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RESEARCH ARTICLE

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EFFECT OF REPLACEMENT OF NATURAL AGGREGATES BY LIGHT WEIGHT AGGREGATES ON THE PROPERTIES OF BLENDED CONCRETE

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ABSTRACT

Concrete is an important and successful material in the construction industry for a long time. It has many applications and utilization in the construction field. Due to advancement in technology and constantly increasing economy, construction industry is progressing leaps and bound day by day. This boom in construction, demands massive amount of concrete to be produced to satisfy the current need. This enormous quantity of concrete requires a deal of quality raw material which produce concrete with same outputs. This creates a technological challenge to work out certain materials which fulfill this task. In the era of advances in technology, one of the concepts is to use waste materials in the production of concrete. Out of many waste materials available, fly ash, blast furnace slag, silica fume are few of them. These waste materials in civil engineering applications will not only solve the disposal problem but also will offer a cost-effective substitute for conventional materials. The main objective of this work is to study the behaviour of blended concrete, in which the natural aggregates are replaced by light weight aggregates in different proportions. The different blended concrete used are flyash concrete, GGBFS concrete, Metakaoline concrete, where in the cement is replaced by these blends in different proportions such as 0%, 10%, 20%, 30%, 40%. The experiments are conducted on M30 grade concrete with 28days of curing.The natural aggregate are replaced by air cooled blast furnace slag aggregates by 30%. The strength properties studied are compressive strength, tensile strength, flextural strength, shear strength, and impact strength. The workability characteristics are studied through slump cone test, compaction factor test, flow table test, and Vee-Bee consistometer test. Also an attempt is made to study the water absorbtion and sorptivity characteristics.

KEY WORDS : Air cooled blast furnace slag aggregates, flyash, metakaolin, ground granulated blast furnace slag, strength properties, workability, water absorption, soroptivity.

INTRODUCTION

Concrete is an important and successful material in the construction industry for a long time. It has many applications and utilization in the construction field. Due to advancement in technology and constantly increasing economy, construction industry is progressing leaps and bound day by day. This boom in construction, demands massive amount of concrete to be produced to satisfy the current need. This enormous quantity of concrete requires a deal of quality raw material which produce concrete. As raw material is the second largest consumed material by human kind, the natural raw material which produce concrete is day by day become scare. There is acute need to work out some other source and type of material which can be utilized for production of concrete with same outputs. This creates a technological challenge to work out certain materials which fulfill this task. In the era of advances in technology, one of the concepts is to use waste materials in the production of concrete. Out of many waste materials available, blast furnace slag is one of them. Since the current methods of stockpiling and land filling are not sustainable, disposal of slag has become a significant concern both to slag processor companies and to environmental agencies in the last decades. Sustainability of blast furnace slag in civil engineering applications will not only solve the blast furnace slag disposal problem but also will offer a cost-effective substitute for conventional materials. In order to identify new applications for blast furnace slag in the construction industry, there is a significant need to characterize blast furnace slag, and to determine their engineering properties. There is strong need to use industrial by-products and marginal materials in construction industry. This solves two major problems of pollution and waste disposal. There is extensive research on this issue throughout the world. It is necessary to recycle and reuse the waste and marginal materials. Many waste materials cannot be disposed off by incineration. Any industrial by-product should be carefully studied before using it as raw material in the manufacture of processed building material. Concrete can act as an effective repository for large quantities of waste materials, if their combination with Ordinary Portland Cement (OPC) based products has no adverse effect. Air cooled blast furnace slag aggregate is strong enough to be used as lightweight aggregate. Flyash, ground granulated blast furnace slag and metakaolin are by-product materials which has the properties of cement and can be used as replacements of cement. There are ecological advantages to use these in construction.

Fly ash is the fine solid residue generated from combustion of ground or powdered coal to produce electricity, which can be easily transported by flue gases and collected with the help of electro filters or cyclones. During coal combustion, carbon particles are burned, volatile matter evaporates and most of the remainder mineral part disintegrates. The disintegrated particles turning out to molten state due to high burning temperature of coal, and later solidifies are mostly spherical particles called fly ash.

Ground granulated blast furnace slag (GGBFS), a byproduct from steel production, is being used with increasing frequency as a partial replacement of cement in portland cement concrete.

Metakaolin is neither the by-product of an industrial process nor it is entirely natural. It is derived from naturally occurring mineral and is manufactured specially for cementing applications.

