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Behavior of Ground Granulated Blast Furnace Slag and Limestone Powder as Partial Cement Replacement

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Abstract*— One of the main ingredients used for the production of concrete is the Ordinary Portland Cement (OPC). Carbon-dioxide (CO_2) gas which is a major contributor in green house effect and the global warming, is produced in the production of cement, hence it is needed either to search for another material or partially replace cement by some other material.[2] In recent years ground granulated blast furnace slag (GGBS) and Limestone powder (LP) when replaced with cement has emerged as a major alternative to conventional concrete and has rapidly drawn the concrete industry attention due to its cement savings, energy savings, and cost savings, environmental and socio-economic benefits.[1]. This paper investigates the possibility of utilizing Blast Furnace Slag (BFS) and Limestone powder (LP) as a cement substitute in concrete, in order to reduce environmental problems due to manufacturing of cement and waste disposal. The present study reports the results of an experimental study, conducted to evaluate the strengths and strength of hardened concrete, by partially replacing the cement by various percentages of blast furnace slag and Limestone powder for M25 grade of concrete at 7 and 28 days. In this study w/c ratio of 0.42 is used. The compressive strengths at various ages are studied. From this study it is observed that BFS and LP could be utilized partially as alternative construction material for replacement of cement in concrete.

Keywords*— Concrete, Replacement, Blast furnace slag, Limestone Powder, Workability, Compressive strength, Flexure strength, Tensile strength, Durability.

I. INTRODUCTION

Concrete is prepared by mixing various constituents like cement, aggregates, water, etc. which are economically available. Concrete is the second most highly used item in the world after water. Production of cement used in concrete involves emission of large amount of CO_2 which is the major contributor for green house effect and global warming.[2] So, this leads to the ecological imbalance and cause pollution. Environmental restrictions of cement use in concrete have resulted in search for alternative which can be used in place of cement in concrete. Now a days, ground granulated blast furnace slag, limestone powder and fly ash is successfully used in concrete as a cement replacement which are cement saving, energy saving and cost saving and moreover cause environmental and socio-economic benefits.[1].

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The paper presents a comparison of the Slump, compressive strength, Split tensile strength, flexure strength and water absorption of the concrete made by Blast furnace slag and Limestone powder by replacing cement at different levels. Concept of using Blast furnace slag and Limestone powder is not new all over the world. But using both at same time is in concrete as a cement replacement is not become popular. Hence this investigation is made to check the simultaneous effect of BFS and LP on the properties concrete.

II. LITERATURE RIVEIW

Pathan V.G, Ghutke V.S and Pathan G. [3] have concluded in their paper that ground granulated blast furnace slag is better replacement of cement than various other alternatives. The rate of strength gain in slag replaced concrete is slow in early stages but with proper curing the strength goes on increasing tremendously. The compressive strength decreases when the cement replacement is more than 50%. Use of slag or slag cements usually improves workability and decreases the water demand due to the increase in paste volume caused by the lower relative density of slag. From their results they concluded that 45% replacement of cement by GGBFS gives the highest amount of compressive strength. They suggested that the replacement of cement with slag should be limited to 40% in India. Latha K.S, Rao M.V.S and Reddy V.S [1] have concluded from their research that Strength efficiency of GGBS increases by 89% in M20, 41% in M40 and 20% in M60 grade concrete mixes when compared to M20, M40 and M60 grade concrete mixes without any mineral admixture at 28 days respectively. The optimum dosage of percentage of replacement of cement with GGBS was found to be 40%, 40%and 50% in Ordinary (M20), Standard (M40) and High strength grade (M60) grades of concrete respectively. They also concluded that the partial replacement of cement with GGBS in concrete mixes has shown enhanced performance in terms of strength and durability in all grades. This is due to the presence of reactive silica in GGBS which offers good compatibility. It is observed that there is an increase in the compressive strength for different concrete mixes made with GGBS replacement mixes. The increase is due to high reactivity of GGBS. Dubey A., Chandak R and Yadav R.K [2] from the experimental investigations observed that the optimum replacement of GGBS Powder to cement without changing much the compressive strength is 15%.

