

Experimental Study on Concrete With Penta Blended Cement Using Pozzolanic Materials & Micro MgO

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ABSTRACT: Due to the rapid urbanization construction industry is expanding exponentially and cement is the most used product only next to the water. The production of every tonne of cement emits carbon dioxide to the tune of 0.87 tonne and it can be said that it amounts to about 7-10% of the world's carbon dioxide emission. Not only the significant contribution to the environmental pollution it also consumes natural resources like limestone etc., and we cannot go on producing more and more cement. Due to rapid growth in industries more pollutants were being added up and some of the industrial wastes like fly ash, Silica fume and slag etc. possess cementitious properties which can be used to replace the cement to economise the consumption. For the generation of electricity the world is depending upon thermal plants which were generating huge volume of fly ash which also contributes to the environmental pollution. An attempt is made to study the strength properties of M₂₀ grade concrete with partial replacement of cement by pozzolanic materials like Slag, Silica fume and pulverised quartz powder individually to find the optimum replacement. An attempt is also made to study the effect of micro MgO particles in combination of above pozzolanic materials i.e., penta blended cement on the strength of concrete.

KEYWORDS: Micro Powder MgO, slag, silica fume, pulverised quartz Powder, Super Plasticizer

I. INTRODUCTION

Concrete is the most widely used material in the construction of buildings, infrastructure development and also in Irrigation. After water, Concrete is the second most consumed material in the world. The construction world in present days requires faster development and also high strength concrete which facilitate the faster construction and economical construction. But there is an environmental issue involved which also is taken into consideration which can't be ignored. 0.7 tonne of carbon dioxide is released into the atmosphere in the production of every one tonne of cement, which is approximately 7-10 percentage of the world's total emission of carbon dioxide. In recent years, there has been increase in incentives to minimise the environmental issues in the construction industry by conducting the programs such as leadership in Energy and Environmental Design Green building rating system, which rewards points for sustainable construction practices. To reduce consumption of precious natural resources like lime stone in the production of cement, replacement of cement by cementitious materials like slag silica fume, fly ash, and silica powder is one of best alternative which also paves alternative way for the disposal of these wastes which otherwise used for land fill.

The basic purpose of using micro size materials in concrete is to improve the compressive and flexural strength compared to early age. It is possible due to the high surface to volume ratio. It also helps to improve the pore structure of concrete. Micro size materials help to reduce porosity as they absorb less water compare to traditional cementitious materials. The presence of Micro materials reduces the amount of cement content in concrete than the conventional concrete. This can be achieved without compromising much with the basic strength characteristics.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 6, June 2017

In this research a comparative study is conducted to calculate and compare the compressive, split tensile and flexural strength with silica fume, slag and pulverized Quartz Powder which were used individually and optimum replacement as 16% was found. Partial replacement of cement was also done by taking silica fume, slag, and pulverized Quartz Powder i.e 5.33% each (Combindly 16%) along with 0.5% to 2.5% micro MgO to make quaternary and Penta blended concrete. The compressive, Split Tensile and flexural strengths were calculated according to IS: 516-1959. The variation of the compressive, Split Tensile and flexural strength comparatively according to the replacement of cement with mineral admixtures is also shown vide tables and graphically.

II. LITERATURE REVIEW

1.Dilip Kumar Singha Roy, Amitava Sil(2012) concluded that the maximum compressive strength of both cubes and cylinders were noted for 10% replacement of cement with silica fume and the values were higher by 19.6% and 16.82% respectively than those normal concrete where as split tensile strength and flexural strength of silica fume concrete is 3.61 and 4.93 respectively were increased by about 38.58% and 21.13% respectively over those 2.6 and 4.07 respectively of normal concrete.

2.T.Shanmugapriya,Dr.R.N.Uma(2013) demonstrates that the compressive strength mainly depend on the percentage of silica fume because of its high pozzolanic nature to form more densely packed C-S-H gel. The percentage of increase in compressive strength is 155%, split tensile strength is 20% and the strength is 23% at the age of 28 days by replacing of 7.5% of cement by silica fume .The optimum percentage replacement of cement by silica fume is 7.5% .

