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A REVIEW ON TERNARY BLENDED CONCRETE SUBJECTED TO ELEVATED TEMPERATURES FOLLOWED BY DIFFERENT COOLING REGIMES

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Abstract

Perlite powder is a material which has low thermal conductivity nature. Researchers have done experiments on perlite powder concrete and find it has a good heat insulating properties. But, very less research on perlite powder concrete at elevated temperatures as though it is a good conductor of reducing heat. In this present research, cement was replaced with silica fume at 10% constant replacement and perlite powder was partially replaced with weight percentage of cement which is turned as a ternary blended concrete(TBC). This TBC is later taken to elevated temperatures and their performance to control concrete are noted.

Introduction

During the past decades we have seen many researches on concrete by replacing with many materials in a suitable way to diminish the economy and pollution. The replacement was done with a stuff which are pozzolanic in nature and these stuff are mostly come from garbage's such as sugarcane bagasse ash, rice husk ash etc., In this study we have taken the replacement material which comes from volcanic rock known as 'perlite powder' which is pozzolanic in nature. Perlite powder is a medium which gets from siliceous volcanic rock. It consists of 2 to 6% of combined powder and it also have a unique nature of having low thermal conductivity to resist in temperature. Having of its remarkable thermal properties it is also very low in cost, easy to handle and meets the fire regulations. Perlite powder contributes good pozzolanic effect with long lasting curing. Increasing the curing period will increase more strength and also shows good pozzolanic effect. Perlite powder gives good strength with long last curing, so as to get good strength from early of the days silica fume is added to the composition which is turned to be a ternary blended concrete. Due to high content of sio_2 in silica fume it gives high strength. In the present work cement was replaced with perlite powder at different replacements and silica fume with a constant replacement of 10%. Later the cubes were taken to different elevated temperature to know the residual strength of TBC cubes at elevated temperature properties such as engineering and Durability also investigated.

Literature review

Silica Fume:

The ACI chairperson Ternaence C.Holl and has published "A guide for the use of silica fume in concrete." Silica fume particles are very smaller in size less than 1µm with an average dia of 0.15µm nearly 1/100th size of average cement particle. Specific gravity of silica fume is generally ranges from 2.2 to 2.3.Silica fume reduces bleeding significantly and it is a very effective pozzolonic material. Silica content in silica fume reacts with calcium ion to form calcium silicate hydrate (C-S-H).

In 1981, Bache signified that water content reduced when silica fume is used as it occupies the voids between cement particles.

In 1989, uchikawa demonstrated that 10% substitution of silica fume increases alkali up to 3times more.

In 2004, vishalsghutte et.al made a research on "influence of silica fume on concrete to determine the ideal substitute percentage of silica fume in concrete." and has proved that when silica fume is mixed with cement up to 10%. It consistently increases the compressive strength but more amount of silica fume leads to lesser strength.

Faseyemi victor ajileye had shown that 5 to 10% silica fume gives higher strength, beyond that strength decreases.

S. Bhanjaand B, senagupta conducted the "Effect of silicafume on tensile strength of concrete". After conducting experiments with different percentages of silica fume in concrete, the result shows increase in flexural strength up to 10% is higher when compared to split tensile strength.

As referring to above literature reviews it is clear at 10 % of silica fume in concrete results in great strength. Finally replacement of silica fume within 5 to15% shows better strength.

Perlite Powder

L-h.yu et.al., (9 july 2002). "Investigation on pozzolanic effect of perlite powder in concrete." done on cement replaced with equal amount of perlite powder and with different proportions he checked different strength analysis and finally concluded the perlite powder has a good pozzolanic effect.

T.K.Erdemet.al., (12 September 2006). "Use of perlite a pozzolanic addition in producing blended cements focuses on the natural perlite powder in blended cement production." Focuses on the natural perlite powder in blended cement production. Next to the examination of of perlite powder as a pozzolons they were redeemed with 20% and 30% of perlite additions. Tests such as durability and compressive tests were done. The attainment results of compressive strength shows better strength results compared to conventional concrete.

