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Study on the Effect of Elevated Temperatures on Residual Compressive Strength of Ternary Blended Concrete using Fly Ash and Micro Silica

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Abstract: Reduction of carbon dioxide emission in to environment has become major challenge to the present scientists. One ton of cement consumption produces one ton of carbon dioxide which damage the climate. Replacement of cement with the industrial and natural bi-products (pozzolanic materials) such as Fly Ash (FA), Micro Silica(MS), Ground Granulated Blast furnace Slag (GGBS), Metakaolin (MK), Rice Husk Ash (RHA) etc., is the only substitute in reducing the consumption of cement and for producing High Strength Concrete (HSC) in the concrete construction industry. Due to the exposure of civil engineering structures to elevated temperatures as in the case of buildings, bridges, tunnels, off shore and nuclear reactors which causes lot of damage to the structures, human and economic losses and these situations necessitate the use of appropriate fire resistant materials and development of designs for construction industry. The investigations were made on the mechanical properties of concrete viz., residual compressive strength of Ternary Blended Concrete (TBC) prepared by replacing the Ordinary Portland Cement (OPC) with10%, 20%, 30% of fly ash and 10% of micro silica at different temperatures from 100^{o} C to 800^{o}C in addition to ambient temperatures and to arrive at the optimum proportions of various constituents which give higher compressive strength.

Keywords: ordinary Portland cement; fly ash; micro silica; ternary blended concrete; elevated temperatures; compressive strength.

I. INTRODUCTION

Many researchers reported that the concrete structures exposed to fire for long duration, remains intact with minor damages. Concrete is the most suitable structural material to resist high temperature because of its low thermal conductivity and high specific gravity Arioz.o et al [1]. The extensive use of concrete as a structural material for the jet air runways, high-rise buildings, tunnels, storage tanks for crude oil, nuclear reactor pressure vessels, coal gasification and liquefaction vessels resulted in concrete being exposed to high temperature. Behavior of concrete subjected to high temperatures is a result of many factors such as dehydration of C-H-S gel, peak temperatures, heating rate, phase transformation and thermal incompatibility between cement paste and aggregates Bishr. H. A. M et al [2]. High performance concrete (HPC) made with partial replacement of cement by additives such as Fly Ash (FA), Micro Silica (MS), Metakaolin (MK), Ground Granulated Blast furnace Slag (GGBS), Palm Oil Fuel Ash (POFA), Poly Propylene Fiber (PP fiber), Finely Grounded Pumice (FGP), Rice Husk Ash (RHA) provides higher fire resistance. These type of ternary concretes play very crucial role in the present day durable concrete construction utilizing the mineral and chemical admixtures with low water cement ratio and high strength aggregates Bentz.D.P. et al [3].

Mechanical properties such as compressive strength, concrete density, modulus of elasticity, color, surface appearance are affected by high temperatures M.S.Morsy et al [4]. The researchers focused on the use of HPC subjected to elevated temperatures to know their fire resistance. It was investigated that the loss in structural quality of concrete due to rise of temperature is influenced by its degradation through changes induced in basic processes of cement hydration and hardening of binding system in the cement paste of concrete Con.X et al, - Garcia.J.I et al [5,6].

It was observed that the concrete prepared by the replacement of silica flour to OPC improves the performance of the produced binary blended Concrete when exposed to elevated temperature up to 400^{0}C and the strength, elasticity modulus and deformation of concrete are irreversibly influenced by temperature elevation mainly to 100^{0}C and 200^{0}C. The compressive strength, indirect tensile strength, phase composition and microstructure of silica flour concrete were compared with those of the pure ordinary Portland cement Ivan Janokta et al [7]. The researchers focused on the energy conservation in the cement and concrete industry, intensive

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materials that are used for less energy are fly ash, slag and natural pozzolanas. Later some attention has been given for the use of pozzolana, Micro Silica as partial replacement to Portland cement. Unlike natural pozzolanas and Fly Ash, the Silica reaction involving Micro Silica is rapid and therefore, a long curing period is not necessary. The performance of concrete made with the addition of fly ash as a replacement of OPC improves the workability, strength and durability properties due to long term curing Rafat Siddique [8]. High early strength properties can be achieved by the addition of micro silica in addition to fly ash because of the presence of high percentage of silica(92%) which helps in the chemical reaction when added water to the cement.

