A THESIS ON

A Study On The Mechanical Property Of Concrete Exposed To High Temperature

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MASTER OF TECHNOLOGY

Degree in

(STRUCTURAL ENGINEERING)

By

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DECLARATION

I, **Mohd Masooduzzaman** (Enr.No.1800102550) student of **Master of Technology (Structural Engineer)** hereby declare that the research thesis entitled "**A Study On The Mechanical Property Of Concrete Exposed To High Temperature**" is the bonafide research work carried out by me, under the guidance of **Anwar Ahmad**, **Associate Professor, Department of Civil Engineering, Integral University, Lucknow**. Further I declare that this has not previously formed the basis of award of any degree, diploma, associate-ship or other similar degrees or diploma, and has not been submitted anywhere else.

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CERTIFICATE

*Certified that the thesis entitled "**A Study On The Mechanical Property Of Concrete Exposed To High Temperature**" is being submitted by **Mohd Masooduzzama (Enr. No 1800102550)** in partial fulfilment of the requirement for the award of degree of Master of Technology (structural Engineering) of Integral University, Lucknow, is a record of candidate's own work carried out by him/her under my supervision and guidance.*

The results presented in this thesis have not been submitted to any other university or institute for the award of any other degree

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(Mohd Masooduzzaman)

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ABSTRACT

The present study is aimed to study the mechanical property of concrete at an elevated temperatures ranging from 100 to 300°C on the compressive strength, Split tensile strength and flexural strength of M25 grade made with ordinary Portland cement (OPC) and pozzolona Portland cement (PPC). Tests were conducted on 150x150x150mm for cube, 150x300mm for cylinder and 100x500mm for beam specimens. The specimens were heated to different temperatures of 100, 200 and 300°C for constant exposure durations of 1h at each temperature. The rate of heating was maintained as per ISO-834 temperature–time curve for standard fire. After the heat treatment, the specimens were tested for compressive strengths, split tensile strength. & flexural strength. Test results were analysed and the effects of elevated temperatures on PPC concrete were compared with OPC concrete. The PPC concrete exhibited better performance than OPC concrete.

Keywords: Elevated Temperature, Portland Pozzolana cement, ordinary Portland Cement Concrete, compressive strength, tensile strength, Flexural strength, Weight Loss.

CHAPTER 1

INTRODUCTION

1.1 General

Concrete is used in nearly every type of construction. Concrete has been primarily composed of cement, water, and aggregates(aggregates including both coarse and fine aggregates).Although aggregates make up the bulk of the mix, it is harden cement pastes that binds the aggregates together and contributes to the strength of concrete, with the aggregates serving largely as low-cost fillers. Concreteis not a homogeneous material, and its strength properties may vary greatly depending upon its ingredients and methods of manufacture. However, concrete is normally treated in design as a homogeneous material. Steel reinforcement are often included to increase the tensile strength of concrete; such concrete is Called reinforced cement concrete (RCC). Reinforcement concrete has been used in a variety of application, such as building, tunnel domes, shells, tanks, pipes chimneys, cooling tower and poles RC offers great resistance to the action of fire and water. A concrete member having sufficient cover can have one to three hours of fire resisting without any special fire proofing material. It has to be noted that steel and wood need to be fireproofed to obtain similar rating—steel members are often enclosed by concrete for fire resistance. If constructed and cured properly, concrete surface could provide better resistance to water than steel section, which require expensive corrosion-resistant coatings

We know that the ambient temperature of concrete structures is assumed to be at room values during construction . For safety of these concrete structures, present design and construction codes are used, in relation to room temperature values. Also the design strength of the structure is affected, at times the environmental temperature may increase extremely. It is important for engineers to be interested in the design strength of concrete subjected to high temperatures in order to perform at these elevated temperatures for practical research applications. The vaults of concrete of high-level waste storage tanks have been exposed to high temperatures due to decay heating of the wastes stored in the tanks for a long period.The effect of elevated temperatures on mechanical properties of concrete is important for understanding the behavior of chimneys, and conditions structures like storage tanks for crude oil, hot water , coal gasification, liquefaction vessels used in petrochemical industries, foundation for blast furnace, containment vessels and furnace walls industrial chimney,etc., fire resistance studies will be subjected to elevated temperatures

At elevated temperatures when conventional concrete is exposed, it begins to dehydration reactions in the hydrated cement paste. We know that the heat resistance property of the structure mainly depends upon the materials used, thermal expansion property, thermal conductivity. Concrete has good resistance against heat and it is a fire resistance material. The type of cement used in concrete and cover thickness of the structure are the main factors that affect the fire or heat resistance in RCC. Due to high elevated temperature, concrete loss there strength and also cracks were developed on the surface and RCC will cause bulging of reinforcement on both the lateral and longitudinal direction. Continuously heating the concrete, the cement materials shrink beyond the point of maximum expansion and the aggregates produce continuous expansion and both combination of expansion and shrinkage weaken and crack the concrete structure

1.2 Object

- The main objective of the current study is to compare the variation of 28-day compressive strength, flexural strength and split tensile strength with controlled elevated temperature (different temperatures of 50, 100, 150, 200) with two types of cements: OPC and PPC by Casting of standard size cubes, beam and cylinder
- Compare experimental results variation of concrete using two types of cement OPC and PPC

1.3 SCOPE

Main focus is on the Boling water tank, Cooling water tank. Storage tanks for hot crude oil and hot water.

It can also included Wastes storage tank, in metallurgical and chemical industries, glassmaking industry, cement and lime industry, , coal gasification and liquefaction vessels etc., the concrete will be subjected to a maximum elevated temperatures of 250^{o}C.

CHAPTER 2

LITRATURE REVIEW

Castilo and Durrani3(1990)[1]: Study was carried out to investigate the effect of transient high temperature on compressive strength and load–deformation properties of HSC under both unloaded and preloaded conditions and to compare the behaviour with that of NSC. Based on the results obtained from the study, it was concluded that when exposed to temperatures in the range of 100to 300^{O}C, HSC showed a 15–20 % loss of compressive strength. After an initial loss of strength, the HSC recovered its strength between 300 to 400^{O}C, reaching a maximum value of 8–13% above the strength at room temperature. At temperatures above 400^{O}C, the HSC progressively lost its compressive strength, which dropped to about 30% of the room temperature streng that 800^{o}C.

Ahmed et al.(1992)[2]:*Residual compressive and bond strengths of limestone aggregate subjected to elevated temperatures*; In this paper, the influence of high temperatures (100–600^{O}C) on the residual compressive and bond strength of concrete made from limestone aggregates was experimentally investigated. The main test parameters involved were, the time of exposure at the maximum temperature. Based on the results obtained from the study it was reported that7-day compressive strength of concrete increased with temperature up to 100^{O}C. Also for this temperature range, young concrete exhibited a higher residual strength than old concrete. It was also reported that a decrease of 15% of original strength appeared at150^{O}C. It was concluded that the cooling method had no significant influence on either the residual compressive or bond strengths.

Sarshar and Khaury(1993)[3]:*Compressive strength of concrete at high temperatures* ;In this paper the cement part replacements used were silica fume, ground granulated blast furnace slag and pulverised fuel ash (PFA).Eleven temperature levels ranging up to 600^{o}C wereused. Based on the results obtained from the study it was concluded that concrete paste containing 100% ordinary Portland cement(OPC) lost significant residual compressive strength above 300^{o}C. It was further concluded that specimens containing PFA and slag performed significantly better than specimens containing 100 % OPC or silica fume. The slag cement paste specimens gave the best results of all the cement pastes tested.

Mohammad M. Smadi*, Rami H. Haddad, Ahmad M. Akour (1999) [4]: ***Potential use of phosphogypsum in concrete*.** In this an experimental study was conducted to investigate the potential use of phosphogypsum (PG) in concrete at a water/cement ratio of 0.6 using two types of cement, ordinary OPC and PPC, and two types of fine aggregate, natural river sand and limestone. These mixes were prepared at different replacements(by weight) of PG and purified PG ranging from 10–100%. The purified PG was obtained by calcining PG (washed in water and not washed) at temperatures of 170, 600, 750, 850, and 950^{o}C.Basedon the results obtained from the study the purification process, by heating PG up to 900^{o}C, has resulted in improving the strengths of the mortar mixes. The highest percentage increase in strength was found to be for PG calcined at temperatures of 850 and 900^{o}C. The soundness of pastes prepared using PPC and OPC was reduced with increases in PG replacement

Chan et al.(2000)[5]:***To evaluate the mechanical properties of high-performance concrete (HPC) and NSC subjected to the temperatures up to 800^{O}C*;.** In this an experimental study of HPC and NSC was conducted to a temperature of 800^{o}Cand evaluated their residual compressive strengths. Base don the results obtained from the study itwas concluded that, the strength of HPC degenerated more sharply than that of the conventional concrete with the increase of exposed temperature, HPC had higher residual strength. Test results revealed no significant changes in strength for specimens exposed to elevated temperatures up to 400^{o}C.

Hoff et al.(2000)[6]:***Study the effect of elevated temperatures on residual strength of HSC;*** Twelve HSC mixes were made including three types of concrete: normal density (ND) concrete, light weight(LW) concrete and the modified normal density (MND) concrete prepared by using 45% (by volume) of structural LW coarse aggregate and 55%(by volume) of NW aggregate. Each concrete was made with and without polypropylene fibres. Based on the results obtained from the study it was concluded that all three types of concrete showed a slight improvement in residual strength, at an exposure of200^{O}C, but this improvement was not observed when subjected to 100^{O}C exposure. At a temperature of300^{O}C, significant loss of strength was observed. At a temperature of 900^{O}C and above, all the concretes essentially had no structural integrity. Residual strengths of HSC at exposed temperatures of 300^{O}C orhigher, are significantly different from the residual strengths of NSC.

Randall Lawson et al.(2000)[7]:*Residual mechanical properties of HPC after being exposed to elevated temperatures;* The average compressive strength for the different grades of concrete adopted in the study was 40 to 100 MPa. The selected temperatures were 100, 200, 300 and 450^{o}C.Basedon the results obtained from the study it was concluded that Significant drops in compressive strengths were reported for concrete exposed to elevated temperatures.

Potha Raju et al.(2004)[8]:*Effect of elevated temperature on the flexural strength of fly ash concrete of different grades of M28, M33 and M35*; Concrete specimens 100 x 100 x 500 mm with partial replacement cement by fly ash were heated to 100, 200 and250^{o}C for 1, 2 and 3 h durations. The specimens were tested for flexural strength in the hot condition immediately after removing from the oven. It was concluded that fly ash content up to 20% showed improved performance compared with the control specimens by retaining greater amount of its strength.

S. Muralidharana, R. Vedalakshmia, V. Saraswathia, James Josephb, N. Palaniswamya (2005)[9]:*Studies on the aspects of chloride ion determination in different types of concrete under macro-cell corrosion conditions*; In this paper various extraction methods have been carried out for the estimation of free chloride and total chloride contents in different types of concretes, namely OPC, PPC and PSC. Macro-cell concrete specimens were cast and subjected to severe alternate wetting and drying cycles of 10-monthsexposureunder different depths, namely20, 40 and 60 mm This is to be observed in all the three types of concretes used, the total chloride econtent in OPC concrete under different depths are0.216%, 0.202% and 0.184%.Basedon the results obtained from the study it was concluded that PSC concrete showed lesser chloride contents when compared to OPC and PPC concretes The total chloride content observed in PPC and PSC concretes are less than the OPC concretes. As the depth of concrete increased, the amount of chloride ions decreased. The amount of free chloride contents in OPC concrete is more when compared to PPC and PSC concretes.

Srinivasa Rao K., Potha Raju M. and Raju P.S.N. (2006)[10]:*Effect of elevated temperature on compressive strength of heated high-strength concrete with superplasticizer*; In this paper the effect of elevated temperatures ranging from 50 to 250^{o}C on the compressive strength of high-strength concrete (HSC) of M60 grade made with OPC and PPC. Tests were conducted on 100 mm cube specimens. The specimens were heated to different temperatures of 50, 100, 150, 200 and 250^{o}C for three different exposure durations of 1, 2 and 3 h at each temperature. It was concluded that the PPC concrete exhibited better performance than OPC concrete. From the observations the residual compressive strength for PPC concrete is considerably higher than OPC concrete at any temperature for all durations

P. Dinakar, K.G. Babu, Manu Santhanam (2007) [11]:*Corrosion behaviour of blended cements in low and medium strength concretes;*In this paper the corrosion behaviour of steel in concrete with blended cements like Portland pozzolana cement and Portland blast furnace slagcement were studied in comparison to their corresponding Ordinary Portland cements. Three concretes of compressive strengths 15, 30 and 45 MPa were designed. Base don the results obtained from the study it was concluded that the resistivities of both fly ash and slag concretes were found to be more than the corresponding ordinary concretes. The compressive strengths of PPCs and BFSCs at both28 and 90 days were higher than the corresponding OPCs.

S. Bhaskar, B.H. Bharatkumar, Ravindra Gettu and M. Neelamegam (2010) [12]: *Effect of corrosion on the bond behaviour of OPC and PPC concretes*; The objective of the present study is to assess the bond behaviour of concrete subjected to accelerated corrosion test. Based on the experimental results, an empirical bond-slip model is proposed for uncorroded rebars. It is concluded that the bond behaviour of PPC concrete is better than OPC concrete under corrosion. Bond behaviour has been studied for corroded rebars at three different time durations viz., 33, 54 and 64 days of accelerated corrosion resulting in 1.2%, 2.5% and 4.2% weight loss for OPC concrete and 33 and 110 days of accelerated corrosion resulting in 0.3% and 2.9% for PPC concrete. It was concluded that the bond behaviour of PPC concretes is better compared to OPC concretes under the corrosive conditions for the same exposure duration.

