

A REVIEW ON DURABILITY AND TEMPERATURE CHARACTERISTICS OF HIGH STRENGTH CONCRETE

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Abstract:

The incorporation of very fine binding materials in the conventional concrete has revolutionized the concrete industry. The fine binding materials whose size ranges from microns to Nano meters has remarkable effects on the strength of concrete. Apart from strength, the incorporation of Nano materials in the conventional concrete has greatly affected the durability and temperature effectiveness of the concrete. This paper reviews the various durability and temperature characteristics that occur in the conventional concrete due to the addition of very fine binding materials. Various remarkable effects on the durability of high strength concrete is discussed which clearly differentiates it from the conventional ordinary concrete.

Key words: Nano materials; Durability of Concrete; Temperature Characteristics; High strength concrete.

INTRODUCTION:

Concrete is most widely used construction material in the modern world. The durability of the concrete is a very important consideration in the application of the concrete in the very adverse environments. The ability of the concrete to resist the weathering action, chemical attack and abrasion is termed as durability of the concrete. The durability of the concrete determines its ability to last a long time without deterioration. The durability issues in the concrete can be caused by the external environmental factors or by internal agents within the concrete. The factors which affect the durability of the concrete can be categorized as physical, mechanical and chemical. The physical factors include the action of frost and difference in thermal properties of aggregates and cement paste of the concrete. The mechanical factors of durability are mainly concerned with the abrasion. The chemical factors that affect the durability of the concrete comprises attack by sulfates, acids, sea water, and also by chlorides which include electrochemical corrosion of steel reinforcement. The durability of the concrete is directly related to the permeability of the concrete, since the chemical attack takes place inside the concrete mass and the chemical should be able to penetrate the concrete mass. The incorporation of Nano particles in the ordinary concrete decreases the porosity of the concrete, thus reducing permeability and hence chances of chemical attacks. Thus the addition of Nano particles not only increases the compressive strength of the concrete, but it enhances the durability of the concrete to a great extent.

High strength concrete is often used in the construction of high rise buildings. In the case of fire or elevated temperatures the concrete building elements such as beams, slabs, columns etc. suffer massive damage. Thus in order to study the effectiveness of the building to extreme temperatures, numerous studies have been made to study the effect of elevated temperatures on the high strength concrete and relate the results with the ordinary concrete. The study involves finding the loss in mass of the concrete and loss in the compressive strength of the concrete after subjecting the high strength concrete to the elevated temperatures. The temperature studies also involves the spalling behaviour of the concrete under elevated temperatures. The cracks that occur in the concrete due to the elevated temperatures greatly affect the durability of the concrete as the cracks pave an easy way for ingress of chemicals.

LITERATURE REVIEW:

M. Bastami, A. Chaboki –Khiabani, M. Baghbadrani, M. Kordi (2011) [1] studied performance of high strength concretes at elevated temperatures. The study revealed the effect of elevated temperature on the compressive strength, spalling and mass loss of high strength concretes. The experimental study involved the high strength concrete (M 65). The mechanical properties of high strength concrete were determined by subjecting 150×300 mm cylinders at 20 °C/min to temperatures of upto 800 °C. The experimental study included sixteen mixtures, twelve containing silica fume and four are without silica fume. The study revealed that the reduction in strength is disastrous if the concrete is subjected to elevated temperatures up to 800 °C. The experiments also revealed that the spalling behaviour in the concrete also decreased when the water to binder ratio levels increased in the mixtures containing silica fume. The study revealed the decrease in the compressive strength of the high strength concrete on increasing the water to binder ratio at room temperatures. While in the heated specimens the compressive strength increased on increasing the water to binder ratio. The concrete sample show no visible effect on the

surface when heated up to 300 °C. After the temperature reached to 800 °C the cracks enlarged highly and spalling of the sample was observed.