MATERIALS AND METHODOLOGY

In this experimental work, ordinary Portland cement (OPC) 43 grade conforming to IS: 8112 – 1989 was used. Low calcium, class F dry fly ash from the silos of Raichur thermal power plant conforming to IS: 3812 (Part 1) – 2003 was used. Metakaolin from 20micron company, vadodara, Gujarat, India conforming to IS: 3812 (Part 1) – 2003 was used. Ground granulated blast furnance slag received from ACC cement factory Hospet, conforming to IS: 3812 (Part 1) – 2003 was used. Locally available river sand belonging to zone II of IS: 383-1970 was used. Air cooled blast furnace slag aggregates is received from the Jindal steel plant, Bellary, and locally available crushed aggregates confirming to IS 383-1970 are used. Water fit for drinking was used.

In this experimentation, the mix design was done as per IS: 10262 – 2009 and the obtained mix proportion is 1:1.47:2.48 with W/C of 0.45 with M30 mix.

In this experimentation, cement is replaced by fly ash or GGBFS or metakaolin in different percentages like 0%, 10%, 20%, 30% and 40%. The natural aggregate is replaced by air cooled blast furnance slag aggregate(light weight aggregate) by 30%. Specimens are cured for 28days.

The following workability tests are conducted on fresh concrete.

1) Slump cone test.
2) Compaction factor test.
3) Vee-Bee consistometer test.
4) Flow table test.

Following tests are conducted on hardened concrete after 28 days curing

1) Compressive strength test on 150mmX150mmX150mm cube.
2) Tensile strength test on 150mmϕ X300mmL cylinder.
3) Flexural strength test on 100mmX100mmX500mm beam.
4) Impact strength test on 150mmϕ X60mmL cylinder.
5) Shear strength test on L shaped specimen.
6) Water absorption and sorptivity tests.

RESULTS AND DISCUSSIONS

Table 1 gives the slump test results for different percentage replacement of cement by various pozzolonas, and fig. 1 shows the variation of slump. Table 2 gives the compaction factor test results for different percentage replacement of cement by various pozzolonas, and fig. 2 shows the variation of compaction factor. Table 3 gives the Vee–Bee test results for different percentage replacement of cement by various pozzolonas, and fig. 3 shows the variation of Vee–Bee degree. Table 4 gives the flow table test results for different percentage replacement of cement by various pozzolonas, and fig. 4 shows the variation in percentage flow.

Table 1 Slump test results for different percentage replacement of cement by various pozzolonas

Percentage replacement of cement by pozzolonas	Slump values in mm for cement replacement by		
	Flyash	Metakaolin	GGBFS
0%	73	73	73
10%	78	75	75
20%	67	82	79
30%	65	72	66
40%	62	63	63

Table 2 Compaction factor test results for different percentage replacement of cement by various pozzolonas

Percentage replacement of cement by pozzolonas	Compaction factor values for cement replacement by		
	Flyash	Metakaolin	GGBFS
0%	0.85	0.85	0.85
10%	0.90	0.87	0.88
20%	0.82	0.91	0.90
30%	0.79	0.82	0.82
40%	0.78	0.80	0.76

Table 3 Vee-Bee test results for different percentage replacement of cement by various pozzolonas

Percentage replacement of cement by pozzolonas	Vee Bee degree values in sec for cement replacement by		
	Flyash	Metakaolin	GGBFS
0%	32	32	32
10%	29	28	30
20%	41	25	26
30%	49	43	49
40%	52	55	54

Table 4 Flow table test results for different percentage replacement of cement by various pozzolonas

Percentage replacement of cement by pozzolonas	Flow table values in % for cement replacement by		
	Flyash	Metakaolin	GGBFS
0%	6.06	6.06	6.06
10%	9.53	9.26	6.26
20%	6.8	10.2	6.86
30%	3.33	4.93	3.33
40%	1.86	2.66	2.40