F.Bektaset.al., (2004) "Use of perlite powder to suppress the alkali-silica reaction." In this study the inflation of motor bars containing different proportion of natural perlite, expanded perlite and silica fume was studied. Aggregate used in this study is also two kinds containing river aggregate and monzodorite aggregate. The casting process was done according to ASTMC1260 known as accelerated motor method, later the cubes were stored in NAOH solution for 30days. Change of length is measured. The results shows both natural and expanded perlite powder have prospective to overpower the harmful alkali-silica expansion.

Nusret Bozkurt (June 2013) "The effect of high temperature on concrete containing perlite powder."Reports on statistical and experimental results carried out at high temperatures using perlite powder as cement replacement with 0%, 5%, 10%, 15%, 20% perlite powder. To reduce the number of experiments taguchi with an L25 orthogonal array method was introduced. After preparation of cubes these cubes were taken to elevated temperatures of 400^0C, 600^0C, 900^0C. And finally concluded these parameters had some importance on ultra pulse velocity and compressive strength using analysis on ANOVA method.

Vandadvosoughi (29 may 2015) "Evalution of perlite powder performance in concrete to replace part of cement." in his study perlite powder was replaced with cement up to cement size of about 5%, 10%, 15%, 20%, 25% and 30%. Experiments such as compressive strength and UPV tests were done. Perlite powder having more pozzolanic properties it gives more strength when it mixed with cement. Results shows that concrete containing perlite powder has good performance on concrete.

Elevated Temperatures:

Omer Arioz studied about the "Effects of elevated temperatures on properties of concrete." He has clearly enlightened the changes that happened in concrete surfaces at different elevated temperatures and the weight-loss of concrete, which was found to be more by increasing the temperature. After 600^oC, the cracks exposed in the surface were more in number. Taking this investigation as reference, the authors have decided to heat the concrete specimens up to 800^oC and to observe the changes that would take place.

Y.N. Chan and Luo investigated on the "Pore structure and compressive strength of concrete." when exposed to a temperature of up to 800^oC and determined that (HPC) had higher residual strength than straight concrete. The correspondence of pore structure, together with pore size distributionand porosity, had shows the degradation of mechanical properties of HPC subjected to higher temperatures.

Rahel K.H. Ibrahim carried out a research on the "Effect of high temperature on mortars." which enclosed silica fume and figured the compressive strength of mortars at different replacements of SF recorded at elevated temperatures of 300^oC and 600^oC. The results indicated at 300^oC, specimens with SF gave more strength compared with those without SF at 600^oC, in all the specimens, they found a decrease in compressive strength. Yet again, those specimens containing silica fume had more strength than the non-silica fume specimens.

Sammy Yin Ninchan et.al.studied the "Effect of high temperature and cooling regimes on pore structure and compressive strength of HPC and NSC." and they noted that both HPC and NSC had reduced strength properties after being expose to high temperatures. Specimens cooled by applying sudden water caused a little more weakening than the specimen with gradual cooling. They also originate that the cumulative pore volume between the two cooling regimes was reduced to high temperatures of 1100^0C compared to 800^0C.

A.FerhatBingol and Rusten Gul performed a research work on the "Effect of elevated temperatures and cooling regimes on NSC." The specimens were heated up to 700^0C for interval of 3 hours at each temperature and finally he concluded the strength was increased at 50^0C and 100^0C and the samplings showed more strength-loss when cooled with water as associated to air cooling.

From the beyond studies, it could be concluded that, while increasing the temperature, the strength properties of the concrete would reduce which arecooled with water due to sudden thermal shock, and had more lessening in strength as compared to those subjected to air cooling.

Subhash Yaragal and Ramanjaneyulu did a research on "Polypropylene concrete exposed to elevated temperatures and cooled with different regimes." In the heating series, the samples were subjected to elevated temperatures fluctuating from 200°C to 800°C with a retention period of 1 hour and were cooled to room temperature using different cooling regimes, namely air cooling, furnace cooling and sudden cooling. The residual compressive strength, weight loss and split tensile strength retaining characteristics were studied. Test results showed that weight and both tensile and compressive strengths significantly reduced, with an upsurge in temperature and are strongly reliant on cooling regimes implemented

A. M. K. Abdelalim et.al., carried out a research on the "Effect of elevated temperatures on normal strength concrete (NC) and self-compacted concrete (SCC)." at different temperatures, viz., 200, 400, 600 and 800°C and later taken for different cooling regimes such as air cooling, CO_2 powder cooling and water cooling; they concluded that tensile strengths and residual compressive strength of SCC were usually greater than those of NC and also specified that adopting CO_2 powder as a cooling regime provided the smallest amount of destruction to both NC and SCC, while water cooling regime provided the extreme damage.