A. Scope of the Study

The object of this study is to evaluate the percentage of cement replacement by Fly Ash and Micro Silica for the maximum residual compressive strength at elevated temperatures. This includes the following aspects :

To investigate the mechanical property of concrete viz., residual compressive strength of ternary blended concrete prepared by replacing the Ordinary Portland Cement (OPC) with fly ash 10%, 20%, 30% and micro silica 10% at different temperatures from 100^oC to 800^oC in addition to room temperatures and to arrive at the optimum proportions of various constituents which give higher compressive strength.

II. MATERIALS AND METHODS

A. Materials

Locally available 53 grade of ordinary Portland cement (Jaypee cement) confirming to IS: 12269 [9] was chosen for investigations. The cement was used in composition with fly ash (SiO2 =60.9%) and micro silica (SiO2 =92%), super plasticizer CONPLAST 430, river sand (specific gravity of fine aggregate = 2.53) in accordance with IS: 2386-1963[10] standard specifications and coarse aggregate (machine crushed angular granite metal of 20mm) with specific gravity is 2.70, bulk density is 15.60 kN/cu m and fineness modules of concrete found to be 7.1 respectively. Locally available potable water was used for mixing and curing.

B. Mix Proportion

The mix proportion was done as per BIS.

Mix proportions for 0.35 w/b ratio concrete mix: 1.00:1.55:2.35

C. Casting of Specimens

A total of 96 concrete cube specimens of 100 mm size (24 for control concrete (100% OPC) (M_o), 24 for ternary blended concrete using 80% OPC, 10% fly ash and 10% micro silica(M_1), 24 for ternary blended concrete using 70% OPC,20% fly ash and 10% micro silica(M_2), and 24 for ternary blended concrete using 60% OPC 30% fly ash and 10% micro silica(M_3)) were cast using steel moulds with w/b 0.35 using needle and table vibrator for consolidation and compaction . All specimens were demoulded after 24 hours and cured in water for 27 days.

D. Testing

After 28 days of curing, the specimens of both normal and ternary blended concrete were exposed to 100^oC, 200^oC, 400^oC, 600^oC and 800^oC for 1 hour duration in furnace and allowed to cool to room temperature. The tests were performed using 2000 kN compression testing machine as per standard procedure for compressive strength. The average strength of four samples was taken per batch.

III. RESULTS AND DISCUSSION

A. Residual Compressive Strength

The following figures show the compressive strength of TBC and control concrete with 0.35 w/b ratio after exposure to 1 hour duration for 100^oC, 200^oC, 400^oC, 600^oC and 800^oC. The decrease in the compressive strength is seen in for temperature exposures in control concrete and the ternary blended concretes. The increase in compressive strength was observed between the temperatures 100^oC and 200^oC due to the replacement of pozzolanic materials (fly ash and micro silica) with OPC which evaporates the water content and accelerate the hydration. A significant decrease in compressive strength was observed between the temperatures 600^oC and 800^oC which is due to deformation of C-S-H gel but an increase of 24.6% residual compressive strength was found in M_3 when compared to OPC (M_o) at 800^oC.

