is replaced by iron blast furnace slag at 20%, 40%, 60%, 80% and 100%, in M_{30} grade concrete.

Concrete Mix IB: In this concrete mixture the sand is replaced by Iron blast furnace slag from 20% to 100% at an increases of 20% by weight of sand. And the cement is replaced by barytes powder at 5%, 7.5%, 10% in M_{30} grade controlled concrete mix.

Concrete Mix IBG: In this mix the sand is replaced by iron blast furnace slag at 20%, 40%, 60%, 80% and 100%. The cement is replaced by Barytes powder at 5%, 7.5% and 10% and 1% (by weight of cement) glass fiber is used in M_{30} grade concrete.

Mix proportions of materials

1. I_0- Iron blast furnace slag 0%, I_{20}- Iron blast furnace slag 20%, I_{40}- Iron blast furnace slag 40%, I_{60}- Iron blast furnace slag 60%, I_{80}- Iron blast furnace slag 80%, I_{100}- Iron blast furnace slag 100%

2. B_5- Barytes 5%, $B_{7.5}$- Barytes 7.5%, B_{10}- Barytes 10%

3. G_1- Glass fiber 1%

Various materials used in the present investigation are

Cement, Fine Aggregate, Coarse Aggregate, Barytes Powder, Iron Blast Furnace Slag, Water.

2.1. Cement

In this study, 53 grade Ordinary Portland Cement manufactured by Bharathi cement industries, confirming to IS 12269is used. The physical properties of cement is presented in the table 2.

Table 2. Properties of Cement

S. No	Properties	Numerical values
1	Fineness	8.6%
2	Specific gravity	3.15
3	Initial setting time	41min
4	Final setting time	468min

2.2. Fine aggregate

For this study, natural sand which is brought from cheyeru river near Nandalur which confirms to zone-II of IS: 383-1970 is used as fine aggregate. The specific gravity of sand is 2.72. The sieve analysis and the properties are shown in table.

Table 3. Fine Aggregates Properties

S. No	Particulars	Results
1	Type	Normal Sand
2	Specific gravity	2.72
3	Fineness modulus	3.13
4	Bulk density	1522 kg/m3

2.3. Coarse aggregate

In the present study crushed aggregate of 20mm size is used. Coarse aggregate is obtained from stone crusher unit situated near Rajampet. Fineness modulus is obtained by conducting sieve analysis. The properties of coarse aggregate are shown

Table 4. Coarse Aggregate's Physical Properties

S. No	Properties	Value
1	Size of Aggregate	20mm down graded
2	Specific gravity	2.74
3	Bulk density	1662kg/m^3
4	Shape	Angular

2.4. Barites powder

Baryte, barite or barites is a mineral consisting of barium sulfate. The Baryte group consists of Baryte, Celestine. Its main properties are its specific gravity (4.2), very low solubility; it is non-toxic, and also chemically and physically unreactive. Low quality of barites which is available at mangampeta in kodur, kadapa (dist) is used.

Table 5. Properties of Barite in the Present Investigation

S. No	Property	Results
1	Colour	Light grey
2	Specific Gravity	4.20
3	Fineness	1.8%

2.5. Iron blast furnace slag

The iron blast furnace slag obtained from local mini steel industry which is in Rajampet is used in the present investigation.

Table 6. Physical Properties of Iron Blast Furnace Slag

S. No	Particulars	Results
1	Specific gravity	3.0
2	Fineness modulus	3.14
3	Bulk density	1563 kg/m^3
4	Size	ZONE-II
5	Colour	Black

2.6. Glass fiber

The glass fiber used in the present investigation in procured from Bhuddha suppliers, Mumbai.

Table 7. Properties of Glass Fiber Reinforced Concrete

S. No	Particulars	Results
1	Diameter	14 microns
2	Length	12mm
3	Specific gravity	2.68

2.7. Water

Water used in the present study is from bore well located in the AITS campus.

3. Results and Discussion

3.1. Acid test

To find the acid resistance of various concrete mixtures the concrete cubes casted with control concrete, concrete with blast furnace slag, barytes and glass fiber, after 28 days water curing were immersed in acid water whose pH was maintained at 2.0 throught out 90days. After 90days of immersion, the cubes were removed from acid water, and tested for compressive strength duly following the procedure given in IS-516- 1959 for testing. The increase or decrease in compressive strength of various mixes compared to the compressive strength of M30 control concrete which were cured in water for 28days and immersed in acid water of pH 2.0 for 90days.

3.1.1. Acid resistance of concrete cubes with sand replaced by iron blast furnace slag

General:

The reduction in increase in the compressive strength of concrete cubes of different composition are compared with the compressive strength of control M30 grade concrete cubes which are cured in water for 28days and immersed in acid water for 90 days. The Ph of acid water is maintained contantly at 2.0. Compressive strength higher than the control concrete strength.

The acid resistance is assessed by comparing the compressive strength of different concrete cubes which are immersed in acid water pH-2.0 for 90days after 28 days of water curing with similar control concrete specimens

In M30 grade concrete the sand is replaced by 20%, 40%, 60%, 80%, 100% of iron slag and cubes were casted. After 28 days water curing, the cubes are immersed in acid water whose pH value is maintained at 2. After 90 days of immersion in acid water, the cubes are taken out from the acid water and tested for compressive strength as per the procedure given in IS 516: 1959. The compressive strength results are shown in table 8

Table 8. Acid Resistance Results for Cubes

S. No	Mix designation on	% Replacement		Compressive strength N/mm^2 120 days
		Fine (sand) Aggregate	Iron blast furnace Slag	
1	I_0	100	-	32.3
2	I_{20}	80	20	30.4
3	I_{40}	60	40	31.53
4	I_{60}	40	60	33.84
5	I_{80}	20	80	33.33
6	I_{100}	-	100	30.76

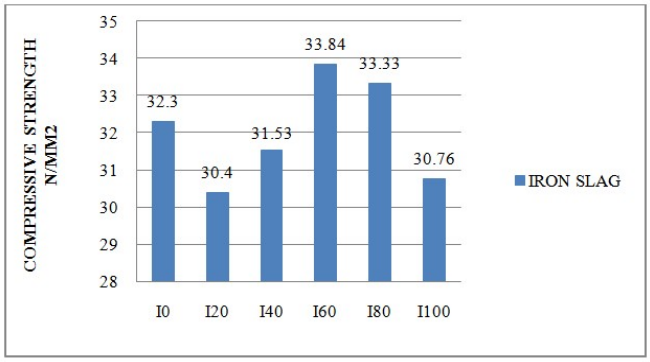

Figure 1. Acid Resistance of Concrete Cubes

For the concrete cubes tested at 120days the compressive strength is measured and the graphical representation of compressive strength of concrete is shown in figure 1.