A.K. Parande *, B. Ramesh Babu, K. Pandi, M.S. Karthikeyan, N. Palaniswamy (2011) [13]: *Environmental effects on concrete using Ordinary and Pozzolana Portland cement;*In this study, the strength of the concrete in various environments has been investigated using different techniques such as compressive strength, flexural test, rapid chloride permeability, weight loss measurements linear polarization and open circuit potential. From the results, it is observed that PPC exposed in different media shows better performance than OPC in both mechanical and electrochemical studies. In flexural strength OPC was performed better than PPC at 150 days and weight loss measurements showed that the corrosion rate in PPC was lesser than OPC

M.V. Krishna Rao, M. Shobhab and N.R.Dakshina Murthyc (2011)[14] : ***Effect of elevated temperature on strength of differently cured concretes -an experimental study*****;**. This paper investigates the effect of sustained elevated temperature on the properties of ordinary concretes of M40 grade, containing different types of cements and cured by two different methods. The specimens were heated to150ºC, 300ºC and 450ºC for1 hour duration in a muffle furnace and tested after air-cooling to the room temperature. The variables considered in the study include type of cementing material, temperature and method of curing. Based on the results obtained from the study it was concluded that the comp. strength of concrete and weight of concrete decreased with increasing temperature. Specimen subjected to conventional water curing performed relatively better than those of membrane curing.

Mushtaq Ahmed Bhavikatti1, Vilas V. Karjinni2 (2012) [15]:***Interaction of Non-Chloride Hardening Accelerator with Type of Cement and Method of Curing in the Strength Development of Pavement Concrete;*** This paper explains the interaction of commercial non-chloride hardening accelerator with type of cement and method of curing in the strength development of pavement concrete.OPC and PPC were the two cements used to produce concrete mixtures were designed as per the new guidelines of IS 10262:2009. The test results revealed that the type of curing affected the optimum performance of accelerator in OPC mixtures but not in PPC mixtures and cured with the water was found to be more for PPC mixtures than for OPC mixtures. Efficiency was found to be more at early age for both OPC and PPC mixtures.

M. S. Morsy, S. H. Alsayed and M. Aqel (2012) [16]: ***Effect of Elevated Temperature on Mechanical Properties and Microstructure of Silica Flour Concrete*****;** An experimental investigation was conducted with the effect of elevated temperatures on the mechanical properties, phase composition and microstructure of silica flour concrete. The OPC were partially replaced by 0, 5, 10, 15 and 20% of silica flour. The fresh concrete pastes were first cured at 100% relative humidity for 24 hours and then cured in water for 28 days. The hardened concrete was thermally treated at 100, 200, 400, 600 and 800 oC for 2 hours.Basedon the results obtained from the study it was concluded that the addition of silica flour to OPC improves the performance of the produced blended concrete when exposed to elevated temperatures up to 400oC.

Prakash Mahadeo Mohite and Umesh Uttam Patil (2012)[17]: ***Comparative study of High Strength concrete under controlled elevated temperature;*** The present paper is aimed to study the effect of elevated temperature ranging from 100^0C to 600 ^{0}C on the compressive strength of high strength concrete (HSC) of M50 grade made with PPC with varying percentage of silica fume (SF) (0%, 5%, 10%, 15% & 20%) by replacement of cement by weight. It was concluded that HSC containing 15% silica fume exhibited better performance upto elevated temperature of600^{o}C. There is maximum loss of strength of16.67MPa at 600^{o}C. It is observed that, strength varies from 74.66MPa to 60.67MPa for dry cooling& 72.67MPa to 50.00MPa for wet cooling for concrete subjected to elevated temperature of100^{o}C to 600^{o}C

Vinay Deulkar, Manish Verma, Umesh Pendharkar (2012) [18]:***Comparative study of Eco Cement with OPC and PPC;*** Greenhouse gases are increasing in the environment this is the major problem arising for world .this problem cannot be reduced but this can be minimized by eco friendly material eco cement. Eco-cements are hydraulic cements containing15-20% reactive magnesia. When this reactive magnesia react with OPC a brucite is form this is capable of absorbing CO2 from environment. This paper discusses the potential impact on sustainability of the new eco-cement Technologies for sustainability and comparison of physical properties of Eco Cement with Ordinary Portland Cement (OPC) and Portland pozzolana cement. It also discusses the amount of CO2 absorb by Eco cement in comparison with OPC and PPC.

B. B. Das, M.ASCE; D. N. Singh, F.ASCE; and S. P. Pandey3 (2012) [19]: ***Rapid Chloride Ion Permeability of OPC- and PPC-Based Carbonated Concrete;*** This paper presents the measurement of rapid chloride ion permeability (charge passed) values through carbonated and non carbonated OPC– and PPC based concretes. The specimens were kept in an accelerated carbonation chamber for 150 days with 10% carbon dioxide (CO2), and then rapid chloride ion permeability through these carbonated specimens was measured with a rapid chloride ion permeability apparatus. Based on the results obtained from the study it was concluded that the result sindicate that a low-w⁄c concrete with PPC has discernible resistance to carbonation and rapid chloride ion permeability compared with its counterpart OPC.

Ankit Nileshchandra Patel, Prof. Jayeshkumar Pitroda (2013)[20]: ***Stone waste as a groundbreaking conception for the low cost concrete*;**. In this paper the use of Stone Waste in concrete by replacing OPC and PPC cement for M-25 Grade concrete. As a result, the compressive Strength increased up to 30% replacing of Stone Waste in OPC and 20%replacing of stone waste in PPC. This research work is concerned with the experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing OPC and PPC cement via 0%, 10%, 20%, 30%, 40% and 50% of stone waste. Based on the results obtained from the study it was concluded that replacement of OPC cement with this stone waste material provides maximum compressive strength at 30% replacement. From this test, replacement of (PPC) cement with this stone waste material provides maximum compressive strength at 20% replacement.

Mr. Dipak S. Gaud1 Mr. Dhiren K. Paghdar2 Dr. Jayesh A. Shah3 Mr. Vyom B. Pathak 4 Mr. Rushabh A. Shah5 (2013) [21]: ***A Compatibility Study on Different Types of Cement and Plasticize;*** In this paper the study was conducted to discover method of making concrete at the lowest possible water/cement ratio while maintaining a high workability. In such instances the use of plasticizers/super plasticizers permits the production of concrete at low water/ cement ratios. We have taken opc and ppc cement to find the compatibility by adding perma plast (plasticizer). From marsh cone test the compatibility has found out that adding 1.5 % perma plast by volume of cement is compatible with ultra tech OPC 53 grade cement & 1.3 % perma plast by volume of cement is compatible with coromandal king PPC cement

S.M.Maheshwarappa1, Madhuvan S2, Chetan Kumar K.M.3, J.K.Dattatreya4(2014) [22]:***Effect of superplasticizers compatibility on the workability, early age strength and stiffening characteristics of OPC, PPC, and PSC pastes and mortar*****;** In this paper, two types Superplasticizers i.e. PCE/Polycarboxylic ethers based and SNF/sulphonated naphthalene-based formaldehyde with three types of cements OPC, PPC and PSC cement by investigating effect of SP on the properties of cement pastes and mortars. The strength properties of mortars are also determined for different proportions of cement and sand for various w/c ratios. From the studies, it can be observed that among PCE and SNF based SP's PCE exhibits better compatibility with all types of cements in terms of workability and also strength and SP dosage required for mortar was found to be 0.8-1% more than dosage required for cement paste due to incorporation of sand.

H. G. MUNDLE (2014) [23]: ***Variation in strength of concrete subjected to high temperature;*** In this paper, the elevated temperatures on mechanical properties of concrete is of very much important for fire resistance studies that the variation of compressive strength, performance are some of the important parameters to be investigated when concrete structures are subjected to temperatures. The compressive strength was found to increase after 72 hours of exposure to an elevated temperature up to 150º C after that the compressive strength of concrete decreases with increasing temperature. The peak value in the ratio of the compressive strength at high temperature is observed around 150º C. This peak value obtained due to the evaporation of free water inside the concrete.

Mohammad Kamran1, Mudit Mishra2 (2014) [24]: ***Behaviour of self-compacting concrete using PPC and OPC with different proportions of fly ash;*** In this paper, comparison in behaviour using PPC and OPC with different proportions of fly ash in the mix which were taken as 15%, 25%, and 35% in place of cement. a set of 6 cubes was casted and tested at 7 days and 28 days for strength. The temperature of sample cubes was kept constant at 24°C for the whole period. The mix design was done for M25 grade. The W/C ratio was kept constant at 0.45. The similar tests conducted on OPC samples showed the same pattern but overall strength gain was higher than PPC samples and the margin was spectacularly high ranging between 40%-60%.

S. O. Osuji1, and U. Ukeme2 (2015) [25]:*Effect of elevated temperature on compressive strength of concrete: A case study of grade M40 concrete*; This study presents the effects of elevated temperatures on the compressive strength of Grade 40 concrete and elevated temperature of 24, 100, 150, 200, 250 and 300 degree Celsius at one hour duration. The result indicated14.49%, 25%, 51%, 35.51% and 43.88% decrease in compressive strength at the earlier quoted temperatures respectively. At an elevated temperature of 300 degrees Celsius a peak decrease of 53.47% in compressive strength was observed. It was concluded that loss of strength at 300^{o}C of53.47% and weight loss of 4.67% are significant. It was concluded that there was loss of weight as the temperature increased starting from 100^{o}C at increments of 50^{o}C up to 300^{o}C,while weight loss increased from 0.87 to 4.67% as compared to the control mix at room temperature of24^{o}C at 28 days age

Ravi Agarwal1, U S Vidyarthi2, N Sivakumar3 and B K Munzni4(2015)[26]: *Comparative Study of the effect of using different types of Portland cement on Alkali-Silica reaction of concrete aggregates : A Comparison;* Alkali silica reaction is potentially a very disruptive reaction within concrete in which silica reacts with alkalis to form a gel which expands and disrupts its mechanical properties. The aim of the current study was to determine the effect of using OPC, PPC and PSC on Alkali silica reaction expansion. The outcome of the study is presented in this paper which is effective in controlling Alkali silica reaction. He concluded that the OPC-aggregate combination is found to be susceptible to reactive while the test results clearly show that PPC is better in controlling expansion due to ASR in comparison to PSC.

Satish R.,, 2 Dr. P.S. Raghu prasad, (2015) [27]: *Drying Shrinkage Study of Blended Cement and OPC Composites in Marine Condition;* This paper presents laboratory investigations on drying shrinkage of concrete made from three different types of cements namely 53 grade OPC, two types of blended cement namely PPC and PSC both are factory blended; for both normal and artificial sea water conditions. An attempt has been made to compare the drying shrinkage of hardened concrete made from above mentioned three types of cements for M30 grade of concrete mix with W/C of 0.45 conducted in accordance with BIS specifications. From the results of the investigation it can be concluded that the performance of blended cement concrete is better when compared to OPC concrete.

C. B. K.Rao, Rooban Kumar (2015) [28]: *A study on behaviour of normal strength concrete and high strength concrete subjected to elevated temperature;* The experimental results of normal concrete and high strength concrete subjected elevated temperatures at 200°C, 400°C, 600°C, and 800°Cand differrent cooling regimes viz. air cooling, water quenching on different grade of concrete are reported in this paper. Principal effects due to elevated temperatures are loss in compressive strength ,loss in weight or mass, change in colour and spall of concrete. It was conclude that the loss in compressive strength at elevated temperature is more in case of High strength concrete compared to Normal strength concrete. Strength of concrete decreased with increase in temperature. Decrease in compressive strength is more at high temperatures of 800°C.

Nandita Suman1, Krishna Murari2(2015)[29]: *Study of Impact of Elevated Temperature on the Characteristic Strength of M30 Grade Concrete Based On Plasticizer;* In this experimental study several steps of work has been included. Concrete cubes were made with plasticizer and without plasticizer are exposed to heat for 12 hours and as a result, undergo physical changes or spalling. This causes reduction of strength of concrete. Two concrete mixes were prepared one mix is with 2%plasticizer (sikament® 581) of cementious material and another mix is without plasticizer and cubes were prepared in moulds. The results show that rate of reduction of residual strength of concrete cubes with plasticizer after exposure to heat is less than that of the residual strength of concrete without plasticizer after exposure to heat to elevated temperature at 200^{o}C, 400^{o}C, 600^{o}C, 800^{o}C for 12 hours.

R.K. Mishra , R.K. Tripathi, Vikas Dubey (2016) [30]:*Early age shrinkage pattern of concrete on replacement of fine aggregate with industrial by-product*; In this paper an experimental work carried out to investigate early age shrinkage pattern of concrete, prepared, on 50% replacement of industrial by-product (like pond ash and granulated blast furnace slag) as fine aggregate using OPC, PPC and PSC as a binder. This is to observe the effect of pond ash and slag as they are having some cementitious propertie sand effect of cement type is also discussed. All the mixes were prepared keeping in view of pumpable concrete without any super plasticizers. It is concluded that slag is the best option for fine aggregate replacement for concrete making and durable structure. From shrinkage point of view PSC cement acts like OPC cement.