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Table 1 Residual Compressive strength of HPC after 28 days of curing

Sample	Cement %	Micro Silica %	Fly Ash %	Residual Compressive Strength (N/mm^2)					
				32°C	100°C	200°C	400°C	600°C	800°C
Control(Mo)	100	0	0	68.5	57.3	60.5	44.5	32.7	16.6
M1	80	10	10	69.3	58.6	61.2	45.3	33.6	17.8
M2	70	10	20	70.6	59.4	62.7	47.1	34.5	19.5
M3	60	10	30	72.4	61.5	64.3	48.6	35.8	20.7

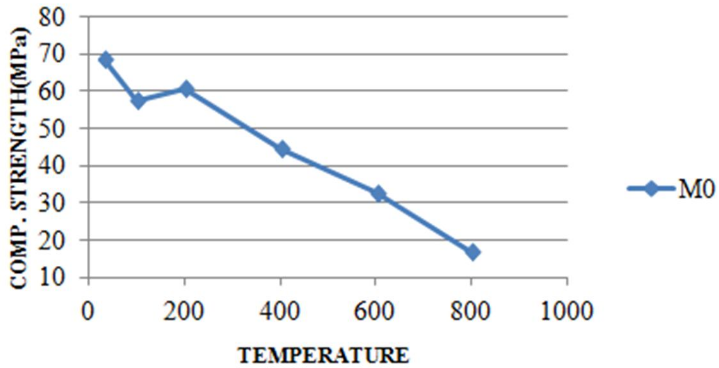

Figure1. Residual Compressive Strength of control concrete (M0)

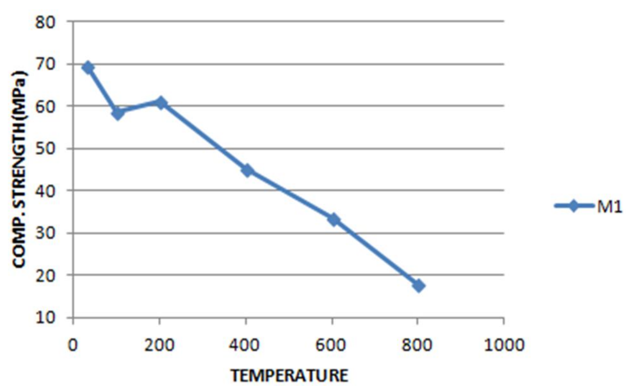

Figure2. Residual Compressive Strength of Ternary Blended Concrete (M1)

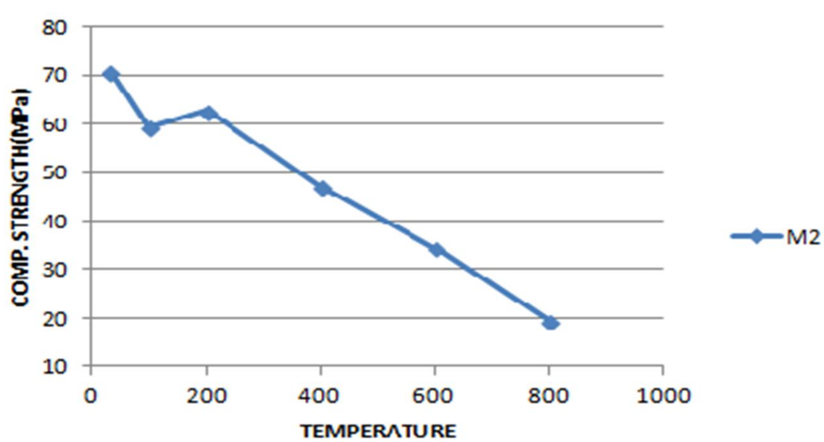

Figure 3. Residual Compressive Strength of Ternary Blended Concrete (M2)