From the above table it is observed that the strength of M30 grade concrete decreases with increase in the percentage of replacement of Iron Blast Furnace slag. The compressive strength of M30 grade concrete with complete replacement of 100% sand by Iron Blast Furnace Slag is 30.76N/mm2 which is 19.52% less than the strength of control concrete. The compressive strength of with 20%, 40%, 60%, 80% and 100% Iron Blast Furnace Slag are 30.4N/mm2, 31.53N/mm2, 33.84N/mm2, 33.33N/mm2, 30.76N/mm2 respectively.

3.1.2. Acid resistance of concrete cubes with cement replaced by barites 5% and sand replaced by iron blast furnace slag

In M30 grade concrete the sand content is replaced by 20%, 40%, 60%, 80%, 100% with iron slag and cement is replaced by 5% with barytes and cubes were casted. After 28 days curing, the cubes are immersed in acid water whose ph value is maintained at 2. After 90 days of immersion in acid water, the cubes are taken out from the curing tank and tested for compressive strength as per the procedure given in IS 516: 1959. The compressive strength results were shown in table 9.

Table 9. Acid Resistance Results for Cubes

S. No	Mix designation on	% Replacement			Compressive strength N/mm^2 120 days
		Fine aggregate	Iron blast furnace Slag	Barytes%	
1	I_0B_5	100	-	5	32.85
2	$I_{20}B_5$	80	20	5	30.51
3	$I_{40}B_5$	60	40	5	32.05
4	$I_{60}B_5$	40	60	5	34.36
5	$I_{80}B_5$	20	80	5	33.91
6	$I_{100}B_5$	-	100	5	31.23

For the concrete cubes tested at 120 days, the compressive strength is measured and the graphical representation of compressive strength of concrete is shown in figure 2.

From the above table it is observed that the strength of M30 grade concrete decreases with increase in the percentage of replacement of Iron Blast Furnace slag and Barytes. The compressive strength of M30 grade concrete with complete replacement of 100% sand by Iron Blast Furnace Slag is 31.23N/mm2 which is 19.50% less than the strength of control concrete. The compressive strength of with 20%, 40%, 60%, 80% and 100% Iron Blast Furnace Slag and Barytes 5% are 30.51N/mm^2, 32.05N/mm^2, 34.36N/mm^2, 33.91N/mm^2, 31.23N/mm^2 respectively.

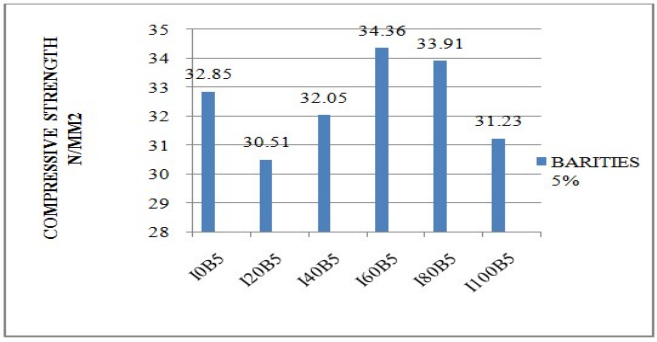

Figure 2. Acid Resistance of Concrete Cubes

3.1.3. Acid resistance of concrete cubes with cement replaced by barites 7.5% and sand replaced by iron blast furnace slag

In M30 grade concrete the sand content is replaced by 20%, 40%, 60%, 80%, 100% with iron slag and cement is replaced by 7.5% with barytes and cubes were casted. After 28 days curing, the cubes are immersed in acid water whose ph value is maintained at 2. After 90 days of immersion in acid water, the cubes are taken out from the curing tank and tested for compressive strength as per the procedure given in IS 516: 1959. The compressive strength results were shown in table 10.

Table 10. Acid Resistance Results for Cubes

S. No	Mix designation on	% Replacement			Compressive strength N/mm^2 120 days
		Fine aggregate	Iron blast furnace Slag	Barytes%	
1	$I_0B_{7.5}$	100	-	7.5	33.17
2	$I_{20}B_{7.5}$	80	20	7.5	31.42
3	$I_{40}B_{7.5}$	60	40	7.5	32.56
4	$I_{60}B_{7.5}$	40	60	7.5	35.10
5	$I_{80}B_{7.5}$	20	80	7.5	34.81
6	$I_{100}B_{7.5}$	-	100	7.5	32.13

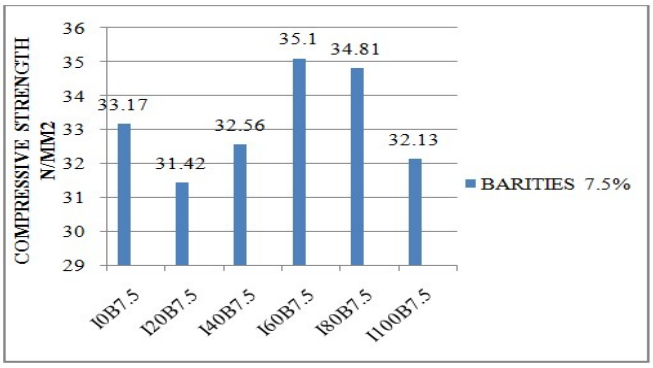

Figure 3. Acid Resistance of Concrete

For the concrete cubes tested at 120 days, the compressive strength is measured and the graphical representation of compressive strength of concrete is shown in figure 3.