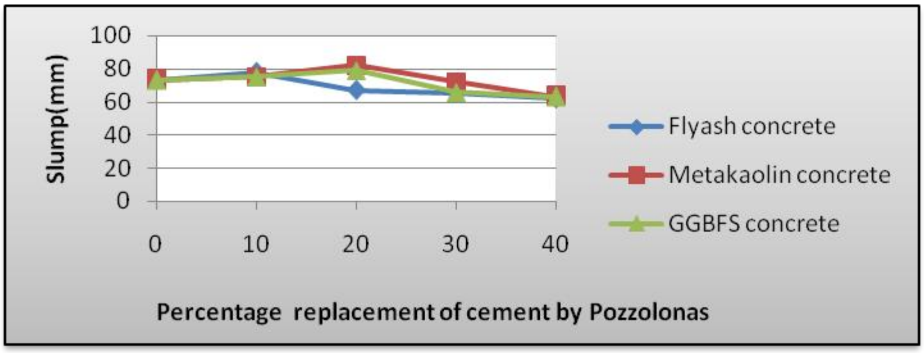

Fig 1 Variation of Slump values

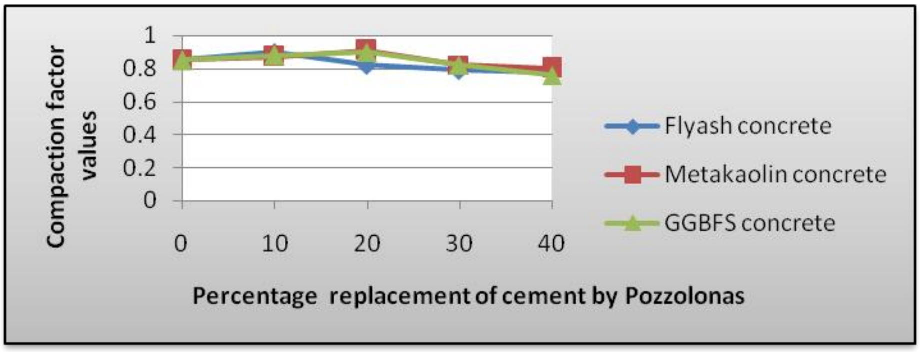

Fig 2 Variation of Compaction factor values

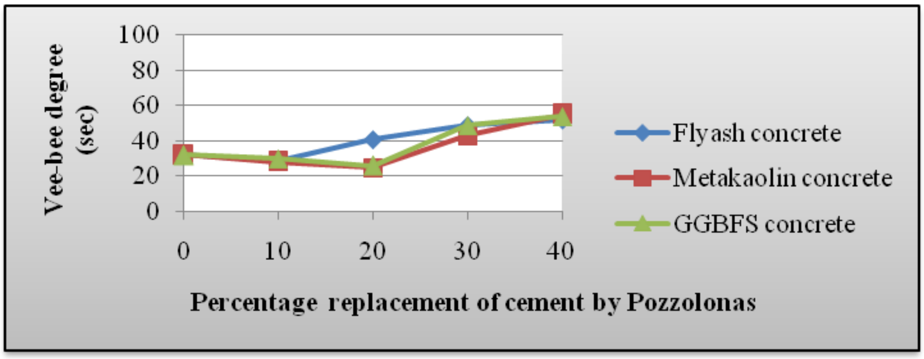

Fig 3 Variation of Vee Bee degree

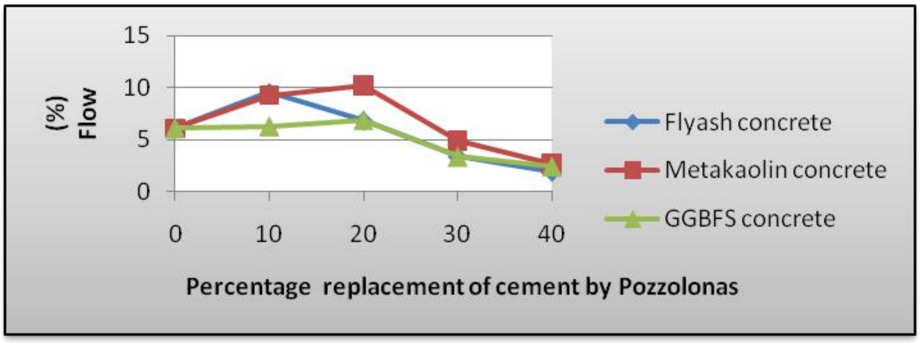

Fig 4 Variation of percentage flow

It is observed that the workability as measured from slump, compaction factor, Vee Bee degree and percentage flow, for flyash blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 10% replacement of cement by flyash. Beyond 10% replacement level the workability decreases. Similarly the blended concrete produced by replacing cement by metakaoline and blended concrete produced by replacing cement by GGBFS show higher workability upto 20% replacement level. Beyond this the workability decreases. This may be due to the fact that at 10% replacement level by flyash, at 20% replacement level by metakaoline and at 20% replacement level by GGBFS may show maximum ball bearing effect, thereby inducing the flow characteristics to the concrete. Thus it may be concluded that the workability of blended concrete produced by replacing natural aggregates by light weight aggregates is higher when 10% cement is replaced by flyash, 20% by metakaoline and 20% by GGBFS.