3.Gunalaan Vasudevan, Seri Ganis Kanapathy pillay(2013) observed that the compressive strength concrete replaced with waste glass powder gives higher strength at 14 days , but at 28 days it decreases by about 1 N/mm² strength than of the standard mix and the lightweight concrete by using this at the same time workability is also higher than standard mix.

4.Bhandari.P.S, Tajne.K.M(2013) demonstrates that usage of waste glass aggregate reduces the water demand and addition of its density of mortar increases, water absorption of cubes is less than control mix cubes.

5.Mrs.Veena G.pathan, Mr.Vishal S. Ghutke, Mr. Guifan pathan.(2012) it is evident that 45% replacement of cement by GGBS give the highest amount of compressive strength, but keeping in view the high heat of hydration produced by GGBS and the highest temperature fluctuations in India, it is suggested that replacement of cement with slag should be limited to 40%.

6.S.Arivalagan(2014) observed that GGBS based concrete have achieved increase in strength for 20% replacement of cement at age of 28 days , degree of workability of concrete was normal with addition of GGBS up to 40% replacement level for M35 concrete its proved that GGBS can be used as alternative method for cement.

7.Fei Jin, Adel Abdollahzadeh, Abir Al- Tabbaa the strength of MgO-GGBS blend is affected by the reactivity of the MgO, more reactive MgO resulted in higher early strength the characteristics of reactive MgO vary significantly in terms of their reactivity and chemical composition

8.Aris Buntoro UPN"veteren"Yogyakarta;Rudi Rubiandini R.S.concentration of neat magnesium oxide as expanding additive from 3 to 5% will provide excellent shear bond and fair compressive strength in thermal and oil well cements at higher temperature of up to 250 degrees

From the brief literature summary conducted here it appears that much less attention has been paid earlier on the study of penta blended cement with pozzolanic materials in combination of micro Magnesium oxide MgO, hence the present investigation has been taken up.

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III. OBJECTIVE/SCOPE

- Determining of solution for disposal of industrial wastes which as hazardous to environment as a useful material in the construction industry.

IV. MATERIALS USED

CEMENT:

Ordinary Portland Cement of grade 53 was used in this project which is confirmed by Bureau of Indian Standard (IS 8112:1989). The cement has uniform colour and it is fresh free from lumps, cement was tested for various properties as per (IS8112:1989)

Table 1: Properties of Cement:

1.	Initial setting time:	48 minutes
2.	Final setting time:	450 minutes
3.	Specific gravity :	3.1
4.	Fineness modulus :	4%
5.	Normal consistency :	34
6.	Soundness of cement :	5mm

SLAG:

Ground granulated blast furnace slag is a non-metallic product consisting essentially of silicates and aluminous silicates of calcium and other bases, that is developed in a molten condition simultaneously with iron in a blast furnace, then water chilled rapidly to form glassy granular particles, and then ground to cement fineness or finer. In concrete, ground granulated blast furnace slag reacts with Portland cement to form cementitious products. Slag possesses both cementing and pozzolanic properties. Slag cement can enhance concrete structures by improving workability in the plastic state, and increases strength and reduces permeability in the hardened state. The correct amount of slag to use on a particular project depends on the materials and admixtures used, as well as ambient conditions during concreting. Silica powder is induced high content SiO_2 which is approximately 99.2%. This is also one type of mineral admixture having pozzolanic properties with it.

Obtained from JSW Steel industries, Bellary, which was passed through 90mm sieve.

Table 2: Properties of Slag:

1.	Colour	Off-white
2.	Specific Gravity	2.45

SILICA FUME:

Silica fume is a by product in the form of smoke results from electric furnaces of producing Silicon metal or ferrosilicon alloys. Silicon and ferrosilicon alloys were produced in electric furnaces and the raw materials were quartz, coal and wood chips. Before the mid 1970's nearly all silica fume was discharged into atmosphere. After environmental concerns necessitated collection and land filling became economically justified to use Silica Fume in various applications. Because of chemical and physical properties it is a very reactive pozzolanic material. Silica fume consists primarily of amorphous (non-crystalline) silicon dioxide (SiO_2). The individual particles were extremely small, approximately 1/100th the size of an average cement particle. Because of its fine particles, large surface werea, and the high SiO_2 content, silica fume is a very reactive pozzolanic material. The quality of silica fume is specified by ASTM C 1240 and AASHTO M 307.