They observed that 7 days, 14 days and 28 days compressive strength on 30% replacement of cement reduces about 30% that is from 21.03N/mm2 to 15N/mm2, 23.N/mm2 to 16.74N/mm2.and 26.9 N/mm2 to 18.81N/mm2 respectively. From study they concluded that as the % of BFSP increase, the strength tends to de-crease. Gudissa W. and Dinku A. [4] examines the effects of partial substitution of Portland cement clinker with limestone addition on the physical and chemical properties of cement paste and hardened mortar in two ranges of blain fineness values. The laboratory test results revealed that up to 15% replacement of clinker by fine limestone powder having blain fineness values in the range of 4000 to 4500 cm2/gm result in comparable compressive strength to similar mixes produced using 100% ordinary Portland cement. It also satisfied the standard compressive strength of high early strength of cement (42.5 MPa) as per EN 197-1 standard requirements. Furthermore, it was found that 25-35% limestone addition by weight results in slightly lesser compressive strength values than the 28th day's standard compressive strength requirement. Allahverdi A. and Salem S[5] study simultaneous influences of both micro silica and limestone powder, i.e. pozzolanicity and plasticity respectively, on important properties of fresh and hardened Portland cement paste. Different mixes were prepared and studied by determining their relative workability, 7 and 50 days compressive strengths, water absorption, bulk specific gravity, and volume of permeable pore space. From the obtained results from measurement of 7 and 50 days compressive strength they concluded that partial replacement of cement by limestone powder always decreases the compressive strength. From the results of water absorption they concluded that Limestone powder has increased the amount of water absorption of the studied hardened cement pastes. Ahmed A.H.H, Abdurrahman R.B and Mohammed Z.A [6] discuss the effect of the limestone powder ($CaCO_3$) as a compensating material with cement on the compressive strength and tensile strength and discuss the effect of elevated temperature on this type of concrete. Limestone powder (LP) was used as a compensating material with different ratio of cement include (0, 10, 15, 20, 25) %. Compressive strength and tensile strength were investigated before and after the exposure to high temperature including (200, 400, 600) °C. The study show that limestone compensate changes in both compressive strength and tensile strength. Negative effects on the properties observed as the amount of limestone exceeds 15% of the cement weight.

III. MATERIAL USED

Cement

Ordinary Portland cement (OPC) of 43 grade satisfying the requirements of IS: 8112–1989 is used. The specific gravity of cement was found to be 3.005.

Fine Aggregates

The sand generally collected from the Haryana region. Sand is the main component grading zone-II of IS: 383-1978 was used with specific gravity of 2.62 and water absorption of 1.80 % at 24 hours.

Coarse Aggregates

Mechanically crushed stone of 20 mm maximum size, satisfying to IS: 383-1978 was used. Coarse aggregates used in this work are 40% 10mm and 60% 20mm of total aggregates. The specific gravity was found to be 2.62 and 2.64 and water absorption is 0.16 % and 0.18 % at 24 hours of 10mm and 20mm aggregates respectively.

Blast furnace slag and Limestone powder

Blast furnace slag used in this work is ground granulated blast furnace slag (GGBS). Ground granulated blast furnace slag (GGBFS) was obtained from JSW Ispat Steel Ltd., India. Limestone powder is obtained from Krishna stone crushers and suppliers, New Delhi.

IV. TEST PROCEDURE

M25 grade is prepared by hand mixing (IS: 10262-2009). The Portland cement was partially replaced by LP and GGBS. Four mixes M-1, M-2, M-3 and M-4 are prepared by combination of LP-GGBS i.e. 0-0%, 5-10%, 10-20%, and 15-30% respectively. For each mix 21 samples were casted, 9 cubes (150 x 150 x 150 mm), 6 cubes for compressive strength, 6 cylinders (150mm diameter × 300 mm height) for splitting tensile strength and 6 beams for flexure strength test at 7 and 28 days and 3 cubes for water absorption test for each mix M-1, M-2, M-3 and M-4 respectively.

V. RESULTS AND DISCUSSION

Following tables shows the experimental results of the test samples made from partial replacement of cement using GGBS and LP.

Table-1 Slump result of M25 grade concrete with various percentages of GGBS and LP

Mix	Slump (mm)
M-1	77
M-2	92
M-3	102
M-4	114

Table-2 Test results of M25 grade concrete with various percentages of GGBS and LP

Mix	Compressive Strength (N/mm^2)		Split Tensile Strength (N/mm^2)		Flexure Strength (N/mm^2)	
	7 days	28 days	7 days	28 days	7 days	28 days
M-1	21.33	30.06	1.838	2.828	3.6	4.2
M-2	22.66	31.84	2.121	3.201	3.9	4.5
M-3	21.47	30.36	1.791	2.876	3.7	4.3
M-4	14.51	19.70	1.178	1.980	2.8	3.0

Table-3 Percentage water absorbed of M25 grade concrete with various percentages of GGBS and LP