Rakesh Kumar (2016) [31]: *A comparative study on dry lean concretemanufactured with OPC vis-a-vis PPC to be used forthe construction of concrete roads;* The current practices of the construction of cement concrete road for highways in India require a layer of drylean concrete (DLC) as a base course over which pavement quality concrete slabs rest. DLC is manufactured with OPC as per Indian Road Congress specification SP-49: 1998. IRC SP-49: 1998, The study concluded that the minimum quantity of PPC for the manufacture of DLC satisfying the compressive strength requirement is at least 10% higher than that of OPC. The aggregate to cement ratio satisfying the strength requirement criteria of the IRC SP-49 is significantly lesser in the case of PPC than that of OPC. The optimum moisture content of DLC containing PPC is about 16-17% higher than that of OPC.

Seung-Jun Kwon, Han-Seung Lee, Subbiah Karthick, Velu Saraswathy b,d,⇑, Hyun-Min Yang b (2017) [32]: *Long-term corrosion performance of blended cement concrete in*

the marine environment – A real-time study; This paper presents the long term corrosion performance of blended cements namely; PPC and PSC concrete under the three marine exposure conditions such as, atmospheric zone (AZ), immersion zone (IZ) and splash zone (SZ). The concrete cubes were exposed over the period of 10 years. It was observed that the strength and alkalinity of the blended cement concretes were relatively equal to that of OPC concrete. For instance, the OPC concrete achieved a compressive strength of 32.15 N/mm2, where as the PPC and PSC concrete achieved a compressive strength value of 31.50 N/mm2 and 31.80 N/mm2 respectively, which is 2.02%and 1.09% lesser than that of OPC.

Md. Shamim Al Razibi, Faysal Ibna Rahman2, Mahmudul Hussaini(2017)[33]: *Elevating the Effect of Temperature on Compressive and Tensile Strength of Concrete with Admixture;* In this paper investigation on the effect of elevated temperature on compressive and tensile strength of concrete with admixture(POZZOLITH CRP4) in the temperature range (25-600) °C. The effect of plasticizer admixture on concrete is also investigated. It was concluded that test results show that the compressive and tensile strength is increased due to use of admixture but there is a reduction in the compressive and tensile strength of concrete with or without admixture for each temperature and the decrease was very limited at temperature up to (200°C) but was clear at (400,600) °C. Concrete with admixture exposed to high temperature, shows a higher overall residual strength than normal concrete. Due to use of admixture, compressive strength is increased about (30% - 60%) and tensile strength is increased about (10% - 20%) than the normal concrete. For compressive strength, the loss of strength with admixture is less than the strength without admixture.

Maheswaran. S Nandhagopalaguhan. B Niveditha. P Pasupathi. K Elango. K .S(2018) [34]: ***Experimental Study on Pervious Concrete with Pebbles as a Coarse Aggregate.*** The present study on the properties of pervious concrete (PC) using pebbles as coarse aggregates (CA) and PPC as binder. The results are compared with conventional control mix made of OPC binder. The results indicated that using of pebbles as coarse aggregate shows sufficient strength, permeability and durability properties. The strength parameters and permeability parameters met the requirements and pervious concrete made with pebblesas a coarse aggregate can be used for sustainable pavement construction. The compressive strength, split tensile strength and flexural strength of PPC mix specimens are slightly lesser than OPC mix specimens due to less heat of hydration.

Rasyiid Lathiif Amhudo, Tavio, I Gusti Putu Raka (2018) [35] : ***Comprison of compressive and tensile strength of dry-cast concrete with OPC and PPC.*** In this study, there are two casting methods used in concrete placement, namely wet- and dry-castings. The dry-cast concreteused for its advantages in precast concrete industries, e.g. its rapid hardening time for fast mold removal (it significantly increases the plant productivity). The compressive strengths of dry-cast concrete with OPC for various w/c ratio and ages are entirely higher than those with PPC. The maximum compressive strength was found at age of 28 days with w/c of 0.3 which can reach up to 1199.8 kg/cm2. The dry-cast concretes with extremely dry condition using both OPC (Type-I cement) and PPC have very much higher compressive strengths (above 492.5 kg/cm2) as compared to the wet-cast concrete from the ACI curves which provides only two curves with respect to non-air-entrained and air-entrained concretes.

2.1 Inferences\Conclusion of literature review

It is concluded that when exposed to elevated temperatures loss of strength (Compressive, Tensile) occurs in concrete, cracks develop and damaging of concrete occurs and weight of concrete decreased with increasing temperature. For maintaining and improving the strength addition of silica flour, Admixtures, plasticizer, Super plasticizers are used to improves the performance of the concrete when exposed to elevated temperature. For compressive strength, the loss of strength with admixture is less than the strength without admixture.

It is also found that the bond behaviour of PPC concretes is better compared to OPC concretes under the corrosive conditions for the same exposure duration.

CHAPTER 3
METHODOLOGY

This part of thesis describes the research methodology used in achieving the objectives mentioned which is discussed in Chapter 1. Details of the materials used, the methods adopted in preparing the test specimens and the different test procedures are discussed. The experimental program is shown in figure. 3.1

1 Collection of material

2 Preparation of Specimens

a. Cube Of Size 150mmx150mmx150 mm.

b. Cylinders Of Size 150mmX300 mm.

c. Beam OF Size 100x100mmx 500 mm.

3 Nominal mix for M25(1:1:2) grade with nominal maximum size of aggregate of 20 mm

a. Mixing,

b. Casting

c. Curing of the Specimens for 7 and 28 days

d. Removing the specimen for 24 hrs from curing tank for 7 and 28 days

e. Testing of Reference Specimens

4. Heating the specimens of Cube cylinder Beam in the electric oven at different controlled elevated temperature (100-300 ^{o}C) for constant duration of 1 hrs .

a. Removing the specimen from oven and Placed at room temperature after 5hrs

5. Testing of Cube ,Cylinder Beam at 7 day and 28 days

Flow chart of lab work

1. Collection of material

2. Preparation of Specimens

- Cube Of Size 150mmx150mmx150 mm.
- Cylinders Of Size 150mmX300 mm.
- Beam OF Size 100x100mmx 500 mm

3 . Nominal mix for M25(1:1:2) grade with nominal maximum size of aggregate of 20 mm

- Mixing,
- Casting
- Curing of the Specimens for 7 and 28 days
- Removing the specimen for 24 hrs from curing tank for 7 and 28 days
- Testing of Reference Specimens

4. Heating the specimens of Cube, cylinder, Beam in the electric oven at different controlled elevated temperature (100-300 ^{o}C) for constant duration of 1 hrs

- Removing the specimen from oven and Placed at room temperature after 5hrs

5.Testing of Cube ,Cylinder Beam at 7 day and 28 days

3.1.Collection of materials

- Cement (OPC, PPC)
- Fine Aggregates
- Coarse aggregate
- Water

3.1.1 Cement: Cement is a binding material used in construction. It has a property of setting and. hardening when mixed with water to attain strength. Cement is always used in the form either grout or mortar or concrete. Grout which is mixture of cement and water. Mortar is a proportioned mixture of cement ,sand and water. Concrete which is proportioned mix of cement coarse aggregate, fine aggregate and water.

PPC :- Pozzolana is a natural or artificial material containing silica in a reactive form. Portland pozzolana cement is a kind of blended cement which is produced by either inter grinding of OPC clinker along gypsum and pozzolanic materials (Volcanic ash, Calcined clay , Fly sah, Silica fumes)separately India is the second-largest consumer of Portland cement (PC) in the world; from thermal power plants the production of fly ash is expected to reach 140 metric tons by 2020. however, OPC-33 was replaced with Portland pozzolana cement (PPC). PPC and OPC-53 are the most commonly used types of concrete in India. PPC is cheaper to manufacture than OPC, it possesses a smaller heat of hydration, and thus, it is highly useful for mass concreting, and it is more durable than OPC because of it contains relatively minor quantities of chlorides, free lime and sulphate alkalis. High temperature resistance is defined as the ability of a structural element to withstand its load-bearing function under high temperature condition.

Table 3.1.1 Physical Properties of Portland Pozzolana Cement

Physical Properties	Required as per BIS 1489:1991(Part-I)
Setting time (Min)	
Initial	30
final	600
Compressive Strength (Mpa)	
3 days	16
7 days	22
28 days	33
Finess (M^2/Kg)	Not less than 300

OPC Cement

three grades of cement, i.e., ordinary Portland cement-33 (OPC-33), OPC-43, and OPC-53, were most commonly used throughout India; In contrast, OPC-53 has a faster setting time, and it develops strength more quickly, and hence, it is suitable for rapid construction; moreover, because of its higher heat of hydration, OPC tends to develop micro-cracks that are not visible at the surface (Taylor,1997).The most commonly used cement in concrete is ordinary Portland cement of satisfying the requirements of IS:12269 (1987) having specific gravity of 3.15. This ordinary Portland cement was classified into three grades which is namely as 33 grade, 43 grade and 53 grade depending upon the strength of the cement obtained at 28 days which was tested as per IS:4031 (1988). If the 28 days strength is not less than 33N/mm2, it is said to be 33 grade cement, if the 28 days strength is not less than 43 N/mm2, it is said to be 43 grade cement and if the 28 days strength is not less than 53 N/mm2, then it is said to be 53 grade cement. In this investigation 53 grade cement has been used. The properties of cement are given in below Table.3.1

Table 3.1.1 Physical Properties of Ordinary Portland Cement

Physical Properties	Required as per BIS 8112:2013(Part-I)
Setting time (Min)	
Initial	30
final	600
Compressive Strength (Mpa)	
3 days	23
7 days	23
28 days	43
Finess (M^2/Kg)	Minimum 225

3.1.2 Aggregate

Aggregates are the major ingredients of concrete which occupy 70 to 80% of the volume of concrete. The ingredients used for the manufacture of mortar and concrete such as sand, gravel etc. are called as aggregate. Aggregates provide strength to the concrete and act as filler material to give the homogeneous mass of concrete along with cement paste.

Aggregate is one of the component of a composite materials that resists compressive stress and provides volume to the composite material. To make efficient filling, aggregate should be much smaller than the finished item, but it have wide variety of sizes. It consists of both sand and aggregates.

3.1.2.1 Fine Aggregate

The aggregate with grain size below 4.75 mm is termed as fine aggregate. Natural sand or crushed stone dust is the fine aggregate commonly used in concrete mix. In the present study, the fine aggregate of locally available river sand conforming to zone II as per Indian Standards IS: 383 (1970) was used. This sand passed through IS Sieve 4.75 mm. The aggregate fraction from 4.75 mm to 150 micron was termed as fine aggregate. Fine aggregates are classified as coarse sand, medium sand and fine sand. The properties of fine aggregates are given in Table.3.2

Table 3.1.2.1 Properties of Fine Aggregates

S.NO	Properties of fine aggregate	value
1.	Specific Gravity	2.62
2.	Fineness modulus	2.56
3.	Bulk Density kg/m3	1709.7

3.1.2.2 Coarse aggregate

The aggregate whose particles are retained on I.S Sieve No, 480(4.75 mm) is termed as coarse aggregate. The size of coarse aggregates used depends on the nature of work. For R. C. C work 20 mm aggregate is commonly used. Coarse aggregate of blue granite crushed stone conforming to IS: 383 (1970) with nominal size of 20 mm was used in the preparation of concrete. The size of aggregate bigger than 4.75 mm is considered as coarse aggregate. The shape of the crushed granite is more important for the high strength concrete. The poorly shaped crushed aggregate will make poor concrete. Usually the aggregate should be angular shaped or granular shape or crystalline non - powdery surfaces. The properties of coarse aggregates are given in below Table

Table 3.1.2.2 Properties of Coarse Aggregates

S.NO	Properties of Course aggregates	Test values
1.	Rock group	Blue Granite
2.	Crushing strength%	193.55
3.	Aggregate Crushing value%	20.1

4.	Abrasion value%	18.89
5.	Impact value%	13.75
6.	Specific Gravity	2.9
7.	Bulk Density kg/m3	1487.64
8.	Fineness modulus%	2.58

3.1.3 Water

Portable fresh water, which should be free from concentration of acid and organic substances, is used for mixing of concrete. The combination of water and cementitious material form a cement paste by the process of hydration. If less water in the cement past will yield in the stronger more durable concrete, ore water will dive free flowing concrete with a higher slum. Hydration involves many different reactions, as the reaction proceed, the products of cement hydration process bond together with sand and gravel particle, and other component of concrete , to form a solid mass. Water is needed for the hydration of cement to provide workability during mixing and placing. Potable water is generally considered satisfactory. In this study tap water was used for both mixing and curing process.