P.Nath , P.Sarker (2011) [2] studied the effect of fly ash on the durability properties of high strength concrete .In this study the durability of high strength concrete utilizing fly ash have been investigated .The study involved the determination of compressive strength ,drying shrinkage ,sorptivity and rapid chloride permeability tests on fly ash based high strength concrete .The high strength concrete show the 28 days strength varying from 65 to 85 MPa. The study revealed that inclusion of fly ash in the concrete reduced sorptivity and chloride ion penetration significantly at 28 days and further decreased after 06 months .The chloride permeability was measured in accordance with the ASTM C 1202-07 at the ages of 28 days and 06 months .The concrete cylinders of 50 mm thickness were sliced at the top .The water saturated specimens were subjected at 60 V electric potential for 06 hours .The study revealed that the addition of fly ash in the concrete reduced the chloride ion permeability up to 40% at 28 days which further reduced to 48% at 180 days .The concrete having fly ash additions show decrease in the rate of drying shrinkage of about 10 % lower than the control specimen. At 28 days, concrete with 40% fly ash show higher sorption as compared with the concrete with 30% fly ash.

A.H.Shekari , M.S.Razzaghi (2011) [3] studied influence of Nano particles on durability and mechanical properties of high performance concrete. The durability of high strength concrete has been investigated through chloride penetration test and concrete permeability. The study revealed that the Nano particles greatly improve the durability of the high strength concrete. The value of the water absorption of Nano silica based high strength concrete is less than 0.4 % of the water absorption of the control specimen. The addition of Nano particles in high strength concrete reduced the chloride penetration by 20 % to 80% as compared to control specimens.

A.H.Shah , U.K.Sharma ,Danie A.B.Roy and P.Bhargava (2013) [4] studied the spalling behaviour of Nano silica high strength concrete at elevated temperatures. The behaviour of high strength concrete containing Nano silica and micro silica exposed to elevated temperatures of 800° C is studied. The study revealed that the maximum thermal damage and temperature induced cracking was noticed in Nano silica based high strength concrete.

R. Sri Ravindrarajah , R. Lopez & H Reslan (2002) [5] studied effect of Elevated Temperature on the properties of High-Strength Concrete Containing Cement Supplementary Materials.The study summarizes and discusses the degradation of stiffness and strengths of high strength concrete in relation to their water to binder ratio. The results revealed that the addition of binder enhances the temperature effectiveness of the high strength concrete upto the elevated temperatures of 800°C.However the influence of binder material type is decreased at temperatures of 1000 °C.The study revealed that the strengths are being more influenced by the increase in the temperature as compared to the stiffness of the concrete.The experimental results revealed that the weight loss of 10 % occurred in the concrete cylinders when the temperature was increased to 800°C. The study revealed that the compressive strength of the concrete decreased significantly as the temperature was increased .The residual strength varied from 73% to 84% of the corresponding initial strengths when the concrete temperature was increased to 200 °C followed by sudden cooling in air. As the temperature of the concrete is increased to 600 °C , the residual strength ranges from 42 % to 74% of the unfired concrete. As the temperature is increased to 800°C the residual strength comes in the range of 24% to 46% of the unfired concrete.

W. Jackiewicz-REK , T.Drzymala, A.KUS, M.Tomaszewski (2016) [6] studied durability of high performance concrete subjected to fire temperature impact. The results revealed that the temperature of 105 °C results in the strength decrease in aerated concrete of 14 % and 4 % for concrete with fibres as compared to strengths at 20 °C .The study revealed that the aerated concrete show the lowest absorptivity after exposure to 300 °C and 450 °C .After increasing the specimen temperature to 300 °C a rapid increase in water penetration depth has been observed .After the exposure of concrete specimens to high temperatures ,the C-S-H gel bonds are destroyed resulting in decrease of slurry resistance as compared to coarse aggregates .The increase of temperature upto 600 °C results in decrease of the strength of the aerated concrete of 24.6 % compared to the concrete at 20 °C.