It is collected from Astra Chemicals, Chennai.

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Table 3: Properties of Silica Fume:

1.	Colour	White
2.	Specific Gravity	2.31

PULVERISED QUARTZ POWDER:

It is collected from Rayalaseema mineral industries, kurnool and passed through 90micron sieve. It has 98% silica content.

Table 4: Properties of Silica Fume:

1.	Colour	White
2.	Specific Gravity	2.3

FINE AGGREGATE:

It is collected from locally available natural river sand.

Table 5: Properties of Fine Aggregate:

1.	Specific Gravity	2.6
2.	Fineness Modulus	3.15

COARSE AGGREGATE:

It is collected from Ulindakonda, Kurnool

Table 6: Properties of Coarse Aggregate:

1.	Specific gravity	2.8
2.	Bulk density	1600 kg/m ³ (fully compacted)
3.	Fineness modulus	3.95
4.	Impact value	16.6%
5.	Elongation index	22.98%
6.	Flakiness index	10.55%

MICRO POWDER(MgO):

Micro powder MgO is a solid mineral admixture and its source is magnesium and it is produced by the calcinations of magnesium carbonate or magnesium hydroxide latter it is obtained by the treatment of magnesium chloride solutions, typically sea water with lime. MgO is prized as refractory material and it is physically, chemically stable and it has two attributes such as high thermal conductivity and low electrical conductivity. The largest consumers of magnesium worldwide were the refractory industry, which consumes about 56% in United States. It is used as fireproofing material and it characterised fire resistance, termite resistance, moisture resistance, mould resistance and strength. It is inorganic, non-toxic, non-pathogenic compound material which is used to replace cement. and passed through 90 microns seive. It is collected from Bottom Up Technologies Corporation Jharkhand, India.

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Table 7: Physical and Chemical Properties(MgO):

1.	Physical state	Solid
2.	Appearance	White fine powder
3.	Vapour pressure @200C	NA
4.	Odour	NA
5.	Vapour density (Air = 1)	NA
6.	Solubility in water @ 300C	Insoluble
7.	Evaporation rate	NA
8.	Specific Gravity	3.58
9.	pH at 200C (saturated solution)	10.3
10.	Particle Size	40-100microns

SUPER PLASTICISER:

PLAXEM was used as plasticiser to increase the workability of concrete and also used as water reducing agent to achieve desirable strength. It is collected from local suppliers.

V.EXPERIMENTAL PROGRAMME

The cement used for casting specimens was ordinary Portland cement of 53 grade and mix design was done for M₂₀ grade concrete with water cement ratio of 0.40. The initiative project commenced with control mix with specimens cubes, cylinders, beams were casted, and then cement is partially replaced with cementitious materials like slag, silica fume, silica powder at various percentages such as 4%, 8%, 12%, 16% and 20% to find the optimum replacement of cement. An attempt is made to study the effect of all these three numbers of pozzolanic materials combinidly taken in equal parts of that of the optimum replacement of cement individually i.e., 16% of the weight of the cement. An attempt is also made to study the effect of micro MgO in combination with three numbers of Pozzolanic materials with replacement of cement at 16% of its weight by Silica fume, Slag and crushed quartz powder in equal proportions along with varying percentages of Micro MgO at 0.5%, 1%, 1.5%, 2%, 2.5% on 84% of weight of cement.

MIX DESIGN:

The mix design for M20 grade concrete with 0.4 water cement ratio was prepared according to IS 10262:2009 concrete mix proportioning guidelines with proportions are 1:1.81:3.4.

