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"Performance Evaluation of High Strength Concrete for Environmental Factors & High Temperature"

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I.ABSTRACT:

The objective this study is to observe the effects of high temperature, sulphate attack, carbonation on high strength concrete. Corrosion in reinforcement is major problem cause and leads to deterioration of concrete. In carbonation, the carbon dioxide reacts with hydrated cement and destroys its alkalinity.
This affects the durability of concrete. Sulphate present soil, sea water, atmosphere, may damage the structure. Sulphate reacts with cement causing cracks and expansion. There is effect on compressive strength of concrete due to high temperature. Exposure of concrete to elevated temperature affects its mechanical and physical properties.

Key Words:

II.INTRODUCTION:

Now a days high-strength and high-performance concrete are widely used throughout the world. To produce them it is necessary to reduce the water/binder ratio and increase the binder content. Super-plasticizers are used in these concretes to achieve the required workability. Different kinds of cement replacement materials are usually added to them because of desired porosity and permeability. Concrete has been defined as a composite material obtained using cement, aggregate, water and when necessary, chemical and/or mineral additives, placed into moulds of various sizes and shapes and hardened under convenient conditions. Today concrete has been used with an increased strength and durability in connection with the developments in technology in pre-stressed concrete, concrete and reinforced concrete structures which are sometimes exposed to fires and many structures get damaged and/or out of use.

The study of behaviour of concrete under elevated temperature has only recently increased. These studies are very useful for the design of special concrete structures subjected to elevated temperatures such as thermal shielding for nuclear reactors, metallurgical and chemical industries, runways etc. As it is known, high temperatures caused as a result of fire decreases the concrete strength and durability of such structures. Fire resistance of concrete is primarily affected by factors like the temperature, duration and condition of the fire. On the other hand, the type of cooling, dry cooling (in air) and wet cooling (in water) affect the residual compressive and flexural strength. Residual mechanical properties reported in most previous literature might be overestimated, where natural cooling was usually employed. Proper evaluation of fire resistance of concrete needs more experimental data obtained under various cooling regimes such as water spraying or water quenching where they cause different stresses in reinforced concrete members at high temperature and the structural member can lose load bearing capacity. Concrete structures are sometimes exposed to the effects of fire. Although there are different ways to extinguish the fire, it is generally done with water spray. In this study, the behaviour of high strength concrete with varying percentage of silica fume replacement of cement by weight exposed to high temperatures is examined after cooling i.e. Dry (in air) cooling and Wet (in water) cooling.

The most important design parameter for concrete structures is compressive strength. This critical parameter drives the design process and can influence the cost of a project. Through the use of certain mineral admixtures, the cost of concrete can be reduced. These admixtures also enhance the properties of mortar or concrete.

III.LITERATURE REVIEW:

Following are some literatures and references by which the objectives of the dissertation work have been decided.

Ali Behnood, Hasan Ziari (2006)[1]: in their paper entitled "Effects of silica fume addition and water to cement ratio on the properties of high strength concrete after exposure to high temperatures" studied the effect of different percentage silica fume and different amount of water cement ratio on the residual compressive strength of high strength concrete after exposure 100°C to 600°C .They replaced cement by silica fume by 0%,6%,10% and w/c ratio was kept constant at 0.30 and evaluated the effect of high temperature HSC.
They concluded that, the dosage of SF had no significant effect on the relative residual compressive strength at 100°C and 200ºC, whereas the amount of SF had considerable influence on the residual compressive strength above 300ºC, similar to the response at 600ºC. The optimum dosage of SF and w/c was found to be 6% and 0.35, respectively.

Chandramouli. K, Srinivasa Rao. P, Pannirselvam, Seshadri Sekhar.T, and Sravana.P (2010)[2]: in their paper entitled "The Effect of Weight Loss on High Strength Concrete at Different Temperature and Time" studied behavior of concrete mixes when subjected to different temperatures is necessary because of huge differences in climatic conditions in summer and winter seasons. In European countries the temperature may fall down to negative temperatures, where as in Asian countries the temperatures are so high. Exposure of concrete to elevated temperature affects its mechanical and physical properties. Elements could distort and displace and under certain conditions, the concrete surfaces could spall due to the buildup of steam pressure.
As the properties of concrete change with respect to time and the environment to which it is exposed, an assessment of the effects of concrete aging is also important in performing safety evaluations. Tests were performed on concretes, prepared with M40 and M50 grade of ordinary concrete. Exposure variables included maximum temperature, time of exposure and the cooling rate. The percentage weight loss of ordinary concrete mixes after exposing the specimens to 200ºC, 400ºC and 600ºC with exposure time of 4, 8 and 12 hrs duration are observed. The percentage weight loss of ordinary concrete mixes after exposure of the specimens to 600ºC for 12 hrs duration are observed to be varied from 4.7 to 4.8.