From the above table it is observed that the strength of M30 grade concrete decreases with increase in the percentage of replacement of Iron Blast Furnace slag and Barytes. The compressive strength of M30 grade concrete with complete replacement of 100% sand by Iron Blast Furnace Slag and barytes 5% is 32.13N/mm2 which is 19.6% less than the strength of control concrete. The compressive strength of with 20%, 40%, 60%, 80% and 100% Iron Blast Furnace Slag and barytes 5% are 31.42N/mm^2, 32.56N/mm^2, 35.10N/mm^2, 34.81N/mm^2, 32.13N/mm^2 respectively.

3.1.4. Acid resistance of concrete cubes with cement replaced by barites 10% and sand replaced by iron blast furnace slag

In M30 grade concrete the sand content is replaced by 20%, 40%, 60%, 80%, 100% with iron slag and cement is replaced by 10% with barytes and cubes were casted. After 28 days curing, the cubes are immersed in acid water whose ph value is maintained at 2. After 90 days of immersion in acid water, the cubes are taken out from the curing tank and tested for compressive strength as per the procedure given in IS 516: 1959. The compressive strength results were shown in table 11.

Table 11. Acid Resistance Results for Cubes

S. No	Mix designation on	% Replacement			Compressive strength N/mm^2 120 days
		Fine aggregate	Iron blast furnace Slag	Barytes%	
1	$I_0B_{7.5}$	100	-	10	32.14
2	$I_{20}B_{7.5}$	80	20	10	29.40
3	$I_{40}B_{7.5}$	60	40	10	30.51
4	$I_{60}B_{7.5}$	40	60	10	32.83
5	$I_{80}B_{7.5}$	20	80	10	32.14
6	$I_{100}B_{7.5}$	-	100	10	29.80

For the concrete cubes tested at 120 days, the compressive strength is measured and the graphical representation of compressive strength of concrete is shown in figure 4.

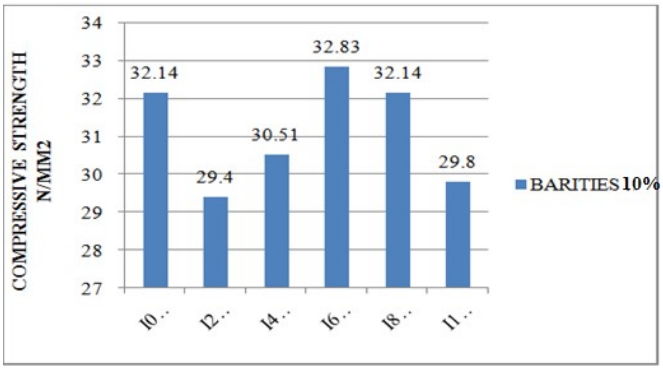

Figure 4. Acid Resistance of Concrete Cubes

From the above table it is observed that the strength of M30 grade concrete decreases with increase in the percentage of replacement of Iron Blast Furnace slag and Barytes. The compressive strength of M30 grade concrete with complete replacement of 100% sand by Iron Blast Furnace Slag and barytes 10% is 29.80N/mm2 which is 19.2% less than the strength of control concrete. The compressive strength of with 20%, 40%, 60%, 80% and 100% Iron Blast Furnace Slag and Barytes 10% are 29.40N/mm^2, 30.51N/mm^2, 32.83N/mm^2, 32.14N/mm^2, 29.80N/mm^2 respectively.

3.1.5. Acid resistance of concrete cubes with sand replaced by iron slag and glass fiber

The replacement of iron blast furnace slag with Fine aggregate for the percentage of 60 and the glass fiber reinforced concrete for the percentage of 1 the acid compressive strength for M30 grade concrete results were shown in table 12.

Table 12. Acid Resistance Results for Cubes

S. No	Mix designation on	% Replacement				Compressive strength N/mm^2 120 days
		Fine aggregate	Iron blast furnace Slag	Barytes%	% OF GLASS FIBER	
1	$I_0B_0G_1$	100	0	-	1	33.10
2	$I_{60}B_0G_1$	40	60	-	1	34.55
3	$I_{60}B_5G_1$	40	60	5	1	33.84
4	$I_{60}B_{7.5}G1$	40	60	7.5	1	34.88
5	$I_{60}B_{10}G_1$	40	60	10	1	33.21

For the concrete cubes tested at 120 days, the compressive strength is measured and the graphical representation of compressive strength of concrete is shown in figure 5.

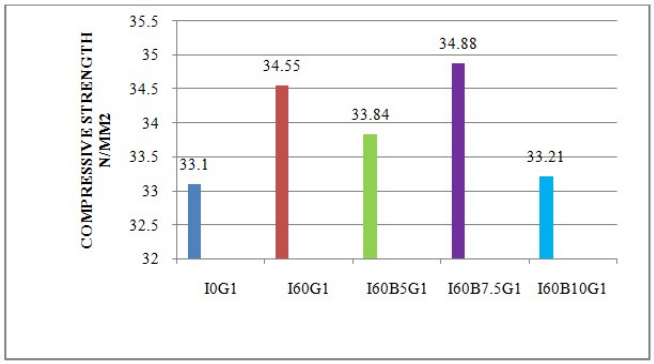

Figure 5. Acid Resistance of Concrete Cubes

From the above table it is observed that the strength of M30 grade concrete increases in the percentage of replacement of Iron Blast Furnace slag, Barytes and Glass Fiber. The compressive strength of M30 grade concrete with replacement of 60% sand by Iron Blast Furnace Slag and Cement by barytes5%, 7.5%, 10% and glass fiber is 1% are 33.84N/mm^2, 34.88N/mm^2, 33.21N/mm^2, respectively.

3.2. Alkaline

To find the alkaline resistance of various concrete mixtures the concrete cubes casted with control concrete, concrete with blast furnace slag, barytes and glass fiber, after 28 days water curing were immersed in alkaline water whose pH was maintained at 12 throught out 90days. After 90days of immersion, the cubes were removed from alkaline water, and tested for compressive strength duly following the procedure given in IS-516- 1959 for testing. The increase or decrease in compressive strength of various mixes compared to the compressive strength of M_{30} control concrete which were cured in water for 28days and immersed in alkaline water of pH 12 for 90days.