CASTING&CURING OF SPECIMENS:

The cement, fine and coarse aggregate and pozzolona materials were thoroughly mixed by hand the moulds are used cubes, cylinders, beams with dimensions are respectively 150mmx150mmx150mm, 150mmx300mm, 500mmx100mmx100mm. The moulds were cleaned from dust particles and then oil is applied well through all sides of moulds before commence to mix. Then casted specimens are placed for curing under controlled conditions for the period of 7 and 28 days

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VI. EXPERIMENTAL RESULTS

Tables:

Table 8: Cube compressive strength of binary cement concrete over control mix at 7 and 28 days(Slag)

Mix	7 Days	28 Days
CM	21.63	29.16
4%	26.6	33.48
8%	28.81	34.81
12%	29.33	35.55
16%	33.33	43.55
20%	30.22	35.33

The above table indicated that the binary cement concrete results i.e. in the total amount of cement is partially replaced with slag at different percentages as 4,8,12,16,20. The cube compressive strength results at the age of 7 and 28 days were tabulated.

Table 9: Cube compressive strength of binary cement concrete over control mix at 7 and 28 days(Pulverised Quartz Powder)

Mix	7 Days	28 Days
CM	21.63	29.16
4%	27.55	35.55
8%	29.77	37.55
12%	32	38.36
16%	33.33	40.88
20%	28.22	36.88

The above table indicated that the binary cement concrete results i.e. the total amount of cement is partially replaced with Pulvarised Quartz Powder at different percentages as 4,8,12,16,20. The cube compressive strength results at the age of 7 and 28 days were tabulated.

Table 10: Cube compressive strength of binary cement concrete over control mix at 7 and 28 days(Silica Fume)

Mix	7 Days	28 Days
CM	21.63	29.16
4%	24.74	31.26
8%	27.36	33.33
12%	29.24	35.39
16%	33.03	41.27
20%	30.96	37.45

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The above table indicated that the binary cement concrete results i.e. the total amount of cement is partially replaced with Silica Fume at different percentages as 4,8,12,16,20. The cube compressive strength results at the age of 7 and 28 days were tabulated.

Table 11: Quaternary blended concrete specimen results at 7 and 28 days

Specimens strengths	7 Days	28 Days
Cubes	32.66	39.33
Cylinder Split tensile	3.2	3.89
Cylinder compressive	21.3	25.6
Beam flexural	4.3	4.59

The above table indicated that the results of Quaternary blended concrete i.e. slag, silica fume pulverised quartz powder. These three numbers of pozzolanic materials combinedly taken in equal parts of that of the optimum replacement of cement individually i.e., 16% of the weight of the cement.

Table 12: Cube compressive strength results of Penta blended concrete over control mix at 7 and 28 days

Mix	7 Days	28 Days
CM	21.63	29.16
0.5%	27.55	34
1%	34.33	41.7
1.5%	29.86	36
2%	26	30.66
2.5%	25.03	29.77

The above table indicated that the results of penta blended concrete i.e. concrete with addition of 0.5-2.5% micro MgO with 16% in equal parts by weight of cement. The cube compressive strength results at 7 and 28 days were tabulated.

Table 13: Cylinder split tensile strength results of Penta blended concrete over control mix at 7 and 28 days.

Mix	7 Days	28 Days
CM	2.83	3.35
0.5%	3.11	3.92
1%	3.53	4.1
1.5%	3.39	3.84
2%	2.82	3.62
2.5%	2.68	3.16

The above table indicated that the results of penta blended concrete i.e. concrete with addition of 0.5-2.5% micro MgO with 16% in equal parts by weight of cement. The cylinder split tensile strength results at 7 and 28 days were tabulated.

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Table 14: Cylinder compressive strength results of Penta blended concrete over control mix at 7 and 28 days.

Mix	7 Days	28 Days
CM	16.79	18.49
0.5%	18.67	25.41
1%	20.37	26.03
1.5%	19.24	24.19
2%	17.54	23.61
2.5%	16.41	22.12

The above table indicated that the results of penta blended concrete i.e. concrete with addition of 0.5-2.5% micro MgO with 16% in equal parts by weight of cement. The cylinder compressive strength results at 7 and 28 days were tabulated.