Emre Sancak a, Y. Dursun Sari b, Osman Simsek (2006)[3]: in their paper entitled "Effects of elevated temperature on compressive strength and weight loss of the light-weight concrete with silica fume and super plasticizer" examines light weight concrete (LWC) and concrete with normal weight concrete (NWC). For mix of concrete silica fume replace by cement in the percentage 0%, 5% & 10% by weight of cement. Also, superplasticizers (SP) to the above mixtures by 2% by weight.
In conclusion, unit weight of LWC was 23% lower than that of NWC. The LWC containing 2% SP could retain 38% of the initial compressive strength. Rate of deterioration was higher in NWC when compared to LWC. The loss of compressive strengths increased depending on the ratio of using SF at about 800ºC and over.

Halit Yazıcı (2005)[4]: in their paper entitled "The effect of curing conditions on compressive strength of ultrahigh strength concrete with high volume mineral admixtures" pulverized fly ash (FA), pulverized granulated blast furnace slag (PS) and silica fume (SF) were quantitatively studied with the incorporation of Portland cement (PC). PC was replaced with FA or PS at specified ratios. Basalt and quartz powder were used as an aggregate in the mixtures. Three different curing methods (standard, autoclave and steam curing) were applied to the specimens.
Test results indicate that high strength concrete can be obtained with high volume mineral admixtures. Compressive strength of these mixtures is over 170MPa. It seems that these mixtures can also be used for reactive powder concrete (RPC) production with some modifications.

Harun Tanyildizi, Ahmet Coskun (2006)[5]: in their paper entitled “Performance of lightweight concrete with silica fumes after high temperature” studied the effect of silica fume on compressive and splitting tensile strength of light weight concrete after high temperatures evaluated experimentally and statistically. Silica fume replaced by 0%, 10%, 20% & 30% and the heated temperature 200°C, 400°C & 800°C. Compressive strength and splitting tensile strength of lightweight concrete was tested in present study. Cube specimen (100x100x100) mm prepared to determine the compressive strength and cylinder 100mm dia. and 200mm in height prepared to determine splitting tensile strength.
They concluded that,
They found that 20% silica fume specimen have height compressive strength and splitting tensile strength for all temperatures.
The strength was decreased when increased temperature.
That decreases of strength were prevented by using silica fume admixtures in light weight concrete.

H. Toutanjia, N. Delattec, S. Aggounb, R. Duvalb, A. Danson (2002)[6]: In their paper entitled “Effect of supplementary cementitious materials on the compressive strength and durability of short-term cured concrete” studied the effect of different supplementary cementitious materials such as silica fume, fly ash, slag and their combinations on strength and durability. Specimens are cured for short period of time 14 days and the dimensions are for beam (3x4x16) inch and (4x8) inch. Mix proportion cement: silica fume: fly ash: slag is prepared for testing. Freeze-thaw test and Wet-dry test were carried out.
Results show that at 14 days of curing, the use of supplementary cementitious materials reduced both strength and freeze–thaw durability of concrete. The combination of 10% silica fume, 25% slag, and 15% fly ash produced high strength and high resistance to freeze–thaw and wet–dry exposures as compared to other mixes. This study showed that it is imperative to cure the concrete for an extended period of time, especially those with fly ash and slag to obtain good strength and durability.
J. E. Park, Y. S. Shina, And H. S. Kima (2010)[7]: in their paper entitled “Various Factors Influencing on Thermal Behaviors of High Strength Concrete (HSC) Columns under Fire” investigated behaviors of high strength concrete (HSC) columns at elevated temperatures including temperature distributions and spalling. Toward this goal, seven short HSC columns having different design parameters are fabricated and placed in a heating chamber for fire tests. The design parameters are cross sectional areas, cover thicknesses, and arrangements of reinforced bars. The columns are heated using temperature control system following ISO 834 time-temperature curve.
Temperature distributions are obtained from temperature gauges located inside the columns during the fire tests, and the spalling depths of the columns are measured after the fire tests in order to examine loss of cross-sectional area due to spalling. Experimental results show that the design parameters, such as cross-sectional areas, cover thicknesses, and reinforcement arrangements, affect on the temperature distributions and spalling of HSC columns, and are important factors of fire safety design.