3.2.1. Alkaline resistance of concrete cubes with sand replaced by iron blast furnace slag

In M30 grade concrete the sand content is replaced by 20%, 40%, 60%, 80%, 100% with iron slag and cubes were casted. After 28 days curing the cubes are immersed in alkaline water whose ph value is maintained at 12. After 90 days of immersion in alkaline water the cubes are taken out from the curing tank and tested for compressive strength as per the procedure given in Is 516:1959. The compressive strength results were shown in table 13.

Table 13. Alkaline Resistance Results for Cubes

S. No	Mix designation on	% Replacement		Compressive strength N/mm^2 120 days
		Fine (sand) Aggregate	Iron blast furnace Slag	
1	I_0	100	-	32.90
2	I_{20}	80	20	31.42
3	I_{40}	60	40	32.73
4	I_{60}	40	60	33.15

5	I_{80}	20	80	33.28
6	I_{100}	-	100	32.36

For the concrete cubes tested at 120 days, the compressive strength is measured and the graphical representation of compressive strength of concrete is shown in figure 6.

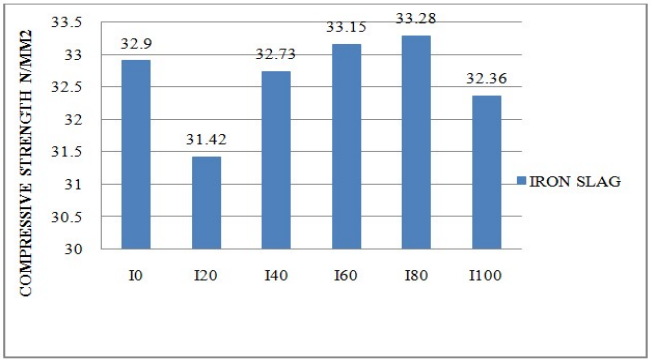

Figure 6. Alkaline Resistance of Concrete Cubes

From the above table it is observed that the strength of M30 grade concrete decreases with increase in the percentage of replacement of Iron Blast Furnace slag. The compressive strength of M30 grade concrete with complete replacement of 100% sand by Iron Blast Furnace Slag is 32.36N/mm2 which is 19.8% less than the strength of control concrete. The compressive strength of with 20%, 40%, 60%, 80% and 100% Iron Blast Furnace Slag are 31.42N/mm^2, 32.73N/mm^2, 33.15N/mm^2, 33.28N/mm^2, 32.36N/mm^2 respectively.

3.2.2. Alkaline resistance of concrete cubes with cement replaced by barities 5% and sand replaced by iron blast furnace slag

In M30 grade concrete the sand content is replaced by 20%, 40%, 60%, 80%, 100% with iron slag and cement is replaced by 5% barites and cubes were casted. After 28 days curing the cubes are immersed in alkaline water whose ph value is maintained at 12. After 90 days of immersion in alkaline water the cubes are taken out from the curing tank and tested for compressive strength as per the procedure given in Is 516:1959. The compressive strength results were shown in table 14.

Table 14. Alkaline Resistance Results for Cubes

S. No	Mix designation on	% Replacement			Compressive strength N/mm^2 120 days
		Fine aggregate	Iron blast furnace Slag	Barytes%	
1	I_0B_5	100	-	5	32.90
2	$I_{20}B_5$	80	20	5	31.26
3	$I_{40}B_5$	60	40	5	33.0
4	$I_{60}B_5$	40	60	5	33.78
5	$I_{80}B_5$	20	80	5	34.56
6	$I_{100}B_5$	-	100	5	32.85

For the concrete cubes tested at 120 days, the compressive strength is measured and the graphical representation of compressive strength of concrete is shown in figure 7.

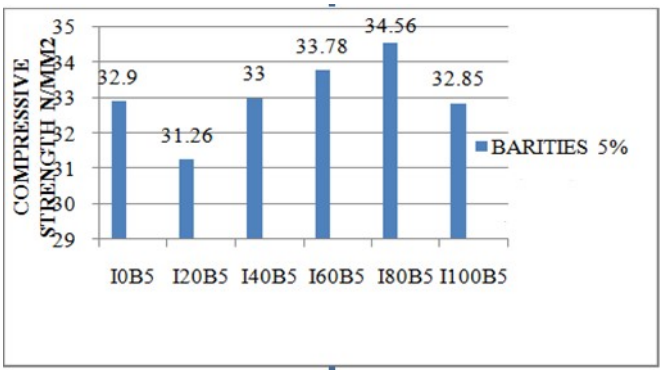

Figure 7. Alkaline Resistance of Concrete Cubes

From the above table it is observed that the strength of M30 grade concrete decreases with increase in the percentage of replacement of Iron Blast Furnace slag and Barytes. The compressive strength of M30 grade concrete with complete replacement of 100% sand by Iron Blast Furnace Slag and Barytes 5% is 32.85N/mm2 which is 19.9% less than the strength of control concrete. The compressive strength of with 20%, 40%, 60%, 80% and 100% Iron Blast Furnace Slag and Barytes 5% are 31.26N/mm^2, 32.0N/mm^2, 33.78N/mm^2, 34.56N/mm^2, 32.85N/mm^2 respectively.

3.2.3. Compressive strength of concrete cubes with cement replaced by barities 7.5% and sand replaced by iron blast furnace slag

In M30 grade concrete the sand content is replaced by 20%, 40%, 60%, 80%, 100% with iron slag and cement is replaced by 7.5% barites and cubes were casted. After 28 days curing the cubes are immersed in alkaline water whose ph value is maintained at 12. After 90 days of immersion in alkaline water the cubes are taken out from the curing tank and tested for compressive strength as per the procedure given in Is 516:1959. The compressive strength results were shown in table 15.

Table 15. Alkaline Resistance Results for Cubes

S. No	Mix designation on	% Replacement			Compressive strength N/mm^2 120 days
		Fine aggregate	Iron blast furnace Slag	Barytes%	
1	$I_0B_{7.5}$	100	-	7.5	33.19
2	$I_{20}B_{7.5}$	80	20	7.5	32.13
3	$I_{40}B_{7.5}$	60	40	7.5	33.30
4	$I_{60}B_{7.5}$	40	60	7.5	33.82
5	$I_{80}B_{7.5}$	20	80	7.5	34.70
6	$I_{100}B_{7.5}$	-	100	7.5	33.15

For the concrete cubes tested at 120 days, the compressive strength is measured and the graphical representation of compressive strength of concrete is shown in figure 8.