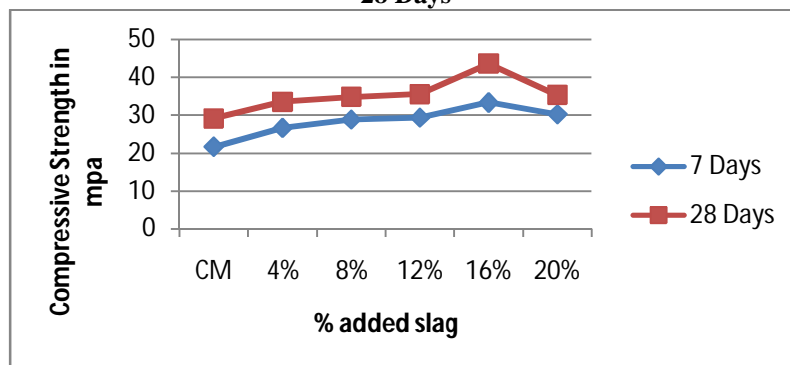
Table 15: Beam flexural strength results of Penta blended concrete over control mix at 7 and 28 days.

Mix	7 Days	28 Days
CM	2.8	3.16
0.5%	4.45	4.81
1%	4.57	4.97
1.5%	4.3	4.72
2%	3.95	4.51
2.5%	3.35	4.36

The above table indicated that the results of penta blended concrete i.e. concrete with addition of 0.5-2.5% micro MgO with 16% in equal parts by weight of cement. The beam flexural strength results at 7 and 28 days were tabulated.

GRAPHS:

Figure 1: Cube Compressive Strength of Binary Blended Concrete Over Control Mix(Slag) at the age of 7 and 28 Days



From the above figure it is observed that the cube compressive strength of binary blended(SLAG) concrete over control mix at the age of 7 and 28 days. The optimum level of partial replacement is found to be at 16%.

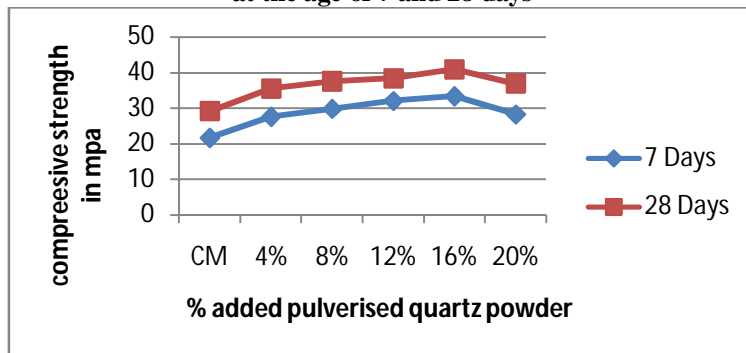
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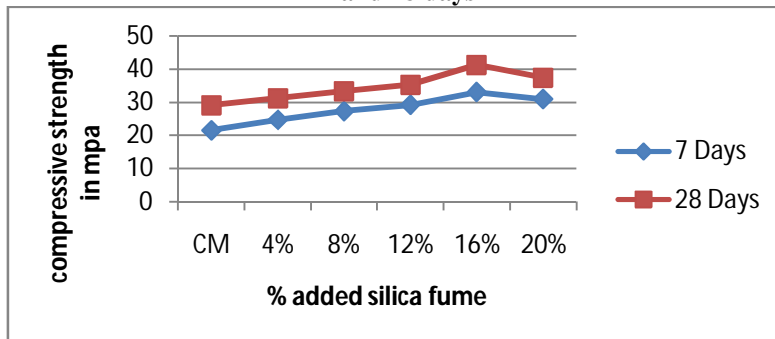
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Figure 2: Cube Compressive Strength of Binary Blended Concrete Over Control Mix(Pulverised Quartz Powder) at the age of 7 and 28 days