Table 5 gives the water absorption test results of concrete produced by different pozzolonas and by replacing natural aggregate by light weight aggregate, and fig 5 shows the variation of water absorbtion. Table 6 gives the soroptivity test results of concrete produced by different pozzolonas and by replacing natural aggregate by light weight aggregate, and fig 6 shows the variation of soroptivity values.

Table 5 Water absorption test results

Percentage replacement of cement by pozzolonas	Percentage water absorption for concrete by replacing cement by		
	Flyash	Metakaolin	GGBFS
0%	0.97	0.97	0.97
10%	0.76	0.95	0.90
20%	0.78	0.79	0.81
30%	0.87	0.80	0.85
40%	0.94	0.83	0.87

Table 6 Sorptivity test results

Percentage replacement of cement by pozzolonas	Sorptivity values for concrete by replacing cement by (mm/mm$^{0.5}$)		
	Flyash	Metakaolin	GGBFS
0%	5.30	5.3	5.3
10%	5.03	5.12	5.21
20%	5.05	5.02	5.13
30%	5.08	5.06	5.15
40%	5.10	5.08	5.18

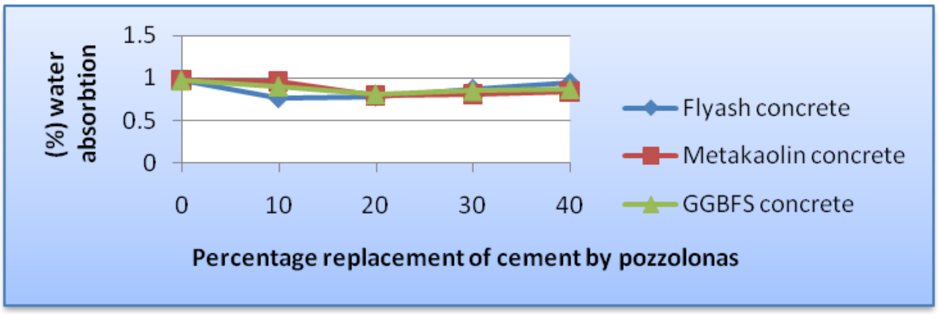

Fig 5 Variation of water absorption values

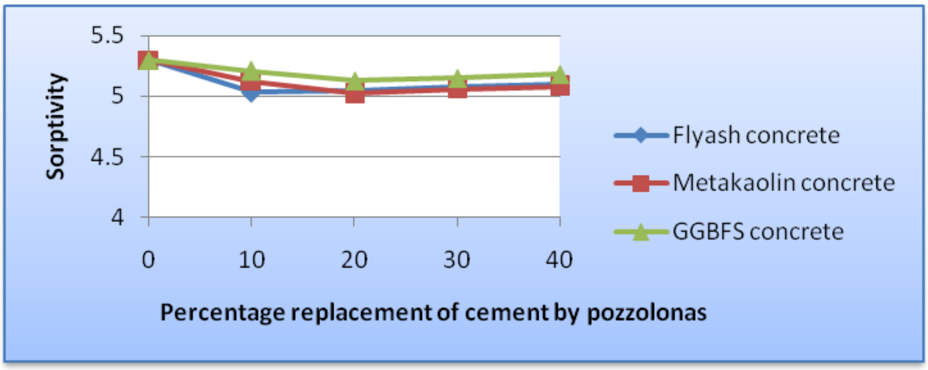

Fig. 6 Variation of sorptivity values

It is observed that the water absorption and sorptivity values for flyash blended concrete produced by replacing natural aggregates by light weight aggregates goes on decreasing upto 10% replacement of cement by flyash. Beyond 10% replacement level the water absorption and sorptivity values increase. Similarly the blended concrete produced by replacing cement by metakaoline and blended concrete produced by replacing cement by GGBFS show lower water absorption and sorptivity values upto 20% replacement level. Beyond this the water absorption and sorptivity values increase.This may be due to the fact that at 10% replacement level by flyash, at 20% replacement level by metakaoline and at 20% replacement level by GGBFS, a maximum pozzolonic reaction may occur and a maximum filler effect may occur thereby improving the morphological structure of concrete which reduce the infiltration of the fluids.Thus it may be concluded that the water absorption and sorptivity for flyash blended concrete produced by replacing natural aggregates by light weight aggregates will reach the least values at 10% replacement level. Similarly the water absorption and sorptivity for metakaoline blended concrete and GGBFS blended concrete produced by replacing natural aggregates by light weight aggregates will reach the least values at 20% replacement level.