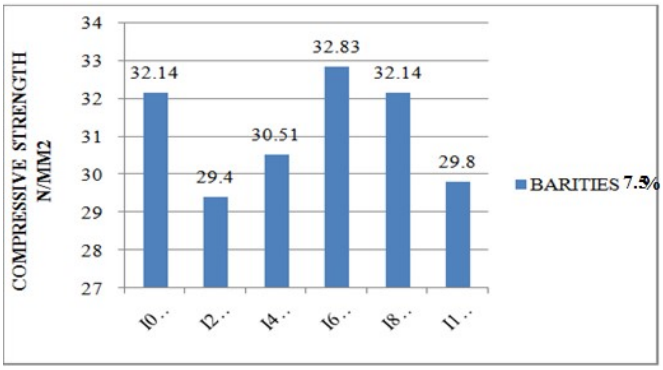

Figure 8. Alkaline Resistance of Concrete Cubes

From the above table it is observed that the strength of M30 grade concrete decreases with increase in the percentage of replacement of Iron Blast Furnace slag and Barytes. The compressive strength of M30 grade concrete with complete replacement of 100% sand by Iron Blast Furnace Slag and Barytes 7.5% is 33.15/mm2 which is 19.9% less than the strength of control concrete. The compressive strength of with 20%, 40%, 60%, 80% and 100% Iron Blast Furnace Slag and Barytes are 33.19N/mm^2, 33.30N/mm^2, 33.82N/mm^2, 34.70N/mm^2, 33.15N/mm^2 respectively.

3.2.4. Alkaline resistance of concrete cubes with cement replaced by barities 10% and sand replaced by iron blast furnace sag

In M30 grade concrete the sand content is replaced by 20%, 40%, 60%, 80%, 100% with iron slag and cement is replaced by 10% barites and cubes were casted. After 28 days curing the cubes are immersed in alkaline water whose ph value is maintained at 12. After 90 days of immersion in alkaline water the cubes are taken out from the curing tank and tested for compressive strength as per the procedure given in Is 516:1959. The compressive strength results were shown in table 16.

Table 16. Alkaline Resistance Results for Cubes

S. No	Mix designation on	% Replacement			Compressive strength N/mm^2 120 days
		Fine aggregate	Iron blast furnace Slag	Barytes%	
1	I_0B_{10}	100	-	10	32.50
2	$I_{20}B_{10}$	80	20	10	30.74
3	$I_{40}B_{10}$	60	40	10	32.11
4	$I_{60}B_{10}$	40	60	10	32.94
5	$I_{80}B_{10}$	20	80	10	33.46
6	$I_{100}B_{10}$	-	100	10	31.80

For the concrete cubes tested at 120 days, the compressive strength is measured and the graphical representation of compressive strength of concrete is shown in figure 9.

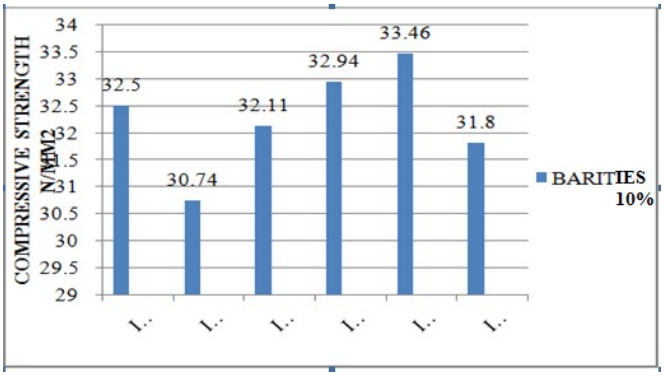

Figure 9. Alkaline Resistance of Concrete Cubes

From the above table it is observed that the strength of M30 grade concrete decreases with increase in the percentage of replacement of Iron Blast Furnace slag and Barytes. The compressive strength of M30 grade concrete with complete replacement of 100% sand by Iron Blast Furnace Slag and Barytes 10%is 31.80/mm2 which is 19.7% less than the strength of control concrete. The compressive strength of with 20%, 40%, 60%, 80% and 100% Iron Blast Furnace Slag and Barytes 10% are 30.74N/mm^2, 32.11N/mm^2, 32.94N/mm^2, 33.46N/mm^2, 31.80N/mm^2 respectively.

3.2.5. Alkaline resistance of concrete cubes with sand replaced by iron slag and glass fiber

In M30 grade concrete the sand content is replaced by 20%, 40%, 60%, 80%, 100% with iron slag and cement is replaced by 7.5% barites and cubes were casted. After 28 days curing the cubes are immersed in alkaline water whose ph value is maintained at 12. After 90 days of immersion in alkaline water the cubes are taken out from the curing tank and tested for compressive strength as per the procedure given in Is 516:1959. The compressive strength results were shown in table 17.

Table 17. Alkaline Resistance Results for Cubes

S. No	Mix designation on	% Replacement				Compressive strength N/mm^2 120 days
		Fine aggregate	Iron blast furnace Slag	Barytes%	% OF GLASS FIBER	
1	I_0G_1	100	0	-	1	33.6
2	$I_{60}G_1$	40	60	-	1	34.81
3	$I_{60}B_5G_1$	40	60	5	1	34.11
4	$I_{60}B_{7.5}G1$	40	60	7.5	1	34.75
5	$I_{60}B_{10}G_1$	40	60	10	1	33.60

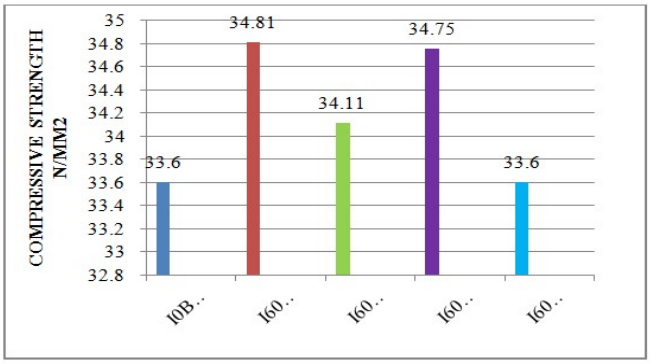

Figure 10. Alkaline Resistance of Concrete Cubes

For the concrete cubes tested at 90 days, the compressive strength is measured and the graphical representation of compressive strength of concrete is shown in figure 10.From the above table it is observed that the strength of M30 grade concrete increases in the percentage of replacement of Iron Blast Furnace slag, Barytes and Glass Fiber. The compressive strength of M30 grade concrete with replacement of 60% sand by Iron Blast Furnace Slag and Cement by barytes5%, 7.5%, 10% and glass fiber is 1% are 34.11N/mm^2, 34.75N/mm^2, 33.60N/mm^2, respectively.