K. Ramujee and N. R. Dakshina Murthy (2005)[8]: in their paper entitled “Compressive strength of fly ash concrete subjected to elevated temperature” studied compressive strength of concrete with fly ash replacement upto 40% of cement at every regular interval of 10% when exposed to 200°C at
regular interval of 1hr, conventional concrete exposed to same duration. From their experiment, it was concluded that, the compressive strength has gradually decreased when the temperature has increased from 50°C to 200°C in all cases of exposure. It was concluded that, the compressive strength has gradually decreased when the temperature has increased from 50°C to 200°C in all cases of exposure. It is also cleared that at 50°C the conc. with 50% fly ash contained has shown an improved performance when compared with ordinary concrete for 1 hr duration of exposure 10% fly ash concrete has shown better performance. At 30% replacement of cement by fly ash the compressive strength has drastically came down.

Leyla Tanacan, Halit Yas Ersoy, Umit Arpacıoglu (2007)[9]: in their paper entitled “Effect of high temperature and cooling conditions on aerated concrete properties” studied the effect of elevated temperatures and various cooling condition on the properties of aerated concrete. Air cooled materials are tested at room temperature and in hot condition right after the fire. Water quenching effect is determined by testing the material in wet condition right after the quenching and in dry condition at room temperature. Unstressed strength of the material tested hot is relatively higher than air cooled unstressed residual strength up to 600ºC. On the other hand, water

quenching decreases the percentage of the strength particularly when the material is wet right after the quenching; strength is lost gradually as the temperature rises. Dimension of specimens (50x50x50) mm & (40x40x40) mm. They are planned under two different cooling conditions air cooled and water quenched. Specimen placed in oven heating up to maximum six temperatures 100°C, 200°C, 300°C, 400°C, 600°C & 965°C.
They concluded that, water quenching decreases the percentage of the strength particularly when the material is wet right after the quenching; strength is lost gradually as the temperature rises. As a result, if the quenching effect is disregarded, temperature rise does not have a considerable effect on the strength of the aerated concrete approximately up to 700°C - 800°C. It is able to maintain its volumetric stability as well. However, more care needs to be taken in terms of its use above 800ºC for fire safety.

M. Potha Raju, K. Srinivasa Rao and P. S. N. Raju (2007)[10]: in their paper entitled "Compressive strength of heated high-strength concrete" studied the effect of elevated temperature ranging from 50°C to 250°C on compressive strength of high strength concrete. The main objective of the current study is to compare the variation of 28-day compressive strength of HSC with temperature. The study considered HSC with two types of cements ordinary Portland cement (OPC) and pozzolona Portland cement (PPC). The cube specimens of size 100x100x100mm were heated to different temperature ranging from 50°C, 100°C, 150°C, 200°C and 250°C with duration of 1,2,3 hrs.
After the heat treatment, the specimens were tested for compressive strengths. Test results were analyzed and the effects of elevated temperatures on PPC concrete were compared with OPC concrete. The PPC concrete exhibited better performance than OPC concrete.