Tables 7 give the compressive strength test results of concrete produced by different pozzolona and when subjected to 28days of curing, and fig. 7 shows the variation of compressive strength. Tables 8 give the tensile strength test results of concrete produced by different pozzolona and when subjected to 28days of curing, and fig. 8 shows the variation of tensile strength. Tables 9 give the flexural strength test results of concrete produced by different pozzolona and when subjected to 28days of curing, and fig. 9 shows the variation of flexural strength. Tables 10 give the shear strength test results of concrete produced by different pozzolona and when subjected to 28days of curing, and fig. 10 shows the variation of shear strength. Tables 11 give the impact strength test results of concrete produced by different pozzolona and when subjected to 28days of curing, and fig. 11 shows the variation of impact strength.

Table 7 Compressive strength test results

Percentage replacement of cement by pozzolona	Compressive strength of concrete by replacing cement by flyash (MPa)	Percentage increase or decrease of compressive strength with respect to reference mix	Compressive strength of concrete by replacing cement by metakaolin (MPa)	Percentage increase or decrease of compressive strength with respect to reference mix	Compressive strength of concrete by replacing cement by GGBFS (MPa)	Percentage increase or decrease of compressive strength with respect to reference mix
0% (Ref mix)	26.67	0	26.67	0	26.67	0
10%	30.07	+3.4	36.44	+9.77	27.56	+0.89
20%	26.96	+0.29	38.22	+11.55	29.19	+2.52
30%	21.33	-5.34	32.89	+6.22	21.33	-5.34
40%	13.93	-12.74	28.15	+1.48	20.00	-6.67

Table 8 Tensile strength test results

Percentage replacement of cement by pozzolona	Tensile strength of concrete by replacing cement by flyash (MPa)	Percentage increase or decrease of tensile strength with respect to reference mix	Tensile strength of concrete by replacing cement by metakaolin (MPa)	Percentage increase or decrease of tensile strength with respect to reference mix	Tensile strength of concrete by replacing cement by GGBFS (MPa)	Percentage increase or decrease of tensile strength with respect to reference mix
0% (Ref mix)	1.98	0	1.98	0	1.98	0
10%	2.22	+0.24	2.73	+0.75	2.17	+0.19
20%	2.03	+0.05	2.92	+0.94	2.36	+0.38
30%	1.89	-0.09	2.07	+0.09	2.07	+0.09
40%	1.6	-0.38	1.93	-3.91	1.93	-0.05

Table 9 Flexural strength test results

Percentage replacement of cement by pozzolona	Flexural strength of concrete by replacing cement by flyash (MPa)	Percentage increase or decrease of flexural strength with respect to reference mix	Flexural strength of concrete by replacing cement by metakaolin (MPa)	Percentage increase or decrease of flexural strength with respect to reference mix	Flexural strength of concrete by replacing cement by GGBFS (MPa)	Percentage increase or decrease of flexural strength with respect to reference mix
0% (Ref mix)	7.6	0	7.6	0	7.6	0
10%	8.53	+0.93	9.33	+1.73	8.67	+1.07
20%	8	+0.4	9.73	+2.13	8.93	+1.33
30%	7.73	+0.13	8	+0.4	7.07	+-0.53
40%	6.8	-0.8	6	-13.6	6.67	-0.93

Table 10 Shear strength test results

Percentage replacement of cement by pozzolona	Shear strength of concrete by replacing cement by flyash (MPa)	Percentage increase or decrease of shear strength with respect to reference mix	Shear strength of concrete by replacing cement by metakaolin (MPa)	Percentage increase or decrease of shear strength with respect to reference mix	Shear strength of concrete by replacing cement by GGBFS (MPa)	Percentage increase or decrease of shear strength with respect to reference mix
0% (Ref mix)	5	0	5	0	5	0
10%	5.56	+0.56	7.96	+2.96	5.56	+0.56
20%	4.63	-0.37	10	+5	5.93	+0.93
30%	4.26	-0.74	5	0	5.19	+0.19
40%	2.96	-2.04	4.44	-9.44	4.44	-0.56