3.3. Rapid chloride permeability

To find the chloride permeability ie resistance to chloride ingress/ attack the concrete disc (100mm dia and 50mm height) specimens of various concrete mixtures were immersed in water for 120days and tested for the total charge passing through the specimens in 6hours duly following the procedure given in ASTM 1202-1997.

3.3.1. Rapid chloride permeability test on concrete disc specimens in which sand is replaced by iron blast furnace slag

In M30 grade concrete the sand content is replaced by 20%, 40%, 60%, 80%, 100% with iron slag and rcpt cylindrical disc were casted. The Rcpt cylindrical discs were immersed in curing tank for 120 days. After the cylindrical discs were taken out from the curing tank and tested as per the procedure given in ASTM 1202-97 and the results were shown in the table 18.

Table 18. Rapid Chloride Permeability Test Results

S. No	Mix designation	%Replacement		Charge passed in (coulombs)
		Fine (sand) Aggregate	Iron blast furnace Slag	
1	I_0	100	-	2439
2	I_{20}	80	20	2549
3	I_{40}	60	40	2466
4	I_{60}	40	60	2341
5	I_{80}	20	80	2480

6	I_{100}	-	100	2530

The results of the rapid chloride permeability test tested at 120 days for the concrete circular discs and the graphical representation of the charge passed as shown in Figure 11.

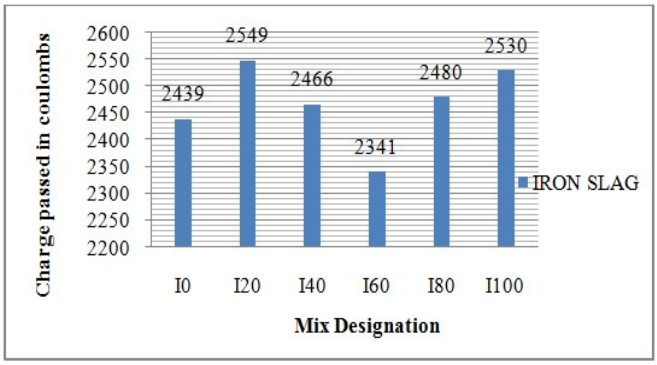

Figure 11. Rapid Chloride Permeability Test

It is observed that with the substitution of fine aggregate by iron blast furnace slag, the chloride permeability findings of M30 grade concrete are higher than regular concrete. But results show that the chloride resistance of concrete with iron blast furnace slag is moderate.

3.3.2. Rapid chloride permeability test on concrete disc specimens in which cement is replaced by barities 5% and sand replaced by iron blast furnace slag

In M30 grade concrete the sand content is replaced by 20%, 40%, 60%, 80%, 100% with iron slag and cement replace by barites 5%, 7.5%, 10% and rcpt cylindrical disc were casted. The Rcpt cylindrical discs were immersed in curing tank for 120 days. After the cylindrical discs were taken out from the curing tank and tested as per the procedure given in ASTM 1202-97. The results were shown in the table 19.

Table 19. Rapid Chloride Permeability Test Results

S. No	Mix designation	% Replacement			Charge passed in (coulombs)
		Fine aggregate	Iron blast furnace Slag	Barytes	
1	I_0B_5	100	-	5	2350
2	$I_{20}B_5$	80	20	5	2410
3	$I_{40}B_5$	60	40	5	2365
4	$I_{60}B_5$	40	60	5	2140
5	$I_{80}B_5$	20	80	5	2290
6	$I_{100}B_5$	-	100	5	2316

The results of the rapid chloride permeability test tested at 120 days for the concrete cylindrical discs and the graphical representation of the charge passed as shown in Figure 12.

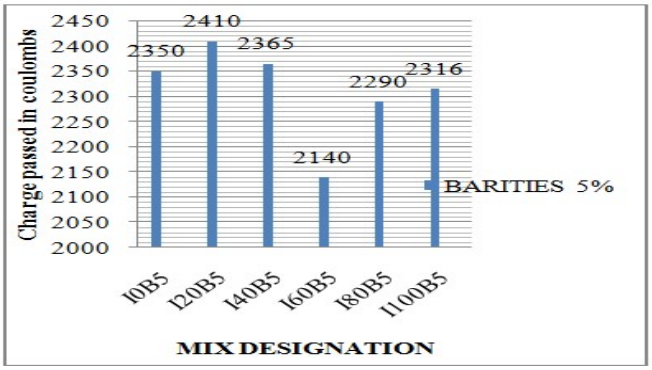

Figure 12. Rapid Chloride Permeability Test

It is observed that it is observed that with the substitution of fine aggregate by iron blast furnace slag, and cement with barites the chloride permeability findings of M30 grade concrete are higher than regular concrete. But results show that the chloride resistance of concrete with iron blast furnace slag and barytes 5% is moderate.

3.3.3. Rapid chloride permeability test on concrete disc specimens in which cement replaced by barities 7.5% and sand replaced by iron blast furnace slag

In M30 grade concrete the sand content is replaced by 20%, 40%, 60%, 80%, 100% with iron slag and cement replace by barites 7.5% and rcpt cylindrical disc were casted. The Rcpt cylindrical discs were immersed in curing tank for 120 days. After the cylindrical discs were taken out from the curing tank and tested as per the procedure given in ASTM 1202-97. The results were shown in the table 20.