3.2. Preparation of Samples

Preparation of Moulds Prier to mixing and casting of specimen one of the most important and time consuming work is preparation of moulds. Moulds should be prepared such that all surfaces of moulds are cleaned and oiled properly and all the bolts are tightened so that it shall not allow any leakage of mortar. Special care should be taken while applying oil. Excessive amount of oil can lead to presence of bug holes on the surface of concrete after demoulding. A suitable brush or cloth should be used while applying oil on the surface of moulds. Also type of oil used is very important as the purpose of oil is to provide necessary lubrication so that concrete may not stick to the surface of moulds and it should be easy to demould the specimen. If suitable oil is not used then it may break your specimens and whole procedure is to be repeated again. The oil used

a.) Cube:- The cube mould of Dimension 150mmx150mmx150mm is taken. Moulds were checked and secured tight to ensure that there were no gaps left on the mould which could lead to a possibility of a slurry leakage. All the cubic moulds were cleaned and oiled properly. The cube specimens are shown in Fig For conducting compressive strength test on concrete cubes of size 150x150x150 mm are casted. After successful casting, the concrete specimens are de-moulded after 24 hours and immersed in water for 28 days Fig.3.2(a),(b)shows some concrete specimen casted in

Fig.3.2a (a)

Fig.3.2a (b)

laboratory 32 cubes were be casted for experiment in which 12 cube are of OPC cement concrete and 12 are of PPC cement concrete and 4-4 cubes for reference for PPC and OPC

b.) Cylinder:- The Dimension of cylinder mould is 150mmx300mm is taken. Moulds were checked and secured tight to ensure that there were no gaps left on the mould which could lead to a possibility of a slurry leakage. All the cubic moulds were

Fig. 3.2b (a)

Fig. 3.2b (b)

cleaned and oiled properly. For conducting tensile strength test, concrete cylinder of size 150mmx300mm are casted. After successful casting, the concrete specimens are de-moulded after 24 hours and immersed in water for 28 days. Fig. 2 shows some concrete specimen casted in laboratory 32 cubes were be casted for experiment in which 12 cube are of OPC cement concrete and 12 are of PPC cement concrete and 4-4 cubes for reference for PPC and OPC

c.) Beam:- The beam mould of Dimension is 100mmx100mmx500mm is taken. Moulds were checked and secured tight to ensure that there were no gaps left on the mould which could lead to a possibility of a slurry leakage. All the beam moulds were cleaned and oiled properly. For conducting flexural strength test, concrete beam of size 100mmx100mmx500mm are casted. After successful casting, the concrete specimens are de-moulded after 24 hours and immersed in water for 28 days. Fig. 3.3 shows some concrete specimen casted in laboratory 16 beams were be casted for

Fig.3.2c (a)

Fig.3.2c (b)

experiment in which 6 beam are of OPC cement concrete and 6 are of PPC cement concrete & 2-2 for referances. The cube specimens are shown in Fig .

3.3. Nominal Mix Proportion :-The control mix has a mix M25 ratio of 1:1:2 (cement: fine aggregate: coarse aggregate) which was adapted for this work with a constant water- cement ratio of 0.45. For making mixes containing nominal wth maximum size of aggregate of 20 mm

a. Mixing, Casting and Curing of the Specimens

3.3.1 Mixing,

The fine aggregate, coarse aggregate and were weighed first and mixed homogeneously for about two minutes in the concrete mixer. This was followed by the addition of cement and mixing water by water cement ratio about 0.45 is taken . After two minutes of mixing, remaining mixing water was added subsequently.

Fig. 3.3.1(a)

Mixing was ceased after five minutes for all mixes when a homogenous mixture has been obtained.

3.3.2 Casting,:- concrete in filled in the cube specimen, beam specimens and cylinder specimens in the three layers and each layer is tamped 25 times with the tamping rod.

(i) Clean the mounds and apply oil

(ii) Fill the concrete in the moulds in layers approximately 5cm thick

(iii) Compact each layer with not less than 25strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long, bullet pointed at lower end)

(iv) Level the top surface and smoothen it with a trowel

Fig 3.3.2(a)

Vibrator:-After tamping the moulds they were then vibrated from side to side . The vibration was stopped as soon as the cement slurry appeared on the top of the moulds.

Figure 3.3.2(b)

Figure 3.3.2(c)

3.3.3) Curing:- After 24 hours the specimens were remove from the moulds then kept in the curing tank for 7 days and 28 days in curing tank containing clean water till the stipulated day and remove specimen after 28 days for testing of mechanical properties.

Fig 3.3.3.(a)

4.) Heating of Specimens

- After 7 days and 28 days of curing, the specimens were taken out from curing tank and kept in room temperature for a day.

- All the specimens were weighed and their initial weights were recorded and tested at the ages of 7 days and 28 days at elevated temperature.
- The specimens were kept in oven and allowed to be heated in hot air oven at various degree of constant elevated temperature ranges such as 100C, 200C and 300C. as shown in Figure 6.1 for the time durations of 1 hour,
- After the concrete cube was heated it was allowed to be cooled at normal room temperature and then the final weight of the cube was noted and the residual compressive strength of the cube was determined after testing The results are furnished in Tables 3.21 to 3.32 checked with their initial weight and tabulated the mean values in Table 6.1.

Fig.4(a)

Fig.4(b)

From the percentage of loss in weight of cube specimens, a graph was plotted as shown in Figure 6.3. The compressive strength test on cube specimens were carried out under CTM as in Figure 6.2. The compressive strengths of all cube specimens were calculated by substituting the ultimate load and area of cube in equation 4.1.

5.) Test Conducted

5.1 Mechanical Properties

- Compressive Strength.
- Split Tensile Strength.
- Flexural Strength.

5.1 (**a) Compressive strength:-** Compressive strength of concrete depend on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during production of concrete etc. The concrete specimens were cast (Fig. 3.3) and. The results were evaluated by testing cube specimens under Compression Testing Machine as per IS: 516 (1959). The test results were furnished in Table Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not.

Test for compressive strength is carried out either on cube or cylinder. Various standard codes recommends concrete cylinder or concrete cube as the standard specimen for the test.

COMPRESSIVE STRENGTH PROCEDURE

- Take the wet specimen from water after 7days and 28 days of curing For 4 hours to Wipe out water from the surface of specimen
- Clean the bearing surface of the testing machine
- Place the specimen within the machine in such a manner that the load will be applied to the other sides of the cube.
- Align the specimen centrally on the bottom plate of the machine
- Rotate the movable portion gently by hand so it touches the highest surface of the specimen
- Load should be applied gradually at the rate of 140 kg/cm2or 14N/mm2 per minute until the specimen fails
- Load at the failure divided by area of specimen gives the compressive strength of concrete.

COMPRESSIVE STRENGTH = (LOAD IN N/ AREA IN mm2)

Table.1 Compressive strength(PPC&OPC-7&28 days)

S. No	Nominal Mix		Load Failure (KN)	7 days	Average strength	Load Failure	28 days	Average strength
1.	M25	PPC	370.5	16.5	16.8	560.7	24.9	25.1
			385.1	17.1		569.8	25.3	
		OPC	446.8	19.8	19.8	619.3	27.5	27.2
			442.5	19.7		605.8	26.9	

5.1 (**b) Split Tensile strength**

The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The split tensile strength of the concrete specimens was evaluated by testing cylinders at the ages of 7 days and 28 days, respectively. As per IS: 456 (2008), the splitting tensile strength of concrete is calculated using Eq. 3.1 The tensile strength of concrete is one of the basic and important properties. To determine the split tensile of concrete

Procedure of Splitting Tensile Test:

- Take the wet specimen from water after 7days and 28 days of curing For 4 hours to Wipe out water from the surface of specimen
- Draw diametrical lines on the two ends of the specimen to ensure that they are on the same axial place.
- Note the weight and dimension of the specimen.
- Clean the bearing surface of the testing machine
- Set the compression testing machine for the required range.
- Keep are plywood strip on the lower plate and place the specimen.
- Align the specimen so the lines marked on the ends square measure vertical and targeted over very cheap plate
- Note the breaking load(P)
- Load should be applied gradually at the rate of rate of roughly 14-21kg/cm2/minute (Which corresponds to a complete load of 9900kg/minute to 14850kg/minute) until the specimen fails
- Note down the breaking load(P)

CALCULATIONS: As per IS456, split tensile strength of concrete.= 0.7Fck

The splitting tensile strength is calculated using the

Formula Tsp = 2P/ pi DL

Where

P = applied load

D = diameter of the specimen

L = length of the specimen

Table.2 splitting tensile strength (PPC&OPC-7&28 days)

S. No	Nominal Mix		Load Failure (KN)	7 days	Average strength	Load Failure	28 days	Average strength
1.	M25	PPC	127.2	1.8	1.9	219.0	3.1	3.0
			141.3	2.0		204.9	2.9	
		OPC	176.6	2.5	2.55	240.2	3.4	3.35
			183.7	2.6		233.2	3.3	

5.1 (**c) FLEXURAL STRENGTH TEST**

Flexural strength In this experiment, a total number of 12 beams of sizes 100 mm × 100 mm × 500 mm without reinforcement were casted (Fig. 3.6) and tested at the ages of 7 days and 28 days, respectively. The specimens were tested under flexural testing machines (Fig. 3.7) The bed of the testing machine shall be provided under one point load with two steel rollers, 38 mm in diameter, on which the specimen is to be supported, and these rollers shall be so mounted that the distance from centre to centre is 40 cm for 1.60 cm specimens or 40 cm for 10.0 cm specimens. The load shall be applied through two similar rollers mounted at the third points of the supporting span that is, spaced at 20 or 13.3 cm centre to centre. The load shall be divided equally between the two loading rollers, and all rollers shall be mounted in such a manner that the load is applied axially and without subjecting the specimen to any torsional stresses or restraints.

- Take the wet specimen from water after 7days and 28 days of curing and Leave the specimen in the atmosphere for 24hours before testing to Wipe out water from the surface of specimen
- The specimen is then placed in the Flexural testing machine in such a manner that the load is applied to the uppermost surface as cast in the mould, along the two lines spaced 20.0cm a part. The axis of the specimen is carefully aligned with the axis of loading devices.

- The load is then applied without shock and increasing continuously

REFERENCE STANDARDS

IS: 516-1959 – Methods of tests for strength of concrete

PROCEDURE

- Take the wet specimen from water after 7days and 28 days of curing and Leave the specimen in the atmosphere for 24hours before testing to Wipe out water from the surface of specimen
- Clean the bearing surfaces of the supporting and loading rollers , and remove any loose sand or other material from the surfaces of the specimen where they are to make contact with the rollers.
- Circular rollers manufactured out of steel having cross section with diameter 38 mm will be used for providing support and loading points to the specimens. The length of the rollers shall be at least 10 mm more than the width of the test specimen.
- A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes. The distance between the outer rollers (i.e. span) shall be 3dz and the distance between the inner rollers shall be
- The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic.

The load shall be applied at a CALCULATION

Flexural strength = Pl/bd^2

Where P = maximum load applied in kg

L = length of the

B = width of the specimen

D = depth of the specimen

The results of the flexural beam are shown in Table 3.9.

The Flexural Strength or modulus of rupture (fb) is given by

fb = pl/bd2 (when a > 20.0cm for 15.0cm specimen or > 13.3cm for 10cm specimen) or

fb = 3pa/bd2 (when a < 20.0cm but > 17.0 for 15.0cm specimen or < 13.3 cm but > 11.0cm for 10.0cm specimen.)

Where,

a = the distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen

b = width of specimen (cm)

d = failure point depth (cm)

l = supported length (cm)

p = max. Load (kg)

Table.3 Flexural Strength (PPC&OPC-28 days)

S. No	**Nominal Mix**		**Load Failure (KN)**	**Strength at 28 days**	**Average strength**
1.	M25	PPC	8.6	3.5	3.5
			8.5	3.4	
		OPC	9	3.6	3.7
			9.5	3.8	

TESTING OF SPECIMENS: All the specimen were tested as per directions given in IS 516 (1959). Compression Testing Machine was used where as to perform check on Flexural Strength of beams, Flexural Testing Machine was used. The load for compression testing machine was set as specified in IS 516 i.e. 140 kg/ sqcm / minute. The load shall be applied slowly without shock and increased continuously until the resistance of specimen (Concrete Cube) to increasing load breaks

. Calculation of Load: Load as per IS Code = 140 kg/sqcm/min

1 Kg = 9.81 N

1000 N = 1 KN

∴ (140 x 9.81 / 1000) = 1.373 KN

1 min = 60 seconds But load specified in IS 516 is in kg/sqcm/minute

∴ 1.373 x surface area of cube = (1.373 x 15 x 15) / 60 = 5.148 kn/sec Similarly, for flexural Strength test, load specified in IS 516 = 180kg/min for 10cm beams that comes out to be 29.42N/sec

CHAPTER 4

TEST RESULTS & DISCUSSION

COMPRESSIVE STRENGTH: These results are obtained by testing the total 32 specimens for 7 days and 28 days in which 12 specimens are of PPC and 12 OPC cement concrete and 4-4 specimens are taken for reference by considering the average of the test results and tabulated in table.