Table 11 Impact strength test results

Percentage replacement of cement by pozzolona	Impact strength of concrete by replacing cement by flyash (N-m)	Percentage increase or decrease of impact strength with respect to reference mix	Impact strength of concrete by replacing cement by metakaolin (N-m)	Percentage increase or decrease of impact strength with respect to reference mix	Impact strength of concrete by replacing cement by GGBFS (N-m)	Percentage increase or decrease of impact strength with respect to reference mix
0% (Ref mix)	452.43	0	452.43	0	452.43	0
10%	514.12	+61.69	658.08	+205.65	486.70	+34.27
20%	486.70	+34.27	678.64	+226.21	541.54	+89.11
30%	329.04	-123.39	411.3	-41.13	377.02	-75.40
40%	157.66	-294.77	267.34	-185.09	185.08	-267.35

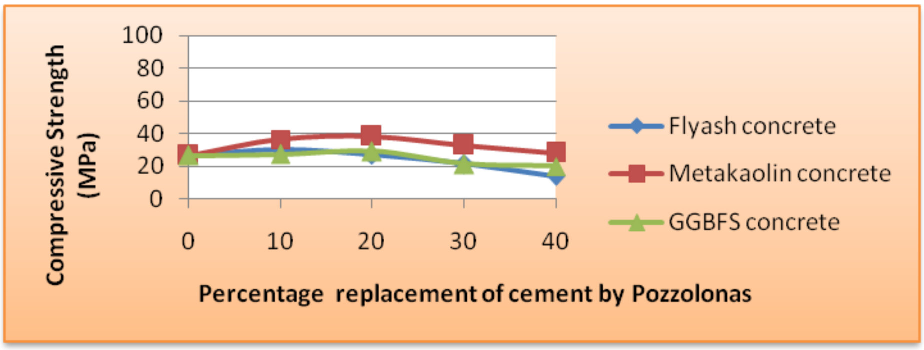

Fig 7 Variation of compressive strength

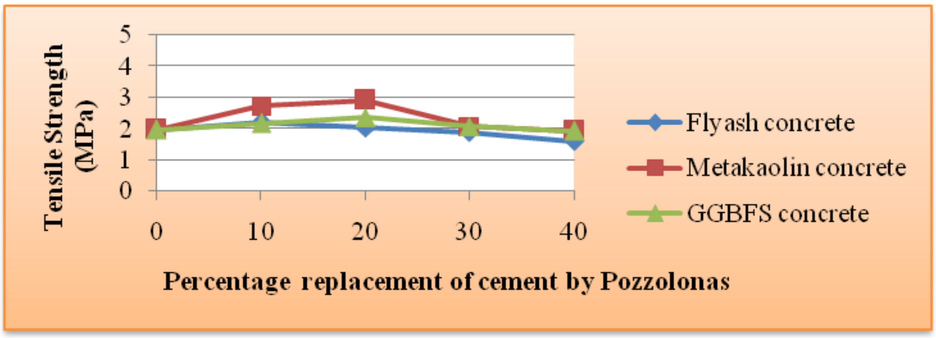

Fig 8 Variation of tensile strength

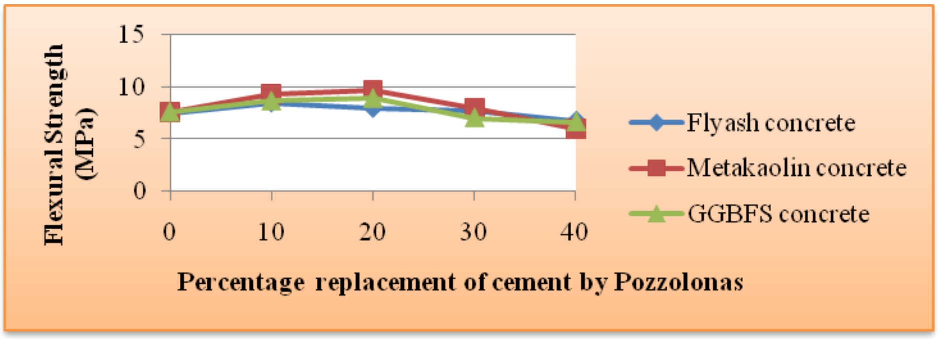

Fig 9 Variation of flexural strength

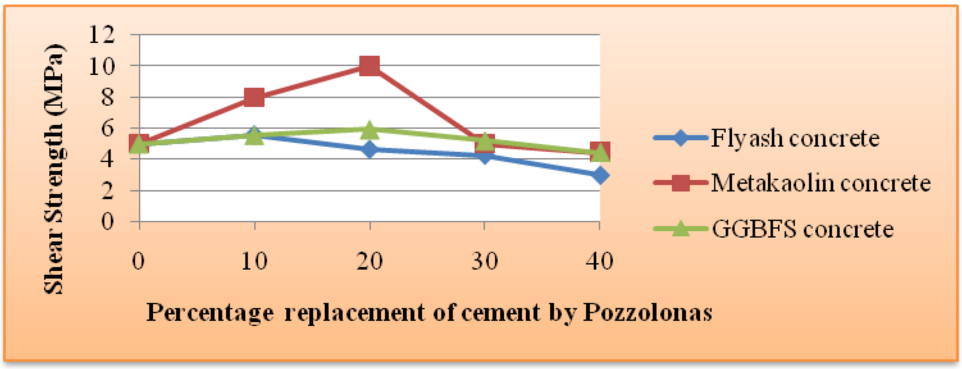

Fig 10 Variation of shear strength

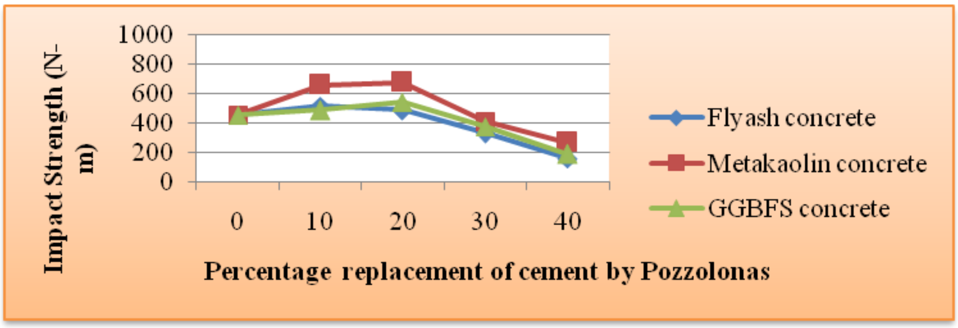

Fig 11 Variation of impact strength

It is observed that the compressive strength of blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 10% replacement by flyash. Beyond 10% replacement level the compressive strength decreases. At 10% replacement level the percentage increase in compressive strength is found to be 3.4%.Similarly it is observed that the compressive strength of blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 20% replacement by metakaolin. Beyond 20% replacement level the compressive strength decreases. At 20% replacement level the percentage increase in compressive strength is found to be 11.55%.Similarly it is observed that the compressive strength of blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 20% replacement by GGBFS. Beyond 20% replacement level the compressive strength decreases. At 20% replacement level the percentage increase in compressive strength is found to be 2.52%.This may be due to the fact that