Table 20. Rapid Chloride Permeability Test Results

S. No	Mix designation	% Replacement			Charge passed in (coulombs)
		Fine aggregate	Iron blast furnace Slag	Barytes	
1	$I_0B_{7.5}$	100	-	7.5	2248
2	$I_{20}B_{7.5}$	80	20	7.5	2354
3	$I_{40}B_{7.5}$	60	40	7.5	2296
4	$I_{60}B_{7.5}$	40	60	7.5	2035
5	$I_{80}B_{7.5}$	20	80	7.5	2170
6	$I_{100}B_{7.5}$	-	100	7.5	2264

The results of the rapid chloride permeability test tested at 120 days for the concrete cylindrical discs and the graphical representation of the charge passed as shown in Figure 13.

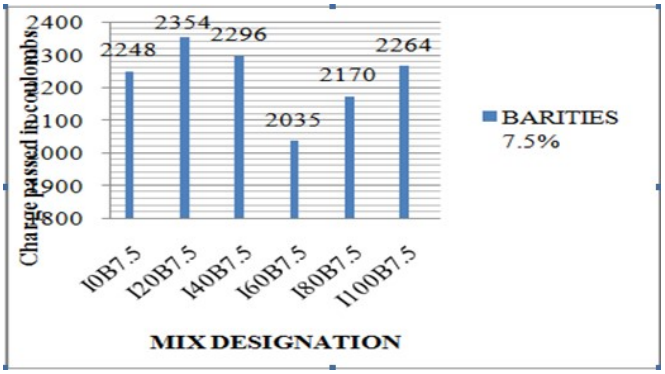

Figure 13. Rapid Chloride Permeability Test

It is observed that it is observed that with the substitution of fine aggregate by iron blast furnace slag, and cement with barites the chloride permeability findings of M30 grade concrete are higher than regular concrete. But results show that the chloride resistance of concrete with iron blast furnace slag and barytes 7.5% is moderate.

3.3.4. Rapid chloride permeability test on concrete disc specimens in which cement replaced by barities 10% and sand replaced by iron blast furnace slag

In M30 grade concrete the sand content is replaced by 20%, 40%, 60%, 80%, 100% with iron slag and cement replace by barites 10% and rcpt cylindrical disc were casted. The Rcpt cylindrical discs were immersed in curing tank for 120 days. After the cylindrical discs were taken out from the curing tank and tested as per the procedure given in ASTM 1202-97. The results were shown in the table 21.

Table 21. Rapid Chloride Permeability Test Results

S. No	Mix designation	% Replacement			Charge passed in (coulombs)
		Fine aggregate	Iron blast furnace Slag	Barytes	
1	I_0B_{10}	100	-	10	2305
2	$I_{20}B_{10}$	80	20	10	2404
3	$I_{40}B_{10}$	60	40	10	2386
4	$I_{60}B_{10}$	40	60	10	2226
5	$I_{80}B_{10}$	20	80	10	2214
6	$I_{100}B_{10}$	-	100	10	2350

The results of the rapid chloride permeability test tested at 120 days for the concrete cylindrical discs and the graphical representation of the charge passed Is shown in Figure 14.

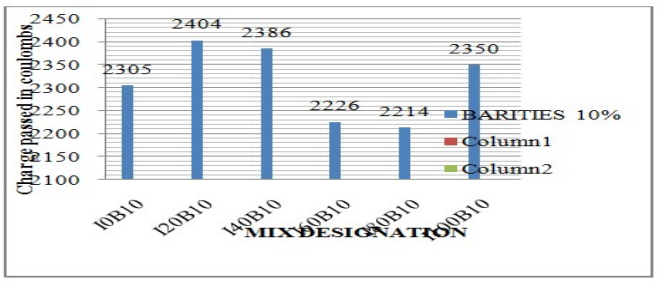

Figure 14. Rapid Chloride Permeability Test

It is observed that it is observed that with the substitution of fine aggregate by iron blast furnace slag, and cement with barites the chloride permeability findings of M30 grade concrete are higher than regular concrete. But results show that the chloride resistance of concrete with iron blast furnace slag and barytes 10% is moderate.

3.4. WATER PERMEABILITY

To find the water permeability of various concrete mixture cylindrical specimen of size200mm dia x120mm height were casted and immersed in water curing tanks and applying 5bar pressure, the depth of penetration of water into the specimen after 48 hours of application of pressure were found. The coefficient of permeability was calculated using the formula.

$$K = \frac{d^2 v}{2ht}$$

Where,

d = depth of penetration of concrete (m)

v = the fraction of volume of water /concrete occupied by pores

h = hydraulic head (m) and

t = time under pressure (seconds)

v is calculated using the expression

$$v = \frac{1000M}{Ad}$$

Where,

M = Gain in mass (g)

A = Cross sectional area of concrete (mm^2)

d = depth of penetration (mm)

3.4.1 Water permeability teston concrete with sand replaced by iron blast furnace slag, and addition of glass fiber:

In M30 grade concrete the sand content is replaced by 60% with iron slag and glass fiber 1% and the concrete cylinders were casted. The cylindrical disc is immersed in curing tank for 90 days. After the disc is taken out from the curing tank and tested for water permeability test as per the procedure IS: 3085-1965. And the results were shown in table 22.

Table 22. Water Permeability Test Results

S. No	Mix designation	%Replacement				Depth of penetration (d in cm)	Coefficient of permeability (K in m/sec)
		Fine aggregate	Iron blast furnace Slag	Barytes%	% OF GLASS FIBER		
1	$I_0B_0G_1$	100	0	0	1	1.7	$7.944x10^{-13}$
2	$I_{60}B_0G_1$	40	60	0	1	1.59	$7.307x10^{-13}$
3	$I_{60}B_5G_1$	40	60	5%	1	1.54	$6.983x10^{-13}$
4	$I_{60}B_{7.5}G1$	40	60	7.5%	1	1.4	$6.673x10^{-13}$
5	$I_{60}B_{10}G_1$	40	60	10%	1	1.44	$6.787X10^{-13}$