Table.4 Compressive Strength of concrete cube for 1hr at diff. elev. Temperature

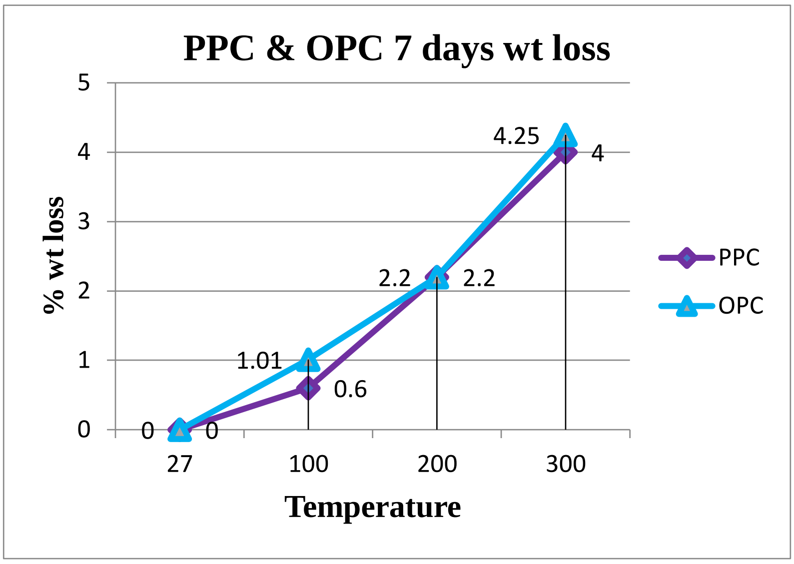
(PPC, M25-1:1:2, 7 days)

Temperature	PPC Specimen	Wt of speci. before kept in oven (Kg)	Wt of speci. After Removing from oven (Kg)	% wt loss (Kg)	Average % wt loss	Specimen failurve at load (KN)	Compressive Strength (Mpa)	Aver. compressive strength
Reference 27°C								16.8
100	A1	8.300 8.245	8.225 8.221	0.9 0.29	0.6	380.6 387.4	16.9 17.2	17.05
200	B1	8.289 8.305	8.115 8.123	2.1 2.19	2.2	348.1 344.6	15.5 15.3	15.4
300	C1	8.312 8.278	7.975 7.955	4.05 3.9	4.0	278 270.3	12.3 12.0	12.15

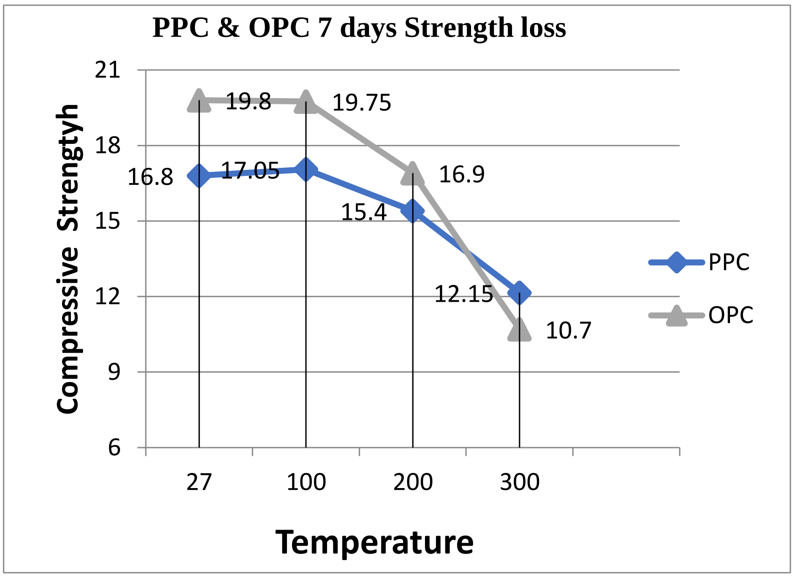
Table.5 Compressive Strength of concrete cube for 1hr at diff. elev. Temperature

(OPC, M25-1:1:2, 7 days)

Temperature	OPC Specimen	Wt of speci. before kept in oven (Kg)	Wt of speci. After Removing from oven (Kg)	% wt loss	Average % wt loss	Specimen failure at load (KN)	Compressive Strength (Mpa)	Aver. compressive strength
Reference, 27°C								19.8
100	A2	8.315 8.299	8.225 8.221	1.08 0.94	1.01	443.7 445.9	19.7 19.8	19.75
200	B2	8.298 8.305	8.115 8.123	2.21 2.19	2.2	382.8 378.4	17.0 16.8	16.9
300	C2	8.309 8.328	7.975 7.955	4.02 4.48	4.25	245.5 236.5	10.9 10.5	10.7



Graph. 1 (Temp vs %wt loss)



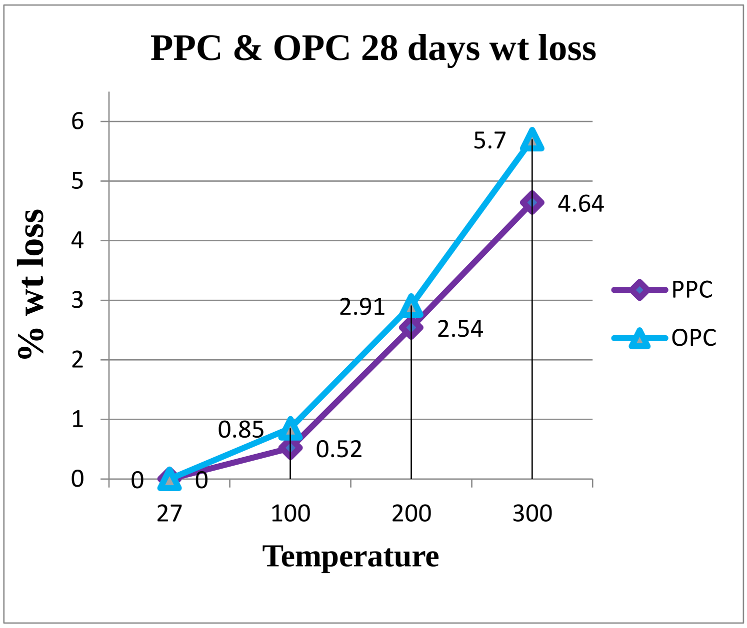
Graph. 2 (Temp vs Compressive streng.)

Table.6 Compressive Strength of concrete cube for 1hr at diff. elev. Temperature (PPC, M25-1:1:2, 28 days)

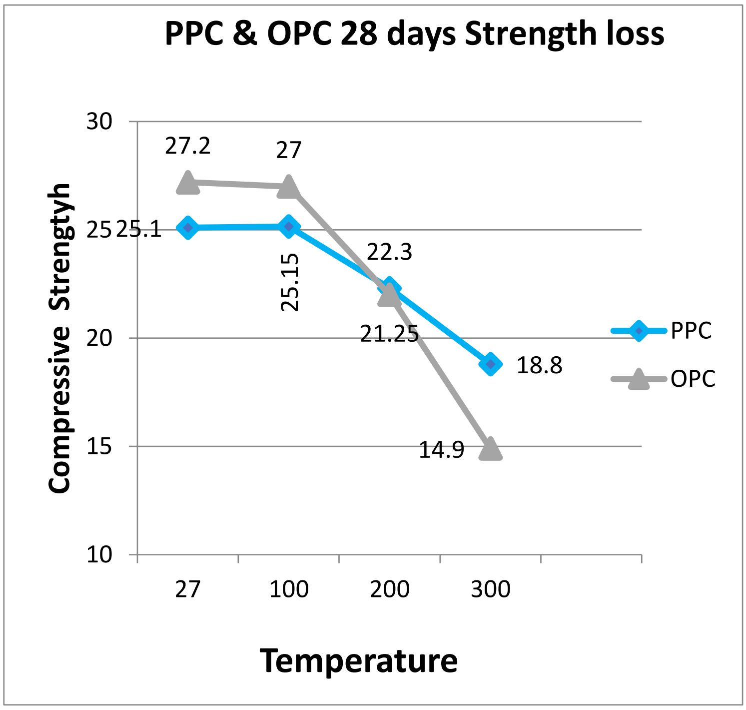
Temperature	PPC Specimen	Wt of speci. before kept in oven (Kg)	Wt of speci. After Removing from oven (Kg)	% wt loss (Kg)	Average % wt loss	Specimen failure at load (KN)	Compressive Strength (Mpa)	Aver. compressive strength
Reference, 27°C								25.1
100	A3	8.350 8.310	8.298 8.275	0.62 0.42	0.52	563 569.8	25.0 25.3	25.15
200	B3	8.340 8.330	8.123 8.123	2.6 2.48	2.54	509 495.4	22.6 22.0	22.3
300	C3	8.389 8.315	7.975 7.955	4.94 4.33	4.64	425.6 418.9	18.9 18.6	18.8

Table.7 Compressive Strength of concrete cube for 1hr at diff. elev. Temperature (OPPC, M25-1:1:2, 28 days)

Temperature	OPC Specimen	Wt of speci. before kept in oven (Kg)	Wt of speci. After Removing from oven (Kg)	% wt loss (Kg)	Average % wt loss	Specimen failure at load (KN)	Compressive Strength (Mpa)	Aver. compressive strength
Reference, 24°C								27.2
100	A4	8.365 8.310	8.289 8.245	0.91 0.78	0.85	610.3 605.8	27.1 26.9	27.0
200	B4	8.340 8.325	8.085 8.095	3.06 2.76	2.91	481.9 475.2	21.4 21.1	21.25
300	C4	8.395 8.401	7.923 7.915	5.62 5.79	5.70	340.0 331.0	15.1 14.7	14.9



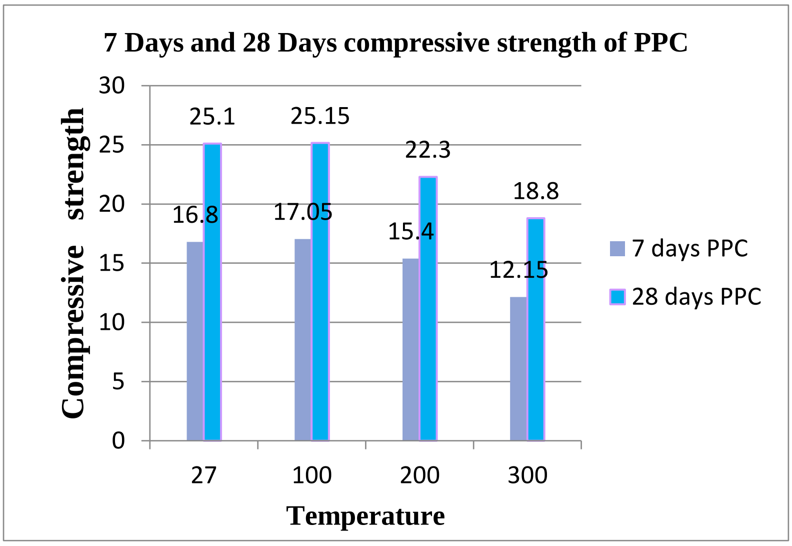
Graph3 (Temp vs %wt loss ,28 days)



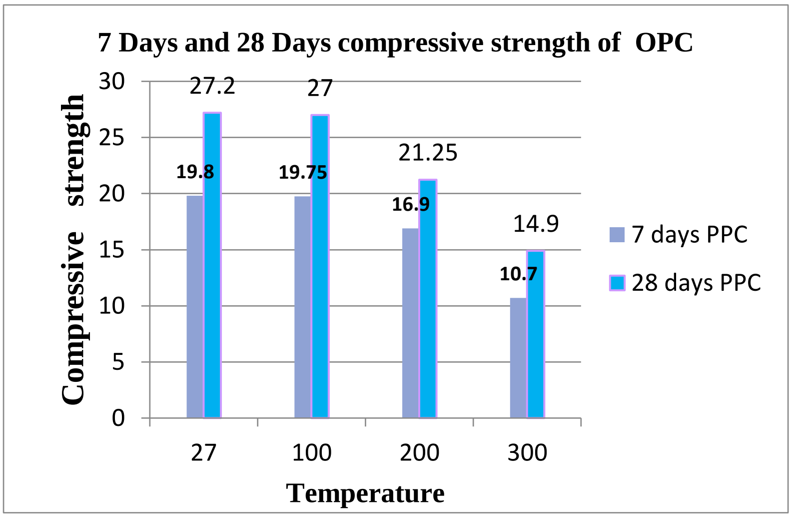
Graph. 4 (Temp vs Compressive streng., 28 days)

Table.8 Compressive Strength of concrete cube for 1hr at diff. elev. Temperature of PPC & OPC for 7 and 28 days

Temperature In ^{O}C	PPC		OPC	
	7Days Aver. compressive strength	28 Days Aver. compressive strength	7 Days Aver. Compressive strength	28 Days Aver. Compressive strength
27	16.8	25.1	19.8	27.2
100	17.05	25.15	19.75	27.0
200	15.4	22.3	16.9	21.25
300	12.15	18.8	10.7	14.9



Graph. 5 (Temp vs Compressive streng. PPC-7,28 days)



Graph. 6 (Temp vs Compressive streng. OPC-7,28 days)

SPLIT TENSILE STRENGTH:

These results are obtained by testing the total 32 specimens, in which 12 for 7 days and 12 specimens for 28 days and by considering the average of the test results that are tabulated in table and 4-4 specimens of both are taken for reference.