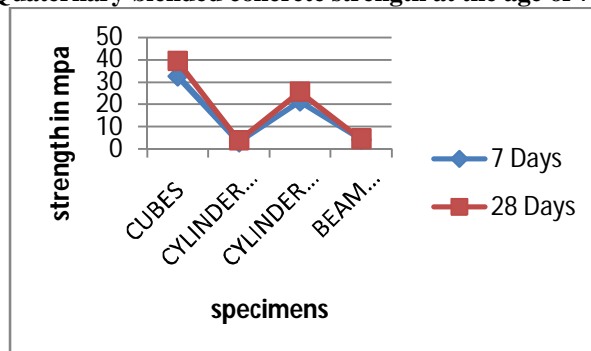
From the above figure it is observed that the cube compressive strength of binary blended(PULVERISED QUARTZ POWDER) concrete over control mix at the age of 7 and 28 days. The optimum level of partial replacement is found to be at 16%

Figure 3: Cube Compressive Strength of Binary Blended Concrete Over Control Mix(Silica Fume) at the age of 7 and 28 days



From the above figure it is observed that the cube compressive strength of binary blended(SILICA FUME) concrete over control mix at the age of 7 and 28 days. The optimum level of partial replacement is found to be at 16%

Figure 4: Quaternary blended concrete strength at the age of 7 and 28 days



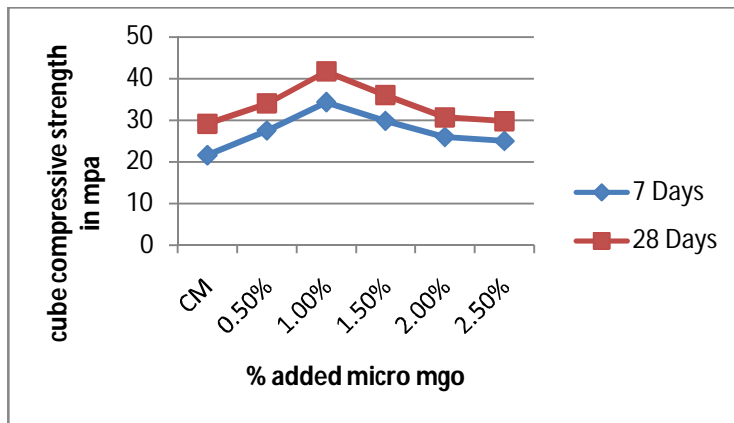
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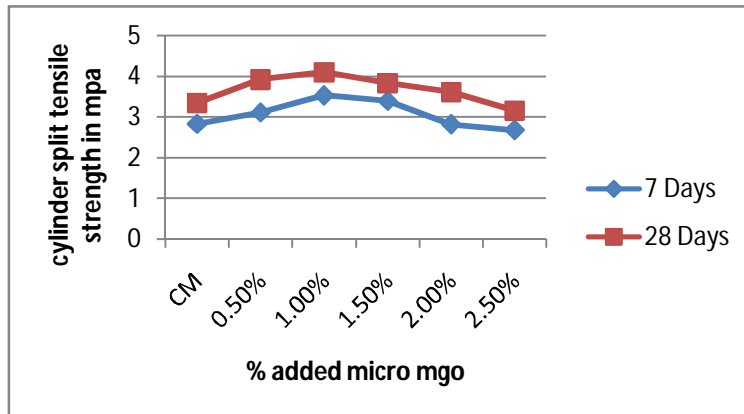
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Figure 5: Cube Compressive Strength of Penta Blended Concrete Over Control Mix at the age of 7 and 28 days



From the above figure it is observed that the cube compressive strength of penta blended concrete over control mix at the age of 7 and 28 days. The optimum level of partial replacement is found to be at 1%

Figure 5: Cylinder Split Tensile Strength of Penta Blended Concrete Over Control Mix at the age of 7 and 28 days



From the above figure it is observed that the cylinder split tensile strength of penta blended concrete over control mix at the age of 7 and 28 days. The optimum level of partial replacement is found to be at 1%