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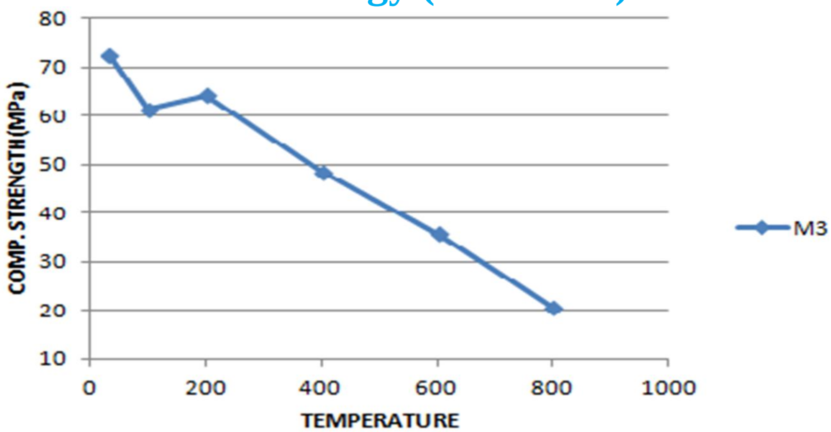


Figure 4. Residual Compressive Strength of Ternary Blended Concrete (M3)

IV. CONCLUSIONS

Based on the experimental results, the following conclusions were drawn:

The M_3 (60% of OPC, 30% of FA and 10% of MS) specimens show better fire endurance compared to replacement mixes in M1(80% of OPC, 10% of FA and 10% of MS) and M2(70% of OPC, 20% of FA and 10% of MS). An increase of 24.6% residual compressive strength was found in M_3 when compared to OPC (M_0) at 800^{o}C.

The residual compressive strength decreases with increase in temperature except for elevated temperature at 200^{o}C. The residual compressive strength at 200^{o}C increased than at 100^{o}C due to the bonding of C-S-H gel.

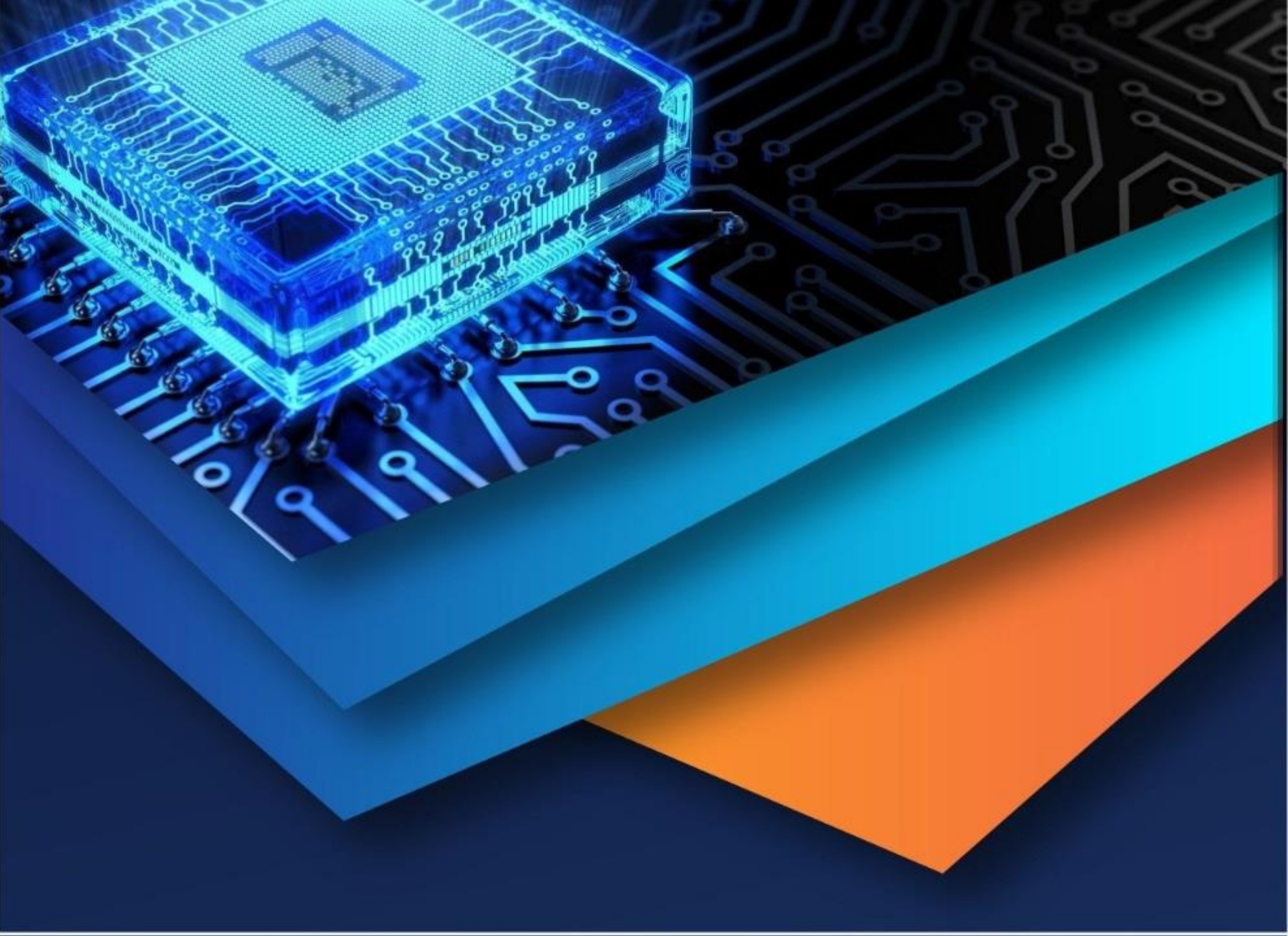
A gradual reduction in compressive strength was found for all percentage replacement mixes from 200^{o}C to 800^{o}C due to deformation of C-S-H gel.