Table.9 Split Tensile Strength of concrete Cylinder for 1hr at diff. elev. Temperature

(PPC, M25-1:1:2, 7 days)

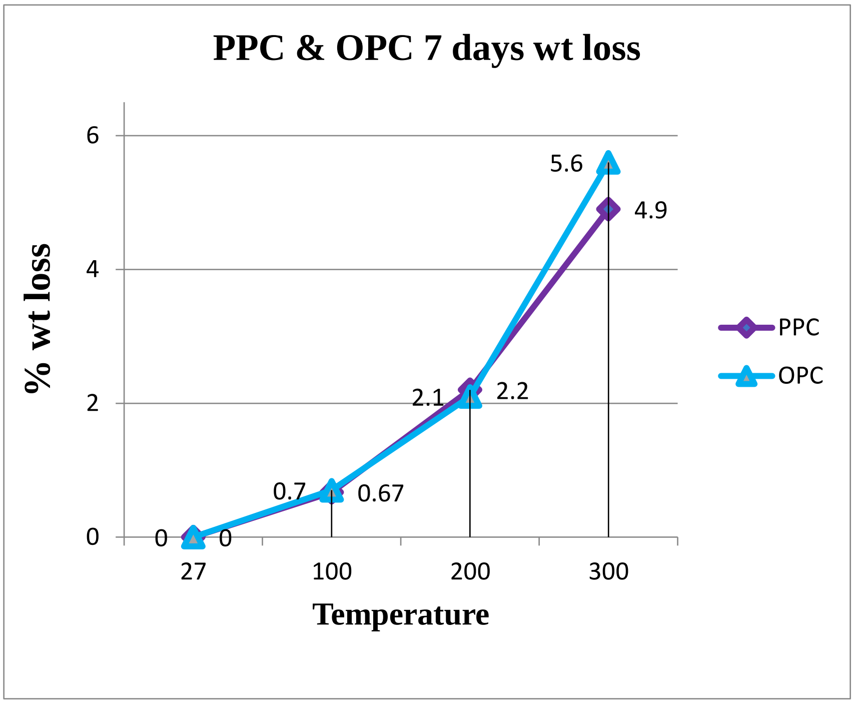
Temperature	**PPC Specimen**	**Wt of speci. before kept in oven (Kg)**	**Wt of speci. After Removing from oven (Kg)**	**% wt loss**	**Average of % wt loss**	**Specimen failure at load (KN)**	**Split Tensile Strength (Mpa)**	**Aver. Split Tensile Strength**
Reference, $27^{o}C$								**1.9**
100	A1	12.782 12.765	12.706 12.670	0.59 0.75	0.67	148.4 141.3	2.1 2.0	2.05
200	B1	12.735 12.744	12.480 12.460	2.1 2.23	2.2	113.0 113	1.6 1.6	1.6
300	C1	12.801 12.770	12.199 12.109	4.23 5.40	4.9	84.8 98.9	1.2 1.4	1.3

Formula Tsp = 2P/ pi DL

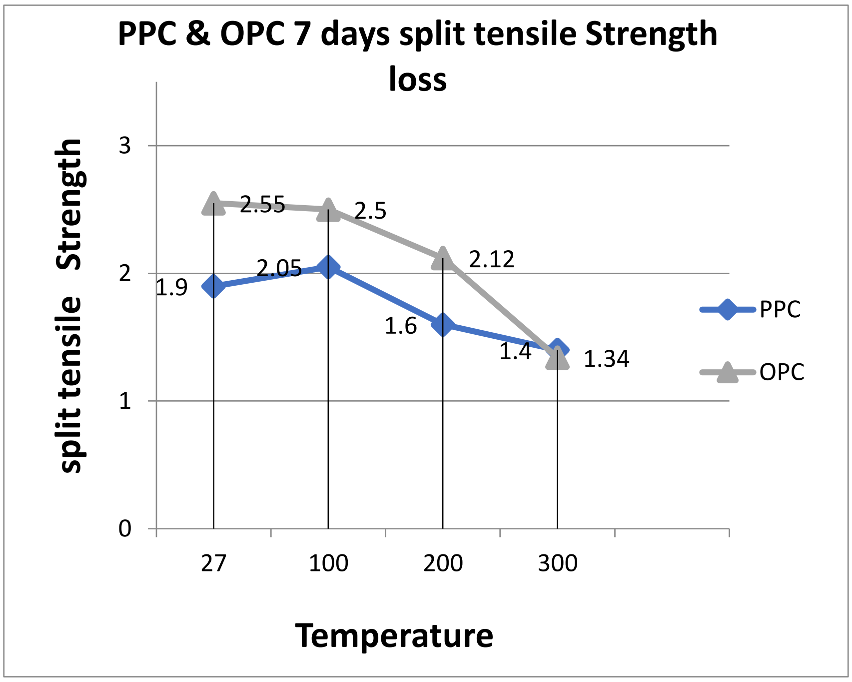
Table.10 Split Tensile Strength of concrete Cylinder for 1hr at diff. elev. Temperature

(OPC, M25-1:1:2, 7 days)

Temperature	**OPC Specimen**	**Wt of speci. before kept in oven (Kg)**	**Wt of speci. After Removing from oven (Kg)**	**% wt loss (Kg)**	**average**	**Specimen failure at load (KN)**	**Split Tensile Strength (Mpa)**	**Aver. Split Tensile Strength**
Reference, $27^{o}C$								2.55
100	A2	12.769 12.781	12.706 12.670	0.49 0.86	0.7	173.8 175.2	2.46 2.48	2.5
200	B2	12.739 12.749	12.480 12.460	2.03 2.26	2.1	150.5 148.4	2.13 2.1	2.12
300	C2	12.790 12.771	12.100 12.023	5.39 5.85	5.6	96.1 92.6	1.36 1.31	1.34



Graph. 7 (Temp vs %wt loss -7 days)



Graph. 8 (Temp vs split tensile Strength-7 days)

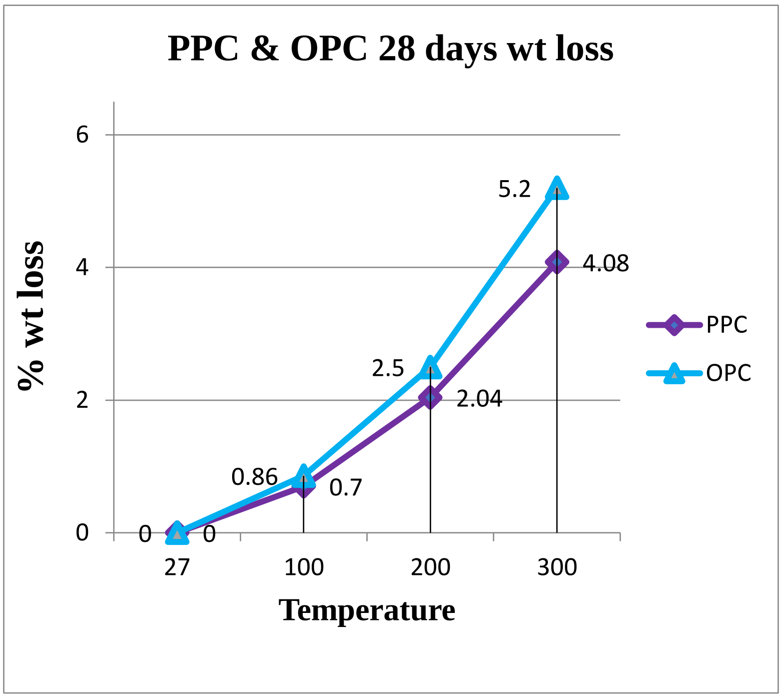
Table.11 Split Tensile Strength of concrete Cylinder for 1hr at diff. elev. Temperature (PPC, M25-1:1:2, 28 days)

Temperature	PPC Specimen	Wt of speci. before kept in oven (Kg)	Wt of speci. After Removing from oven (Kg)	% wt loss (Kg)	Average % of wt	Specimen failure at load (KN)	Split Tensile Strength (Mpa)	Aver. Split Tensile Strength
Reference, 27°C								3.0
100	A3	12.810 12.799	12.70.6 12.725	0.81 0.58	0.7	204.9 191.5	2.9 2.7	2.8
200	B3	12.801 12.806	12.54 12.545	2.04 2.04	2.04	169.6 162.5	2.4 2.3	2.35
300	C3	12.812 12.799	12.3 12.265	3.99 4.17	4.08	134.2 120.1	1.9 1.7	1.8

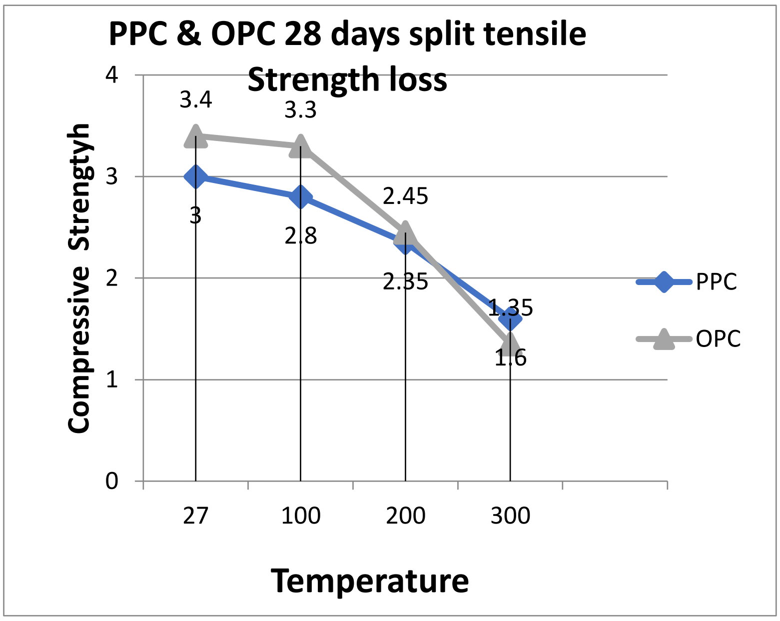
Table.12 Split Tensile Strength of concrete Cylinder for 1hr at diff. elev. Temperature (OPC, M25-1:1:2, 28 days)

Temperature	OPC Specimen	Wt of speci. before kept in oven (Kg)	Wt of speci. After Removing from oven (Kg)	% wt loss	Average % wt loss	Specimen failure at load (KN)	Split Tensile Strength (Mpa)	Aver. Split Tensile Strength
Reference, 27°C								3.4
100	A4	12.809 12.801	12.706 12.685	0.8 0.9 1	0.86	226.1 233.1	3.2 3.4	3.3
200	B4	12.809 12.816	12.475 12.499	2.61 2.47	2.5	170 176.6	2.4 2.5	2.45
300	C4	12.796 12.810	12.155 12.125	5.01 5.35	5.2	127.2 113.0	1.8 1.6	1.7

Pi/4D2xhx2400



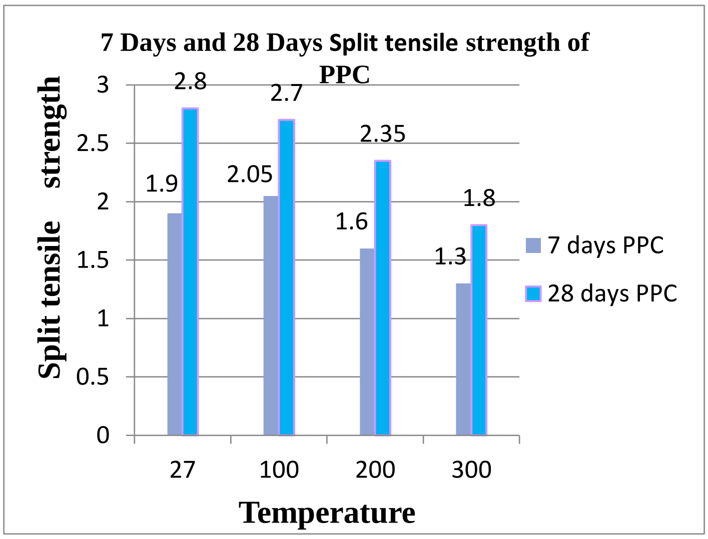
Graph. 9 (Temp vs %wt loss, 28 day)



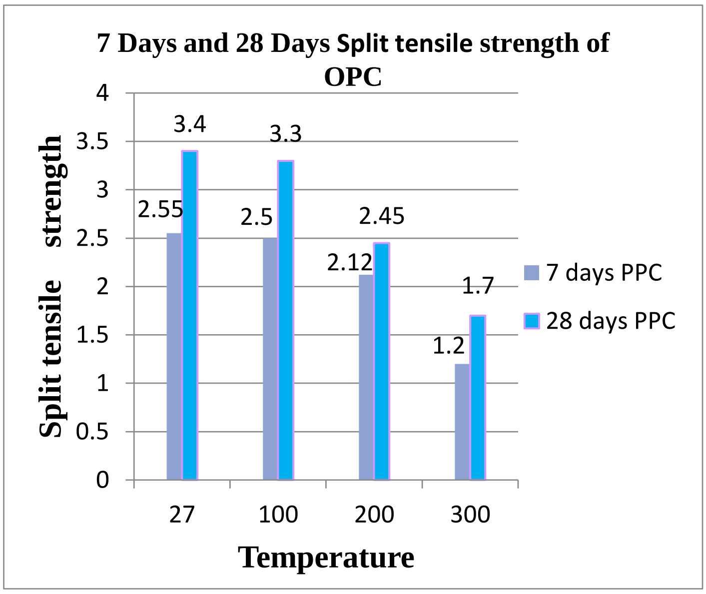
Graph. 10 (Temp vs split tensile Strength ,28 days)

Table.13 split tensile Strength comparison of concrete cylinder for 1hr at diff. elev. Temperature of PPC & OPC for 7 and 28 days

Temperature In ^{O}C	PPC		OPC	
	7Days Split tensile	28 Days Split tensile	7 Days Split tensile	28 Days Split tensile
27	**1.9**	2.8	2.55	3.4
100	2.05	2.7	2.5	3.3
200	1.6	2.35	2.12	2.45
300	1.3	1.8	1.34	1.7



Graph. 11 (Temp vs split tensile Strength ,PPC, 7&28 days)



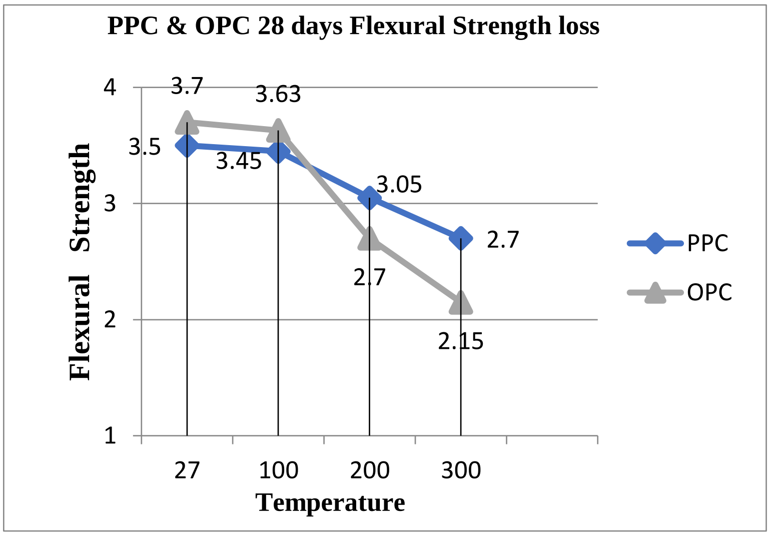
Graph. 12 (Temp vs split tensile Strength ,OPC, 7&28 days)

FLEXURAL STRENGTH :

These results are obtained by testing the total 16 specimens in which 6 for 7 days and 6 for 28 days and by considering the average of the test results that are tabulated in table &2-2 are taken for referance.