at 10% replacement level by flyash, at 20% replacement level by metakaolin, and at 20% replacement level by GGBFS, a maximum pozzolonic reaction may occur and maximum filler effect may occur thereby improving the microstructure of concrete which can result in higher strength characteristics.Thus it can be concluded that the compressive strength for flyash blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 10% replacement level. Similarly the compressive strength for metakaolin blended concrete and GGBFS blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 20% replacement level.

It is observed that the tensile strength of blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 10% replacement by flyash. Beyond 10% replacement level the tensile strength decreases. At 10% replacement level the percentage increase in tensile strength is found to be 0.24%. Similarly it is observed that the tensile strength of blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 20% replacement by metakaolin. Beyond 20% replacement level the tensile strength decreases. At 20% replacement level the percentage increase in tensile strength is found to be 0.94%. Similarly it is observed that the tensile strength of blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 20% replacement by GGBFS. Beyond 20% replacement level the tensile strength decreases. At 20% replacement level the percentage increase in tensile strength is found to be 0.38%. This may be due to the fact that at 10% replacement level by flyash, at 20% replacement level by metakaolin, and at 20% replacement level by GGBFS, a maximum pozzolonic reaction may occur and maximum filler effect may occur thereby improving the microstructure of concrete which can result in higher strength characteristics. Thus it can be concluded that the tensile strength for flyash blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 10% replacement level. Similarly the tensile strength for metakaolin blended concrete and GGBFS blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 20% replacement level.