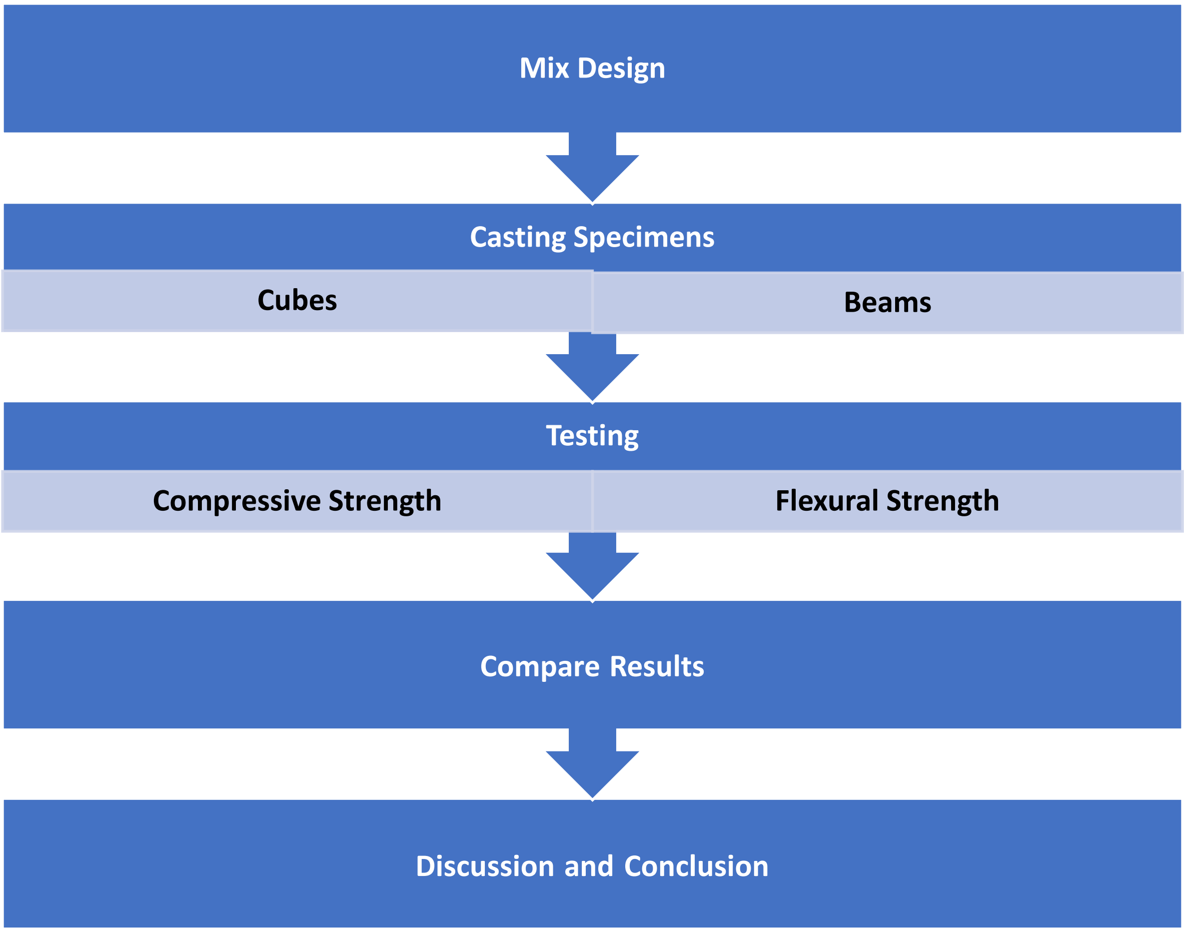
M. Mandy, P.R. S Spare and A. H. Abdel–Raheem (2002)[11]: in their paper entitled "Effect of transient high temperature on heavyweight, high strength concrete" investigated by using 3 levels of silica fume (0%, 10% & 20% by weight of cement), two coarse aggregate proportion of total aggregate (0.48, 0.65 by volume). The effect of transient high temperature on strength heavy weight high strength concrete was investigated. There were three exposure durations (0, 1hrs, 2hrs) at a temperature of 100°C, 300°C, 500°C & 700°C .from this investigation it was concluded that, as the temperature increased to 100°C, the strength decreased compared to room temperature, with further increase in temperature, the specimens recovered the strength loss and reached the peak strength of 10% to 30% above the room temperature strength. At the temperature 500°C and 700°C, the strength in each case dropped sharply. There is no effect of coarse aggregate contains on residuals compressive strength after exposure to high temperature.

M. Lakmipathy and M. Balchandar (2005)[12]: in their paper entitled "Studies on effect of elevated temperature on the properties of high strength concrete containing supplementary cementitious materials' investigated the five mixed proportion with binder such as silica fume, fly ash, ground granulated blast furnace slag, rise husk ash and super plasticizer. A total no. of 450 specimens (150 cubes,150cylinder & 150beams) are cast, cured & three different elevated temperature i.e. 600°C to 1000°C with three different durations of exposures i.e. 4hrs, 6hrs and 8hrs and tested. From this experiment it was concluded that specimens made from five different mixes of high strength concrete were subjected to unstressed residual test conditions. This is commonly used method to evaluate the effect of elevated temperature. The scheme of test includes a range of temperature from 600°C to 1000°C. The specimens heated upto 1000°C for six hours and eight hours have blasted during heating. High strength concrete has shown the 90% drop in its strength once exposed to 1000°C irrespective of binder materials used.