Table.14. Flexurakl Strength of concrete beam for 1hr at diff. elev. Temperature of PPC & OPC for 28 days

Temperature	**PPC Specimen**	**Specimen failure at load (KN)**	**Flexural Strength**	**Aver. Flexurakl Strength**
Reference, 27ºC				3.5
100	D1	8.5 8.6	3.4 3.5	3.45
200	D2	7.6 7.5	3.1 3.0	3.05
300	D3	7 6.5	2.8 2.6	2.7
Temperature	**OPC Specimen**	**Specimen failure at load (KN)**	**Flexural Strength (Mpa)**	**Aver. Flexural Strength**
Reference, 27ºC				3.7
100	E1	9.1 9	3.65 3.60	3.63
200	E2	7 6.5	2.8 2.6	2.7
300	E3	5.5 5.3	2.2 2.1	2.15



Graph. 13(Temp vs. Flexural Strength, PPC& OPC, 28 days)

DISCUSSION

Residual compressive strength of all heated specimens at an elevated temperature has been compared to the 7 days and 28-day of compressive strength, Split tensile strength and flexural strength of unheated specimens of PPC & OPC cement concrete. From the observations the residual compressive strength for PPC concrete is considerably higher than OPC concrete at elevated temperature for all durations. On the other hand normally compared the specimen, the strength of OPC is more than PPC.

Experimental observations establish a decrease in % of wt loss of M25 grade concrete using PPC cement concrete by 0.6 %, 2.2% &4.0 and OPC by 0.85%, 2.91%,5.70% at elevated temperature 100 ,200 ,300^{O}C also found the decrease in the compressive strength using PPC by 1.2%, 7.3% , 20% and OPC cement by 1%, 12%, 35% at elevated temperature 100, 200, 300^{O}C respectively in comparison with the conventional concrete. It is observed that the tensile strength of M25 grades using PPC is decreased by 3%, 12.%, 30% and of OPC by 3%,16%,35% at elevated temperature 100, 200, 300^{O}C respectively when compared to the conventional concrete. While of flexural strength using PPC cement by 2%,10%, 22% and of OPC cement by 4%,18%,40% at elevated temperature 100, 200, 300^{O}C respectively when compared to the conventional concrete.

CHAPTER 5

CONCLUSION

The following conclusions are drawn based on the experimental investigations on compressive strength, split tensile, flexural strength tests:

- It is concluded that PPC concrete exhibited lower decrease in percentage residual strength than OPC concrete at an elevated temperature. As we know that Presence of Pozzolanic material10-25% %(Volcanic Ash, Calcined clay, Fly ash, Silica fumes)in PPC concrete improved mechanical characteristics, durability and thermal stability, so that concrete maintains its structural integrity at high temperatue, which can fit into the spaces between cement grains because of its fineness. While OPC concrete contains large amounts of calcium hydroxide, the residual compressive strength suffered at elevated temperatures which increased micro cracking around the calcium hydroxide crystals This results in a relatively lower reduction in compressive strength in PPC concrete compared with OPC concrete

- The loss of strength associated with the increase in temperature could be the result of moisture driven off during heating and the incompatibility in thermal expansion between the cement paste and aggregates. The loss of water might have resulted in shrinkage of the cement paste, thermal expansion might have taken place due to which thermal stresses were induced in the paste and aggregates. These induced stresses resulted in the breakdown of the bond between the aggregate and the surrounding paste, with strength loss of the concrete. Up to 300°C, concrete remains almost unaffected in appearance & strength & the concrete used in the cubes maintained its structural integrity below 300 °C.

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A Study On The Mechanical Property Of Concrete Exposed To High Temperature: Review

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Abstract*: The effect of elevated temperatures on mechanical properties of concrete is important for understanding the behavior of chimneys, and conditions structures like storage tanks for crude oil, hot water , coal gasification, liquefaction vessels used in petrochemical industries, foundation for blast furnace, containment vessels and furnace walls industrial chimney,etc.,fire resistance studies will be subjected to elevated temperatures. There are many experimental studies to strengthen concrete by adding plasticizer, admixture, but there is still a need to improve the performance or to check the behaviors of different grade of concrete.. The comp. strength of concrete and weight of concrete decreased with increasing temperature aim of this work is to investigate the effects of elevated temperatures upon the properties of concrete. This paper focus on the effect of elevated temperature on the properties of ordinary concretes of M25 grade, containing different types of cements. So that the variation of compressive strength, performance are some of the important parameters to be investigated when concrete structures are subjected to elevated temperatures.

Keywords: *Elevated Temperatures, Ordinary Conventional Concrete, Compressive Strength , OPC & PPC Cement.*

I. INTRODUCTION

1.1General

Cement concrete has a good resistance against heat and it is a fire resistance material, the heat resistance of the structure depends upon the materials used, thermal conductivity and thermal expansion property. The main factors that affect the heat or fire resistance in RCC are cover thickness of the structure and the type of cement used in concrete. The heat resist from burned brick bats and blast furnace slag also possess good fire resistance. Portland blast furnace slag cement is well known heat resistance material. Due to elevated temperature, the RCC will tends to cause bulging of reinforcement on both the lateral and long it may tend to drastic loss of strength in bond and separation takes place. Concrete is a widely used construction material in buildings and several other structures for a quite long time. In case of reinforced concrete structures Concrete though not a refractory material is incombustible and has good fire resistant properties. The property of concrete to resist the fire reduces damage in a concrete structure in the event of an accidental fire. At elevated temperatures, ordinary concrete losses strength due to formation of cracks between cement paste and aggregate and associated thermal incompatibility between the two ingredients

Concrete is used in nearly every type of construction. Concrete has been primarily composed of cement, water, and aggregates(aggregates including both coarse and fine aggregates).Although aggregates make up the bulk of the mix, it is harden cement pastes that binds the aggregates together and contributes to the strength of concrete, with the aggregates serving largely as low-cost fillers material. Concrete is not a homogeneous material, and its strength properties depend upon its ingredients and methods of manufacture. However, concrete is normally treated in design as a homogeneous material. Steel reinforcement are often included to increase the tensile strength of concrete; such concrete is Called reinforced cement concrete (RCC). Reinforcement concrete has been used in a variety of application, such as building, tunnel domes, shells, tanks, pipes chimneys, cooling tower and poles RC offers great resistance to the action of fire and water. A concrete member having sufficient cover can have one to three hours of fire resisting without any special fire proofing material. If constructed and cured properly, concrete surface could provide better resistance to water than steel section, which require expensive corrosion-resistant coatings

We know that the ambient temperature of concrete structures is assumed to be at room values during construction . For safety of these concrete structures, present design and construction codes are used,in relation to room temperature values. Also the design strength of the structure is affected, at times the environmental temperature may increase extremely. It is important for engineers to be interested in the design strength of concrete subjected to high temperatures in order to perform at these elevated temperatures for practical research applications. The vaults of concrete of high-level waste storage tanks have been exposed to high temperatures due to decay heating of the wastes stored in the tanks for a long period. The effect of elevated temperatures on mechanical properties of concrete is important for understanding the behavior of chimneys, and conditions structures like storage tanks for crude oil, hot water , coal gasification, liquefaction vessels used in petrochemical industries, foundation for blast furnace, containment vessels and furnace walls industrial chimney,etc.,fire resistance studies will be subjected to elevated temperatures

At elevated temperatures when conventional concrete is exposed, it begins to dehydration reactions in the hydrated cement paste. We know that the heat resistance property of the structure mainly depends upon the materials used, thermal expansion property, thermal conductivity. Concrete has good resistance against heat and it is a fire resistance material. The type of cement used in concrete and cover thickness of the structure are the main factors that affect the fire or heat resistance in RCC. Due to high elevated temperature, concrete loss there strength and also cracks were developed on the surface and RCC will cause bulging of reinforcement on both the lateral and longitudinal direction. Continuously heating the concrete, the cement materials shrink beyond the point of maximum expansion and the aggregates produce continuous expansion and both combination of expansion and shrinkage weaken and crack the concrete structure.

1. 2 Material to be used

- Cement (OPC, PPC)
- Fine Aggregates
- Coarse aggregate
- Water

1.2.1 Cement

Cement is a binding material used in construction. It has a property of setting and hardening when mixed with water to attain strength. Cement is always used in the form either grout or mortar or concrete. Grout which is mixture of cement and water. Mortar is a proportioned mixture of cement ,sand and water. Concrete which is proportioned mix of cement coarse aggregate, fine aggregate and water

PPC: -Pozzolana is a natural or artificial material containing silica in a reactive form. Portland pozzolana cement is a kind of blended cement which is produced by either inter grinding of OPC clinker along gypsum and pozzolanic materials (Volcanic ash, Calcined clay , Fly sah, Silica fumes)separately India is the second-largest consumer of Portland cement (PC) in the world; from thermal power plants the production of fly ash is expected to reach 140 metric tons by 2020. however, OPC-33 was replaced with Portland pozzolana cement (PPC). PPC and OPC-53 are the most commonly used types of concrete in India. PPC is cheaper to manufacture than OPC, it possesses a smaller heat of hydration, and thus, it is highly useful for mass concreting, and it is more durable than OPC because of it contains relatively minor quantities of chlorides, free lime and sulphate alkalis. High temperature resistance is defined as the ability of a structural element to withstand its load-bearing function under high temperature condition.

OPC:- The most commonly used cement in concrete is ordinary Portland cement of satisfying the requirements of IS:12269 (1987) having specific gravity of 3.15. This ordinary Portland cement was classified into three grades which is namely as 33 grade, 43 grade and 53 grade depending upon the strength of the cement obtained at 28 days which was tested as per IS:4031 (1988). If the 28 days strength is not less than 33N/mm2, it is said to be 33 grade cement, if the 28 days strength is not less than 43 N/mm2, it is said to be 43 grade cement and if the 28 days strength is not less than 53 N/mm2, then it is said to be 53 grade cement. High temperature resistance is defined as the ability of a structural element to withstand its load-bearing function under high temperature condition three grades of cement, i.e., ordinary Portland cement-33 (OPC-33), OPC-43, and OPC-53, were most commonly used throughout India; In contrast, OPC-53 has a faster setting time, and it develops strength more quickly, and hence, it is suitable for rapid construction; moreover, because of its higher heat of hydration, OPC tends to develop micro-cracks that are not visible at the surface (Taylor,1997).

1.2.2 Aggregate

Aggregates are the major ingredients of concrete which occupy 70 to 80% of the volume of concrete. The ingredients used for the manufacture of mortar and concrete such as sand, gravel etc. are called as aggregate. Aggregates provide strength to the concrete and act as filler material to give the homogeneous mass of concrete along with cement paste.

1.2.2.1 Fine Aggregate

The aggregate with grain size below 4.75 mm is termed as fine aggregate .Natural sand or crushed stone dust is the fine aggregate commonly used in concrete mix.

1.2.2.2 Coarse aggregate

The aggregate whose particles are retained on I.S Sieve No, 480(4.75 mm) is termed as coarse aggregate. The size of coarse aggregates used depends on the nature of work. For R. C. C work 20 mm aggregate is commonly used.

1.2.3 Water

Portable fresh water, which should be free from concentration of acid and organic substances, is used for mixing of concrete. The combination of water and cementitious material form a cement paste by the process of hydration. If less water in the cement past will yield in the stronger more durable concrete, ore water will dive free flowing concrete with a higher slum. Hydration involves many different reactions, as the reaction proceed, the products of cement hydration process bond together with sand and gravel particle, and other component of concrete , to form a solid mass.