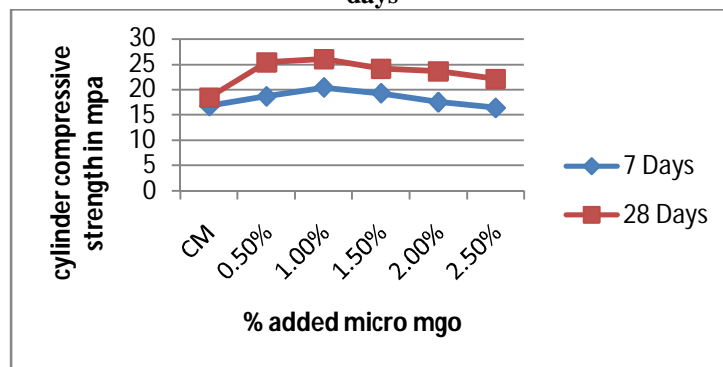
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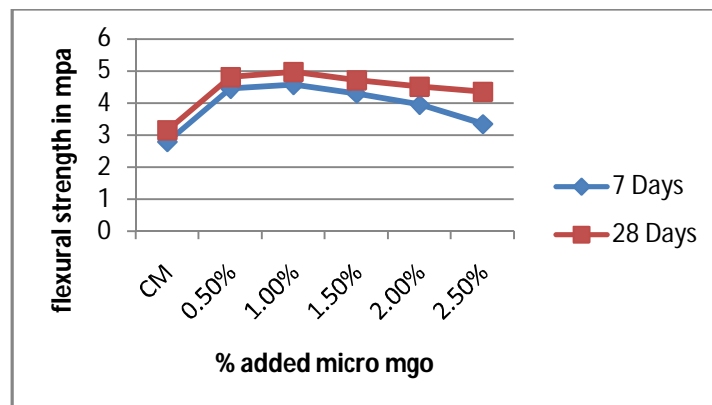
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Figure 6: Cylinder Compressive Strength of Penta Blended Concrete Over Control Mix at the age of 7 and 28 days



From the above figure it is observed that the cylinder split tensile strength of penta blended concrete over control mix at the age of 7 and 28 days. The optimum level of partial replacement is found to be at 1%

Figure 7: Beam Flexural Strength of Penta Blended Concrete Over Control Mix at the age of 7 and 28 days



From the above figure it is observed that the beam flexural strength of penta blended concrete over control mix at the age of 7 and 28 days. The optimum level of partial replacement is found to be at 1%

VII .CONCLUSIONS

1. The cube compressive strengths of concrete with partial replacement of cement by slag the optimum percentage replacement was 16%.The strengths of 7 and 28 days were 33.33 & 43.55Mpa with an increase of 11.7% & 14.39% over that of nominal mix.
2. The cube compressive strengths of concrete with partial replacement of cement by pulverised quartz powder the optimum percentage replacement was 16%.The strengths of 7 and 28 days were 33.34 & 40.88Mpa with an increase of 11.7% & 11.72% over that of nominal mix.

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3. The compressive strengths of concrete with partial replacement of cement by silica fume the optimum percentage replacement was 16%. The strengths of 7 and 28 days were 33.03 & 41.27Mpa with an increase of 11.7% & 12.11% over that of nominal mix.
4. The cube compressive strengths of concrete with partial replacement of cement by 16% of its weight by three numbers of pozzolanic materials in equal parts and 1% of Micro magnesium oxide (MgO) on 84% of weight of cement at 7 days and 28 days were 34.33 & 41.7Mpa with an increase of 12.7% & 12.54% of that of the nominal mix.
5. The split tensile strengths of concrete with partial replacement of cement by 16% of its weight by three numbers of pozzolanic materials in equal parts and 1% of Micro magnesium oxide (MgO) on 84% of weight of cement at 7 days and 28 days is 3.53 & 4.10Mpa with an increase of 24.7% & 22.39 % of that of the nominal mix.
6. The cylinder compressive strengths of concrete with partial replacement of cement by 16% of its weight by three numbers of pozzolanic materials in equal parts and 1% of Micro magnesium oxide (MgO) on 84% of weight of cement at 7 days and 28 days is 20.37 & 26.03Mpa with an increase of 21.32% & 40.79 % of that of the nominal mix.
7. The flexural strengths of strengths of concrete with partial replacement of cement by 16% of its weight by three numbers of pozzolanic materials in equal parts and 1% of Micro magnesium oxide (MgO) on 84% of weight of cement at 7 days and 28 days 4.57 & 4.97Mpa with an increase of 63.2% & 57.30% of that of the nominal mix.

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