The ternary blended concrete with increase in percentage of Fly Ash has shown improved resistance for higher temperature at 0.35 water/binder ratio.

The replacement of OPC with Fly Ash and Micro silica reduces the emission CO_2 and saves the environment and also minimize the natural resources that are used in manufacturing of cement

REFERENCES

[1] Arioz.O, "Effect of elevated temperature on properties of concrete", Fire Safety Journal, 42(2007), pp. 516–522 cited by M.S. et. al, 2010.
[2] Bishr. H. A. M, "Effect of elevated temperature on the compressive strength" ICCBT 2008-A-(019) – pp. 217-220.
[3] Bentz. D. P, Garboczi. E. J, ACI Materials journal, Detroit, v.88, n.5, p 518-29, sep-oct. 1991 cited by Evandro Tolentino et al, 2002
[4] Morsy. M. S, Alsayed. S. H and Aquel. M "Effect of elevated temperature on mechanical properties and microstructure of silica flour concrete" International journal of Civil & Environmental Engineering IJCEE-IJENES Vol: 10 No: 01\
[5] Cong. X and Kirkpatrick. R. J, "Effect of the temperature and Relative Humidity on the structure of C-S-H gel", In: Jour. Cement and Concrete research. 25 (1995), pp.1237-1245 cited by Ivon Jonatka et al, 2003
[6] Escalante- Garcia. J. I. and Sharp.J.H, "Effect of temperature hydration of the main clinker in portland cement". Part 1, Neat Cement. In: jour. Cement and Concrete research. 28 (1998), pp.1247-1257 cited by Ivon Jonaktka et al, 2003
[7] Jonaktka, Terezia Nurenbergerova, "Effect of temperature on structure quality of high strength concrete wiith silics fume". Transactions of the 17th international conference on Structural Mechanics in Reactor technology (SMIRT17) Prague, Czech republic, august 17-22, 2003
[8] Rafat Siddique , "Performance characteristics of high-volume Class F fly ash concrete", Cement and Concrete Research(34), 2004, pp 487-493
[9] I.S. 12269-1987 Specifications for 53 grade ordinary Portland cement
[10] I.S. 2386-1963 – Part I to VIII. Indian Standard Methods of Test for Aggregate for concrete, Bureau of Indian Standards, New Delhi.



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