III. Materials and Properties

(i) ***Cement****:*

OPC-53 grade cement was used for the trail mix work and special care was taken for cement. The physical properties of cement are listed in Table 1.

Table1: Properties of Cement.

S No	PROPERTY		VALUE
1	Specific Gravity of cement		3.15
2	Fineness of the cement		8.56%
3	Soundness Test(Le-Chatlier)		3.8mm
4	Setting Time	Initial	180min
		Final	240min

(ii) ***Perlite powder:***

Perlite powder was taken from aastrachemicals located at Chennai.

(iii) Silica Fume:

Silica fume, which is also known as micro silica, is an non-crystalline poly-morph of silicon di-oxide. It is an ultrafine powder which contains of sphere-shaped particles with an average particle diameter of 150 nm. Its physical properties are listed in Table 3.

Table 3 Physical properties of silica fume.

S.	Physical Property	Tested Value
1.	Specific Surface	18 cm^2/gm
2.	Bulk Density	600 – 630 kg/
3.	Specific Gravity	2

(iii) **C*oarse Aggregate:***

Locally existing stonework, sieved with a 20 mm sieve, was used as coarse aggregate. It was then washed to clear dirt and dust, and kept under surface dry conditions. The aggregates were tested as per the IS: 383-1970. Table 4 illustrates the properties of the coarse aggregate used.

Table 4: Properties of Coarse Aggregate.

S No	PROPERTY	VALUE
1	Specific gravity	2.8
2	Water absorption	0.2%
3	Fineness modulus	7.3

(iv) ***Fine Aggregate*:**

The locally available river sand conforming to Zone-II of IS 383-1970 was used as fine aggregate. It was ensured that the fine aggregate was clean, inert and free from organic matter, silt and clay. Its properties are shown in Table 5.

Table 5: Properties of Fine aggregates.

S No	PROPERTY	VALUE
1	Specific gravity	2.65
2	Water absorption	4.16%
3	Fineness modulus	2.69

(v) ***Chemical Admixture:***

Super Plasticizer (Conplast SP-430) was used to obtain better workability for the mix of chosenw/c ratio of 0.48. The specific gravity was varying from 1.220 to 1.225 at 30^{o}C in the lack of chloride. The air entrained in the mix is nearly taken as 1%. The various physical properties of Conplast SP-430 are as listed in Table 6.

Table 6: Properties of Conplast SP-430.

S. No.	Description	Property
1	Appearance	Brown liquid
2	Specific Gravity (BSEN 934-2)	1.2 @ 22°C + 2.2°C
3	Water soluble chloride (BSEN 934-2)	-
4	Alkali content (BSEN 934-2)	Typically less than 53 g. Na_2O equivalent/ litre of admixture

Objectives:

- To involve partial replacement of silica fume and perlite powder with cements and finds its compressive strength behaviour with conventional concrete.
- To find the thermal conductivity nature of concrete.
- Asses the stress-strain behaviour of ternary blended concrete for building elements.
- To identify suitable admixture to improve bonding among concrete materials.
- To know the behaviour of ternary blended concrete at elevated temperatures.
- Weight loss of concrete after taken to elevated temperatures.

Methodology:

- It is proposed to carry partial replacement of silica fume and perlite powder with different combinations for cement of M30 grade concrete.
- To investigate the engineering properties of ternary blended concrete such as Workability, Compressive strength, Split tensile strength, Sorptivity, Shrinkage, Heat resistance and Thermal conductivity tests.
- Durability properties such as Sorptivity test, Rapid chloride penetration test, Shrinkage test.
- Taking ternary blended concrete to different elevated temperatures.
- Performing analysis in Ansys-software to find out the strength behaviour in columns and beams.

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