Mix	Percentage water absorbed
M-1	4.103
M-2	3.287

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M-3	4.217
M-4	4.675

The obtained results can be depicted in graphical form as follows:-

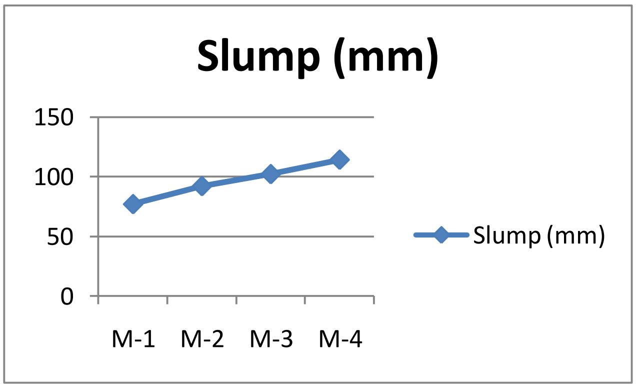

Fig-1 Slump of M25 grade concrete with various percentages of GGBS and LP

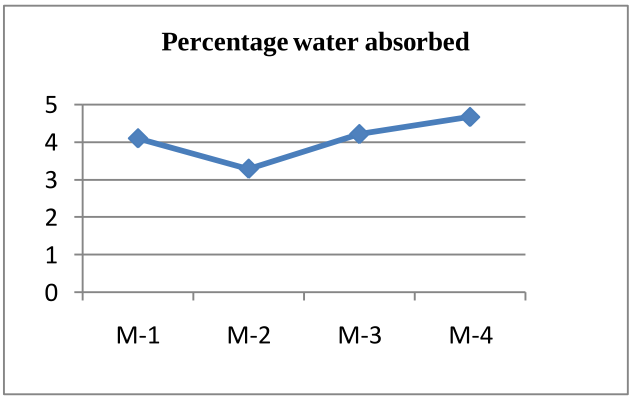

Fig-2 Percentage water absorbed of M25 grade concrete with various percentages of GGBS and LP

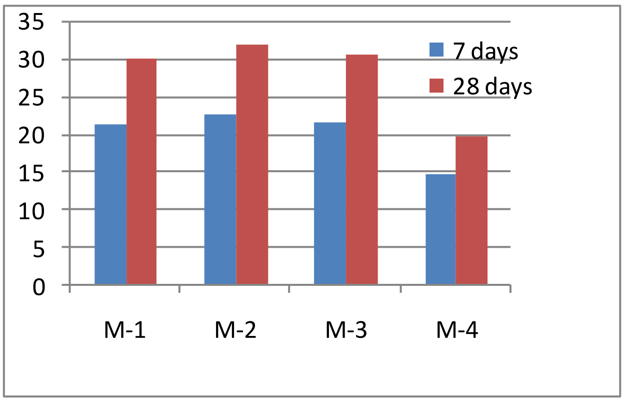

Fig-3 Compressive Strength of M25 grade concrete with various percentages of GGBS and LP

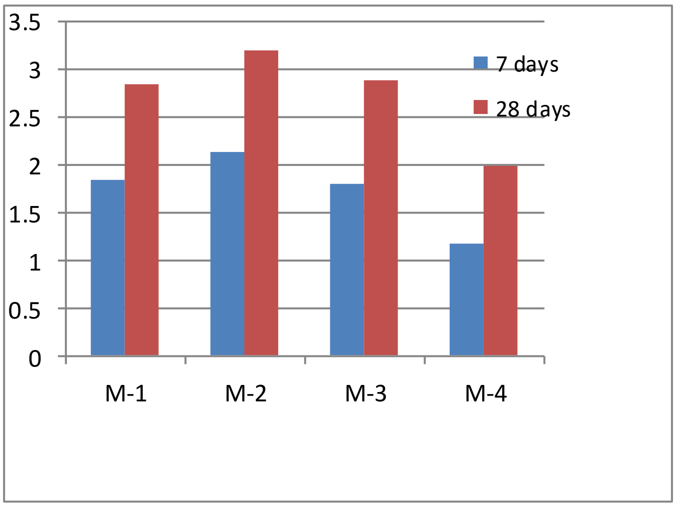

Fig- 4 Split Tensile Strength of M25 grade concrete with various percentages of GGBS and LP

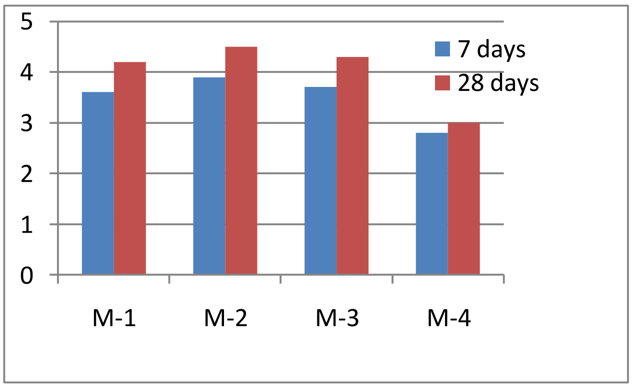

Fig- 5 Flexure Strength of M25 grade concrete with various percentages of GGBS and LP