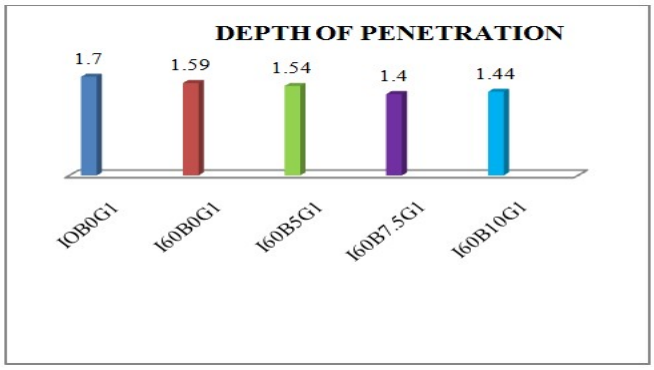

Figure 15. Water Permeability Test

The results of the water permeability test tested at 90 days for the concrete cylinders and the graphical representation of the depth of water penetration as shown in figure 15The results of M30 grade concrete water permeability show the decreases with a rise in iron blast furnace slag percentage from 60 percent fine aggregate replacement and barytes 7.5% replacement of cement.

4. Conclusion

1. The acid resistance of M30 grade concrete with Iron Blast Furnace Slag as Fine aggregate increases with increase in replacement of sand from 20% to 80%. Highest acid resistance is offered by the concrete with 60% replacement of sand by Iron Blast Furnace Slag which is 6.34% more than the M30 grade controlled concrete.
2. The acid resistance of M30 grade concrete with replacement of sand by Iron Blast Furnace Slag can be improved by the barytes powder as replacement of cement. Compared to the M30 grade controlled concrete the concrete with 60% sand replaced by Iron Blast Furnace Slag and 5%, 7.5% and10% replacement of cement by barytes powder shows 7.0%, 8.63% and 1.6% increase in acid resistance.
3. The alkaline resistance of M30 grade concrete with replacement of sand by Iron Blast Furnace Slag can be improved by the barytes powder as replacement of cement. Compared to M30 grade conventional concrete the concrete with 80% sand replaced by Iron Blast Furnace Slag and 5%, 7.5%

and10% replacement of cement by barytes powder shows increased alkaline resistance which is 5.05%, 7.39% and 1.71% more than the alakaline resistance of controlled concrete.

4. It can be concluded from test results that the acid resistance and alkaline resistance of M30 grade fiber reinforced concrete with replacement of sand by Iron Blast Furnace Slag and cement replaced by Barytes powder can be slightly improved.
5. The chloride resistance (RCPT) of M30 grade concrete with sand replaced by Iron Blast Furnace Slag can be improves by the Barytes powder as replacement to cement up to 10%.
6. The test results shows that the water permeability of M30 gradecontrolled concrete with replacement of sand by Iron Blast Furnace Slag and addition of 1% Glass fiber can be improved by the replacement of cement with barytes powder up to 10%.
7. It can be concluded that the Iron Blast Furnace Slag as replacement of sand in M30 grade concrete improves the durability properties of concrete. The replacement of Barytes powder upto 10% improves the durability properties of M30 grade concrete with replacement of sand by Iron Blast Furnace Slag.

Finally, it can be concluded that the durability of concrete will not be reduced by using Iron Blast Furnace Slag as replacement to sand and there is slight enhancement in durability when barytes powder is used as partial replacement to cement.

5. Scope for future study

In the present study the durability properties of M30 grade concrete with replacement of sand by iron blast furnace slag confirm to zone II of IS 383-1970 and the replacement of cement by barytes powder and addition of 1% glass fiber were investigated.

The investigations may be carried out using iron blast furnace slag with different fineness moduli. In the present study barytes powder used has fineness of 1.8%. Investigation may be done on durability properties of concrete using nano barytes powder. In the present investigation 1% of glass fiber is used and the durability properties of m30 grade concrete were found.

In future different percentages of glass fiber can be used in different grades of concrete with replacement of cement by nano barytes powder and replacement of sand by iron blast furnace slag with different fineness moduli.

In the present investigation the durability properties namely the acid test, alkaline test, rapid chloride permeability test at 120 days were found and water permeability test at 90 days were found. Experiments may be done to find the above properties at late age ie., at 240 days, 360 days etc.

REFERENCES

11.1. Journal Article

[1] *John (2009), The impact of sand mining in kallada river in kerala, Journal of basic and applied biology., 3(1&2),* ***(2009),*** *pp. 108-113.*

[2] *Sand and sustainability: Finding new solutions for environmental governance of global sand resources, ISBN NO: 978-807-3751-6 job dew/2237/ce, published by united nations environment programe (UNEP),* ***(Feb 2019)****.*

[3] *Recep Arter et al- procedia- social and behavioral science, world conference on technology innovation and entrepreneurship, sustainability of blast furnace slag: Use of some construction wastes., 195,* ***(2015)****, 2191-2198.*

[4] *"Indian minerals year book", 2017.*

[5] *C. Navya Kiran, Dr.S.M.V.Narayana, "Effect of barytes power on mechanical and durability properties of M_{30} concrete", Journal of Emerging Technologies and Innovative Research., Vol 5, Issue 9,* ***(sep 2018)****, pp. 493-507.*

[6] *S. Sowmyanadh, Dr.S.M.V. Narayana, "Experimental investigation on the mechanical and durability properties of opc concrete with iron blast furnace slag as fine aggregate", PENSEE., Vol 51, Issue1,* ***(2021)****, pp.1131-1144.*

[7] *SadıkAlperYıldızel, "Effects of barite sand addition on glass fiber reinforced concrete mechanical behavior", International Journal of Engineering & Applied Sciences., Vol.9, Issue 4, (****2017****), pp. 100-105.*

[8] *Ghasan Fahim Huseien, "Effects of pofa replaced with FA on durability properties of GBFS included alkali activated mortars", construction and building materials., Vol 175,* ***(2018)****, pp. 174-186.*

[9] *S.Hemalatha, Dr.A.Leema Rose, "An experimental study on glass fiber reinforced concrete", International Research Journal of Engineering and Technology., Vol 03 Issue 04,* ***(April-2016)****, pp. 2285-2289.*

[10] *Tung-Chai Ling and Chi-Sun Poon, "High temperature properties of barites concrete with crt funnel glass", Journal of Cleaner Production., Vol 33, (****2012****), pp. 1-17.*