II. LITERATURE REVIEW

Castilo and Durrani3(1990)[1]: Study was carried out to investigate the effect of transient high temperature on compressive strength and load–deformation properties of HSC under both unloaded and preloaded conditions and to compare the behavior with that of NSC. From the study, it was concluded that when exposed to temperatures in the range of 100 to 300^{O}C, HSC showed a 15–20 % loss of compressive strength. After an initial loss of strength, the HSC recovered its strength between 300 to 400^{O}C, reaching a maximum value of 8–13% above the strength at room temperature. At temperatures above 400^{O}C, the HSC progressively lost its compressive strength, which dropped to about 30% of the room temperature strength at 800^{o}C.

Ahmed et al.(1992)[2]:*Residual compressive and bond strengths of limestone aggregate subjected to elevated temperatures*; In this paper, the influence of high temperatures (100–600^{O}C) on the residual compressive and bond strength of concrete made from lime stone aggregates was experimentally investigated. The main test parameters involved were, the time of exposure at the maximum temperature. Based on the results obtained from the study it was reported that7-day compressive strength of concrete increased with temperature up to 100^{O}C. Also for this temperature range, young concrete exhibited a higher residual strength than old concrete. It was also reported that a decrease of 15% of original strength appeared at150^{O}C. It was concluded that the cooling method had no significant influence on either the residual compressive or bond strengths.

Sarshar and Khaury(1993)[3]:*Compressive strength of concrete at high temperatures ;*In this paper the cement part replacements used were silica fume, ground granulated blast furnace slag and pulverized fuel ash (PFA).Eleven temperature levels ranging up to 600ºC were used. Based on the results obtained from the study it was concluded that concrete paste containing 100% ordinary Portland cement(OPC) lost significant residual compressive strength above 300ºC. It was further concluded that specimens containing PFA and slag performed significantly better than specimens containing 100 % OPC or silica fume. The slag cement paste specimens gave the best results of all the cement pastes tested.

Chan et al.(2000)[4]: *To evaluate the mechanical properties of high-performance concrete (HPC) and NSC subjected to the temperatures up to 800^{O}C.* In this an experimental study of HPC and NSC was conducted to a temperature of 800ºC and evaluated their residual compressive strengths. Based on the results obtained from the study it was concluded that, the strength of HPC degenerated more sharply than that of the conventional concrete with the increase of exposed temperature, HPC had higher residual strength. Test results revealed no significant changes in strength for specimens exposed to elevated temperatures up to 400ºC.

Randall Lawson et al.(2000)[5]: *Residual mechanical properties of HPC after being exposed to elevated temperatures;* The average compressive strength for the different grades of concrete adopted in the study was 40 to 100 MPa. The selected temperatures were 100, 200, 300 and 450ºC. Based on the results obtained from the study it was concluded that Significant drops in compressive strengths were reported for concrete exposed to elevated temperatures.

Potha Raju et al.(2004)[6]: *Effect of elevated temperature on the flexural strength of fly ash concrete of different grades of M28, M33 and M35*; Concrete specimens 100 x 100 x 500 mm with partial replacement cement by fly ash were heated to 100, 200 and250ºC for 1, 2 and 3 h durations. The specimens were tested for flexural strength in the hot condition immediately after removing from the oven. It was concluded that fly ash content up to 20% showed improved performance compared with the control specimens by retaining greater amount of its strength.

Srinivasa Rao K., Potha Raju M. and Raju P.S.N. (2006)[7]: *Effect of elevated temperature on compressive strength of heated high-strength concrete with super plasticizer.* In this paper the effect of elevated temperatures ranging from 50 to 250ºC on the compressive strength of high-strength concrete (HSC) of M60 grade made with OPC and PPC. Tests were conducted on 100 mm cube specimens. The specimens were heated to different temperatures of 50, 100, 150, 200 and 250ºC for three different exposure durations of 1, 2 and 3 h at each temperature. It was concluded that the PPC concrete exhibited better performance than OPC concrete. From the observations the residual compressive strength for PPC concrete is considerably higher than OPC concrete at any temperature for all durations

P. Dinakar [a], K.G. Babu [b], Manu Santhanam [c],* (2007) [8]:*Corrosion behaviour of blended cements in low and medium strength concretes;* In this paper the corrosion behaviour of steel in concrete with blended cements like Portland pozzolana cement and Portland blast furnace slag cement were studied in comparison to their corresponding Ordinary Portland cements. Three concretes of compressive strengths 15, 30 and 45 MPa were designed. Based on the results obtained from the study it was concluded that the resistivities of both fly ash and slag concretes were found to be more than the corresponding ordinary concretes. The compressive strengths of PPCs and BFSCs at both28 and 90 days were higher than the corresponding OPCs.

S. Bhaskar_,*, B.H. Bharatkumar*, Ravindra Gettuand M. Neelamegam*(2010) [9]:** ***Effect of corrosion on the bond behaviour of OPC and PPC concretes*;** The objective of the present study is to assess the bond behavior of concrete subjected to accelerated corrosion test. Based on the experimental results, an empirical bond-slip model is proposed for uncorroded rebars. It is concluded that the bond behaviour of PPC concrete is better than OPC concrete under corrosion. Bond behavior has been studied for corroded rebars at three different time durations viz., 33, 54 and 64 days of accelerated corrosion resulting in 1.2%, 2.5% and 4.2% weight loss for OPC concrete and 33 and 110 days of accelerated corrosion resulting in 0.3% and 2.9% for PPC concrete. It was concluded that the bond behaviour of PPC concretes is better compared to OPC concretes under the corrosive conditions for the same exposure duration.

A.K. Parande *, B. Ramesh Babu, K. Pandi, M.S. Karthikeyan, N. Palaniswamy (2011) [10]: ***Environmental effects on concrete using Ordinary and Pozzolana Portland cement;*** In this study, the strength of the concrete in various environments has been investigated using different techniques such as compressive strength, flexural test, rapid chloride permeability, weight loss measurements ,linear polarization and open circuit potential. From the results, it is observed that PPC exposed in different media shows better performance than OPC in both mechanical and electrochemical studies. In flexural strength OPC was performed better than PPC at 150 days and weight loss measurements showed that the corrosion rate in PPC was lesser than OPC.

M.V. Krishna Rao*a, M. Shobhab and N.R.Dakshina Murthyc (2011)[11] : ***Effect of elevated temperature on strength of differently cured concretes -an experimental study*;**. This paper investigates the effect of sustained elevated temperature on the properties of ordinary concretes of M40 grade, containing different types of cements and cured by two different methods. The specimens were heated to150ºC, 300ºC and 450ºC for1 hour duration in a muffle furnace and tested after air-cooling to the room temperature. The variables considered in the study include type of cementing material, temperature and method of curing. Based on the results obtained from the study it was concluded that the comp. strength of concrete and weight of concrete decreased with increasing temperature. Specimen subjected to conventional water curing performed relatively better than those of membrane curing.

Prakash Mahadeo Mohite and Umesh Uttam Patil (2012)[12]: ***Comparative study of High Strength concrete under controlled elevated temperature;*** The present paper is aimed to study the effect of elevated temperature ranging from 100^0C to 600 ^{0}C on the compressive strength of high strength concrete (HSC) of M50 grade made with PPC with varying percentage of silica fume (SF) (0%, 5%, 10%, 15% & 20%) by replacement of cement by weight. It was concluded that HSC containing 15% silica fume exhibited better performance up to elevated temperature of600ºC. There is maximum loss of strength of16.67MPa at 600ºC. It is observed that, strength varies from 74.66MPa to 60.67MPa for dry cooling& 72.67MPa to 50.00MPa for wet cooling for concrete subjected to elevated temperature of100ºC to 600ºC

Mr. Dipak S. Gaud1 Mr. Dhiren K. Paghdar2 Dr. Jayesh A. Shah3 Mr. Vyom B. Pathak 4 Mr. Rushabh A. Shah5 (2013) [13]: ***A Compatibility Study on Different Types of Cement and Plasticize;*** In this paper the study was conducted to discover method of making concrete at the lowest possible water/cement ratio while maintaining a high workability. In such instances the use of plasticizers/super plasticizers permits the production of concrete at low water/ cement ratios. We have taken opc and ppc cement to find the compatibility by adding perma plast (plasticizer). From marsh cone test the compatibility has found out that adding 1.5 % perma plast by volume of cement is compatible with ultra tech OPC 53 grade cement & 1.3 % perma plast by volume of cement is compatible with coromandal king PPC cement

H. G. MUNDLE (2014) [14]: ***Variation in strength of concrete subjected to high temperature;*** In this paper, the elevated temperatures on mechanical properties of concrete is of very much important for fire resistance studies that the variation of compressive strength, performance are some of the important parameters to be investigated when concrete structures are subjected to temperatures. The compressive strength was found to increase after 72 hours of exposure to an elevated temperature up to 150^0 C after that the compressive strength of concrete decreases with increasing temperature. The peak value in the ratio of the compressive strength at high temperature is observed around 150^0 C. This peak value obtained due to the evaporation of free water inside the concrete.

Mohammad Kamran[1], Mudit Mishra[2] (2014) [15]: ***Behaviour of self-compacting concrete using PPC and OPC with different proportions of fly ash;*** In this paper, comparison in behaviour using PPC and OPC with different proportions of fly ash in the mix which were taken as 15%, 25%, and 35% in place of cement. a set of 6 cubes was casted and tested at 7 days and 28 days for strength. The temperature of sample cubes was kept constant at 24°C for the whole period. The mix design was done for M25 grade. The W/C ratio was kept constant at 0.45. The similar tests conducted on OPC samples showed the same pattern but overall strength gain was higher than PPC samples and the margin was spectacularly high ranging between 40%-60%.

S. O. Osuji1,* and U. Ukeme2 (2015) [16]:***Effect of elevated temperature on compressive strength of concrete: A case study of grade M40 concrete*****;** This study presents the effects of elevated temperatures on the compressive strength of Grade 40 concrete and elevated temperature of 24, 100, 150, 200, 250 and 300 degree Celsius at one hour duration. The result indicated14.49%, 25%, 51%, 35.51% and 43.88% decrease in compressive strength at the earlier quoted temperatures respectively. At an elevated temperature of 300 degrees Celsius a peak decrease of 53.47% in compressive strength was observed. It was concluded that loss of strength at 300^{o}C of53.47% and weight loss of 4.67% are significant. It was concluded that there was loss of weight as the temperature increased starting from 100^{o}C at increments of 50^{o}C up to 300^{o}C,while weight loss increased from 0.87 to 4.67% as compared to the control mix at room temperature of24^{o}C at 28 days age

C. B. K.Rao, Rooban Kumar (2015) [17]: ***A study on behaviour of normal strength concrete and high strength concrete subjected to elevated temperature;*** The experimental results of normal concrete and high strength concrete subjected elevated temperatures at 200°C, 400°C, 600°C, and 800°Cand different cooling regimes viz. air cooling, water quenching on different grade of concrete are reported in this paper. Principal effects due to elevated temperatures are loss in compressive strength, loss in weight or mass, change in colour and spall of concrete. It was conclude that the loss in compressive strength at elevated temperature is more in case of High strength concrete compared to Normal strength concrete. Strength of concrete decreased with increase in temperature. Decrease in compressive strength is more at high temperatures of 800°C.

Nandita Suman1, Krishna Murari2(2015)[18]: ***Study of Impact of Elevated Temperature on the Characteristic Strength of M30 Grade Concrete Based On Plasticizer;*** In this experimental study several steps of work has been included. Concrete cubes were made with plasticizer and without plasticizer are exposed to heat for 12 hours and as a result, undergo physical changes or spalling. This causes reduction of strength of concrete. Two concrete mixes were prepared one mix is with 2%plasticizer (sikament® 581) of cementious material and another mix is without plasticizer and cubes were prepared in moulds. The results show that rate of reduction of residual strength of concrete cubes with plasticizer after exposure to heat is less than that of the residual strength of concrete without plasticizer after exposure to heat to elevated temperature at 200^{o}C, 400^{o}C, 600^{o}C, 800^{o}C for 12 hours.

Rasyiid Lathiif Amhudo a, Tavio b*, I Gusti Putu Raka b (2018) [19] : ***Comprison of compressive and tensile strength of dry-cast concrete with OPC and PPC.*** In this study, there are two casting methods used in concrete placement, namely wet- and dry-castings. The dry-cast concrete used for its advantages in precast concrete industries, e.g. its rapid hardening time for fast mold removal (it significantly increases the plant productivity). The compressive strengths of dry-cast concrete with OPC for various w/c ratio and ages are entirely higher than those with PPC. The maximum compressive strength was found at age of 28 days with w/c of 0.3 which can reach up to 1199.8 kg/cm2. The dry-cast concretes with extremely dry condition using both OPC (Type-I cement) and PPC have very much higher compressive strengths (above 492.5 kg/cm2) as compared to the wet-cast concrete from the ACI curves which provides only two curves with respect to non-air-entrained and air-entrained concretes.

III. CONCLUSION

Following conclusions are drawn:

- It is concluded that when exposed to elevated temperatures loss of strength (Compressive, Tensile) occurs in concrete, cracks develop and damaging of concrete occurs and weight of concrete decreased with increasing temperature.
- It was concluded that for maintaining and improving the strength addition of silica flour, Admixtures, plasticizer, Super plasticizers are used to improves the performance of the concrete when exposed to elevated temperature. For compressive strength, the loss of strength with admixture is less than the strength without admixture.
- It is also found that the bond behavior of PPC concretes is better compared to OPC concretes under the corrosive conditions for the same exposure duration.

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