The results obtained from slump cone test as a measure of workability are shown in table-1 and presented in Fig-1 From results it is clear that slump increases with the increases in replacement levels. The increase in slump is 19.48%, 32.46% and 48.05 compared to control mix M-1 for various replacement levels. The results of compressive strength are shown in table-2 and Fig-3. From results it is clear that the compressive strength of M-25 grade concrete at 7 and 28 days increases up to 5-10% and almost equal to control mix (M-1) at 10-20% replacement and large decreases on 15-30% replacement of cement with LP and GGBS as compared to control mix M-1. The results of split tensile strength are shown in table-2 and Fig-4. From results it is clear that the split tensile strength of M-25 grade concrete at 7 and 28 days increases up to 5-10% and almost equal control mix (M-1) at 10-20% replacement and large decreases on 15-30% replacement of cement with LP and GGBS as compared to control mix M-1. The results of flexure strength are shown in table-2 and Fig-5. From results it is clear that the flexure strength of M-25 grade concrete at 7 and 28 days increases up to 5-10% and almost equal control mix (M-1) at 10-20% replacement and large decreases on 15-30% replacement of cement with LP and

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GGBS as compared to control mix M-1. The results obtained from water absorption test as a measure of durability are shown in table-3 and presented in Fig-2. From results it is clear that percentage water absorb decreases initially when replacement is 5-10%. The percentage water absorb increases at 10-20% replacement and 15-30% replacement of cement with LP and GGBS as compared to control mix M-1.

VI. CONCLUSION

This paper has described the variation of compressive strength, flexure strength and tensile strength, also workability and durability of different specimens having different percentage of GGBS and LP as a partial replacement of cement. From the results following conclusions are concluded:-

1. The workability of the concrete increases with the increase in the replacement levels.
2. From the results it is clear that maximum compressive strength is at 5-10% replacement of LP and GGBS. The compressive strength of M-1 (control mix) and M-3 (10-20% replacement of LP and GGBS) is near about same.
3. From the results it is clear that maximum tensile strength is at 5-10% replacement of LP and GGBS. The tensile strength of M-1 (control mix) and M-3 (10-20% replacement of LP and GGBS) is near about same.
4. From the results it is clear that maximum flexure strength is at 5-10% replacement of LP and GGBS. The flexure strength of M-1 (control mix) and M-3 (10-20% replacement of LP and GGBS) is near about same.
5. From the results of water absorption test it is concluded that durability of the concrete increases with the increase in replacement levels.

   Therefore limestone powder and ground granulated blast furnace slag can be used up to 30% (10%LP and 20% GGBS) as a partial replacement of concrete.

REFERENCES

[1] Latha K.S, Rao M.V.S, and Reddy V. S. “Estimation of GGBS and HVFA strength efficiencies in concrete with age”, International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Vol. 2, Issue 2, December (2012)

[2] Dubey A, Chandak R, and Yadav R.K. “Effect of blast furnace slag powder on compressive strength of concrete”, International Journal of Scientific & Engineering Research. ISSN 2229-5518, Vol. 3, Issue 8, August (2012)

[3] Pathan V.G, Ghutke V.S, and Pathan G. “Evaluation of concrete properties using ground granulated blast furnace slag”, International Journal of Innovative Research in Science, Engineering and Technology Vol. 1, Issue 1, November (2012)

[4] Gudissa W, and Dinku A. “The use of limestone powder as an alternative cement replacement material: An experimental study”, Journal of EEA. Vol. 27, (2010)

[5] Allahverdi A, and Salem S, “ Simultaneous influences of micro silica and Limestone powder on properties of Portland cement paste”, Ceramics – Silikáty 54 (1) 65-71 (2010)

[6] Ahmed A.H.H, Abdurrahman R.B, and Mohammed Z.A, “Influence of Limestone Powder as Partial Replacement of Cement on Concrete and the Effect of High Temperature on It”, Received 13/5/2009 and Accepted 10/12/2009

[7] IS: 8112-1989 Specification for coarse and fine aggregate from natural sources of concrete

[8] IS: 456-2000 Plain and reinforced concrete - Code of practice

[9] IS: 9013-1999 Specification for admixtures for concrete (First Revision).

[10] IS: 10262-2009 Concrete mix proportioning-guidelines (First Revision).

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