N. Suresh, Y. M. Manjunatha and D. S. Prakash (2005)[13]: in their paper entitled "Studies on compressive strength of concrete subjected to cyclic heating" an attempt has been made to understand the effect of cyclic heating on concrete. For this laboratory, investigated were carried out by making 250 specimens and subjecting them to cyclic heating in the range of 100°C to 400°C at duration of exposure from 0 to 180 min. They concluded that concrete cubes subjected to cycle heating and water quenching have shown a considerable decrease in residual compressive strength when temperature of exposure was varied from 100°C to 400°C.hairline Cracks were observed from concrete cubes subjected to cyclic heating and water quenching when temperature of exposure was 300°C & above.

Tarun R. Naik, Rudoiph N. Kraus (2002)[14]: in his paper entitled "Temperature effects on High-performance concrete" from their investigations conducted at the UWM center for By-products Utilizations; two different HPC mixtures were proportioned to have the 28-days compressive strength of 85MPa. The first mixture contained 9% class C fly ash and 14% silica fume and the other mixture contained 25% Class C fly ash, 17% Class F fly ash, and 6% silica fume by weight of cementations materials. Two types of curing methods, standard moist-curing and variable Temperature curing environment were used. Tests were conducted to study the influence of temperature on compressive strength, resistance to chloride-ion penetration.
They concluded that, Both HPC mixtures showed high rate of strength development up to 28 days. Beyond 28 days, the rate of strength development decreased significantly and after 56 days of curing in either environment, the rate of strength gain became insignificant. The resistance to chloride-ion penetration increased with increased amount of silica fume from 6% to 14% of total cementitious materials.

IV.METHODOLOGY:



V.OBJECTIVE AND SCOPE OF PRESENT RESEARCH:

- To investigate mechanical properties of high strength concrete before exposed to high temperature, Carbonation, and sulphate attack.
- To investigate mechanical properties of high strength concrete after exposed to high temperature, Carbonation, and sulphate attack.
- To compare mechanical properties of high strength concrete before and after exposed to high temperature, Carbonation, and sulphate attack.

- To validation of results.

VI.PROPERTIES OF MATERIALS:

1) Cement:-

Pozzolona Portland Cement (Ultratech PPC cement) is used throughout the work. The important physical properties of the cement tested in laboratory are mentioned in Table 3.1.

Table 3.1 Physical properties of cement

Properties	Average Values	Standard Values as per IS: 1489 (part-1) Fly Ash based
Specific Gravity	2.9	-
Consistency (%)	32 %	-
Initial Setting Time(min)	185	>30
Final Setting Time (min)	255	<600
Soundness (mm)	0.5	<10
Compressive strength (MPa) 28 – days	58.7	>33

2) Coarse Aggregate:-

A crushed basalt rock of 20mm maximum size is used as coarse aggregates. The important physical properties of the coarse aggregates tested in laboratory are mentioned in Table 3.2.

Table 3.2 Physical properties of coarse aggregate

Property	Average Values
Fineness Modulus	7.15
Specific Gravity	2.8
Water absorption (%)	1.35
Surface moisture (%)	1.0

3) Fine Aggregate:-

Locally available river sand is used as fine aggregate. The important physical properties of the fine aggregates tested in laboratory are mentioned in Table 3.3.

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Table 3.3 Physical properties of fine aggregates

Property	Average Values
Fineness Modulus	3.5
Specific Gravity	2.6
Water absorption (%)	2.08
Surface moisture (%)	2.04

From sieve analysis, sand is medium and it is conforming to Zone-I

4) Water:- Clean potable water is used for mixing.

5) Admixtures:- With a Proportion of 1 to 2% with respect to weight of cement is used to achieve the desired workability because the addition of silica fume adversely affects the workability of concrete.

FINE AGGREGATE

COARSE AGGREGATE

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