It is observed that the flexural strength of blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 10% replacement by flyash. Beyond 10% replacement level the flexural strength decreases. At 10% replacement level the percentage increase in flexural strength is found to be 0.93%. Similarly it is observed that the flexural strength of blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 20% replacement by metakaolin. Beyond 20% replacement level the flexural strength decreases. At 20% replacement level the percentage increase in flexural strength is found to be 2.13%. Similarly it is observed that the flexural strength of blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 20% replacement by GGBFS. Beyond 20% replacement level the flexural strength decreases. At 20% replacement level the percentage increase in flexural strength is found to be 1.33%. This may be due to the fact that at 10% replacement level by flyash, at 20% replacement level by metakaolin, at 20% replacement level by GGBFS, a maximum pozzolonic reaction may occur and maximum filler effect may occur thereby improving the microstructure of concrete which can result in higher strength characteristics. Thus it can be concluded that the flexural strength for flyash blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 10% replacement level. Similarly the flexural strength for metakaolin blended concrete and GGBFS blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 20% replacement level.

It is observed that the shear strength of blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 10% replacement by flyash. Beyond 10% replacement level the shear strength decreases. At 10% replacement level the percentage increase in shear strength is found to be 0.56%. Similarly it is observed that the shear strength of blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 20% replacement by metakaolin. Beyond 20% replacement level the shear strength decreases. At 20% replacement level the percentage increase in shear strength is found to be 5%. Similarly it is observed that the shear strength of blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 20% replacement by GGBFS. Beyond 20% replacement level the shear strength decreases. At 20% replacement level the percentage increase in shear strength is found to be 0.93%. This may be due to the fact that at 10% replacement level by flyash, at 20% replacement level by metakaolin, and at 20% replacement level by GGBFS, a maximum pozzolonic reaction may occur and maximum filler effect may occur thereby improving the microstructure of concrete which can result in higher strength characteristics. Thus it can be concluded that the shear strength for flyash blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 10% replacement level. Similarly the shear strength for metakaolin blended concrete and GGBFS blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 20% replacement level.

It is observed that the impact strength of blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 10% replacement by flyash. Beyond 10% replacement level the impact strength decreases. At 10% replacement level the percentage increase in impact strength is found to be 61.69%. Similarly it is observed that the impact strength of blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 20% replacement by metakaolin. Beyond 20% replacement level the impact strength decreases. At 20% replacement level the percentage increase in impact strength is found to be 226.21%. Similarly it is observed that the impact strength of blended concrete produced by replacing natural aggregates by light weight aggregates goes on increasing upto 20% replacement by GGBFS. Beyond 20% replacement level the impact strength decreases. At 20% replacement level the percentage increase in impact strength is found to be 89.11%. This may be due to the fact that at 10% replacement level by flyash, at 20% replacement level by metakaolin, and at 20% replacement level by GGBFS, a maximum pozzolonic reaction may occur and maximum filler effect may occur thereby improving the microstructure of concrete which can result in higher strength characteristics. Thus it can be concluded that the impact strength for flyash blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 10% replacement level. Similarly the impact strength for metakaolin blended concrete and GGBFS blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 20% replacement level.

CONCLUSIONS

The following conclusions may be drawn based on the observation made in the effect of replacement of natural aggregates by light weight aggregates on the properties of blended concrete.

1) The workability of blended concrete by replacing natural aggregates by light weight aggregates will be higher when 10% cement is replaced by flyash, 20% by metakaoline and 20% by GGBFS.
2) The water absorption and sorptivity for flyash blended concrete produced by replacing natural aggregates by light weight aggregates will reach the least values at 10% replacement level. Similarly the water absorption and sorptivity for metakaoline blended concrete and GGBFS blended concrete produced by replacing natural aggregates by light weight aggregates will reach the least values at 20% replacement level.
3) The compressive strength for flyash blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 10% replacement level. Similarly the compressive strength for metakaolin blended concrete and GGBFS blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 20% replacement level.
4) The tensile strength for flyash blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 10% replacement level. Similarly the tensile strength for metakaolin blended concrete and GGBFS blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 20% replacement level.
5) The flexural strength for flyash blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 10% replacement level. Similarly the flextural strength for metakaolin blended concrete and GGBFS blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 20% replacement level.
6) The shear strength for flyash blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 10% replacement level. Similarly the shear strength for metakaolin blended concrete and GGBFS blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 20% replacement level.
7) The impact strength for flyash blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 10% replacement level. Similarly the impact strength for metakaolin blended concrete and GGBFS blended concrete produced by replacing natural aggregates by light weight aggregates will be higher at 20% replacement level.

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