V.S. Babu, A.K. Mullick, K.K. Jain, P.K. Singh (2014) [7] studied strength and durability characteristics of High strength concrete with recycled aggregate –influence of processing .The experimental study found the effect of recycled aggregate on the strength and durability of the concrete .The durability properties of the concrete that were studied were water absorption ,sorptivity ,chloride ion penetration ,drying shrinkage and abrasion resistance .The study revealed that the recycled aggregate concrete can be used for developing high strength concrete .In processed recycled aggregate the cement mortar thickness is reduced considerably as compared to unprocessed aggregate concrete by grinding action .Then the paste made with cement ,silica fume and sand forms a thin layer around the periphery of processed recycled aggregate filling the cavities ,gaps ,fissures ,thus strengthening the ITZ in the resulting concrete.

Walid Safwat El- Sayed, Dina M. Sadek, Amr Basuoni Ibrahim Al- Samahy (2011) [8] studied the behaviour and durability of high and ultra-high strength concrete manufactured by local materials. The different classes of concrete with a wide range of compressive strength varying from 250 to 1000 kg /cm ² are manufactured and their durability aspects are

studied .The study revealed that the water cement ratio plays a very important role in abrasion resistance of concrete ,while the addition of Nano particles governs the compressive strength and permeability of the concrete .The study revealed that the permeability and water absorption of high strength was very less as compared to the ordinary concrete. The study revealed that the abrasion resistance of ultra-high strength concrete increased by about 55 % as compared to normal strength concrete. While as increase in abrasion resistance increased by 44 % as compared to high strength concrete. The water absorption of high strength concrete decreased by about 29 % as compared to the normal strength concrete.

Hilmi Bin Mahmud,Muhammad Fakhar Abdul Malik,Rahaimi Abdul Kahar, Muhammad Fauzi Mohd.Zain, Sudharshan Naidu Raman (2009) [9] studied mechanical properties and durability of normal and water reduced high strength grade 60 concrete containing rice husk ash .The study reported an investigation on the strength properties , time dependent property as well as durability characteristics of normal and water reduced high strength concrete. The study revealed that the concrete containing rice husk ash (RHA) show very less values of sorptivity compared to normal ordinary Portland concrete .After 03 cycles of exposure all concrete mixes produce maximum expansion of less than 0.03% , thus helping in resistance of concrete against magnesium sulphate attack. The study revealed decrease in the strength of RHA concrete by 6 % when subjected to attack by magnesium sulphate solution and 8% in case of normal concrete .Thus the study helps to establish the fact that the RHA (Rice Husk Ash) helps in enhancing the durability of the concrete .

Michel Mbessa , Jean Pera (2001) [10]studied durability of high –strength concrete in ammonium sulfate solution .The effect of aluminum sulphate attack on high strength concrete is found experimentally .An accelerated attack consisting in wetting drying cycles was adopted throughout the study .The study revealed no swelling in the concrete after six cycles of degradation and the chemical attack was limited to superficial zone of 5 mm thick .The study revealed that the high strength concrete is very durable in 20 % ammonium sulphate solution due to its very low porosity and permeability. The ammonium sulphate attack remains very superficial and gypsum is not found in the core of the specimens . The study revealed no swelling in the concrete during the durability cycles. The experimental study found the loss in mass of 6-10 % depending on the nature of fine particles used in the concrete. The concrete with silica fume addition led to the lowest loss in the mass of the specimen while as the concrete with metakaolin generated higher values . The porosity of the concrete specimen was determined by mercury intrusion porosimetry. The dimensions of the sample used for determining the porosity was (h= 40 mm and diameter =23.7 mm).The results from the porosimetry revealed that there is the general decrease in the porosity of high strength concrete after 28 days.

SUMMARY:

The incorporation of Nano materials in the ordinary concrete has remarkable effect on the durability and temperature effectiveness of the concrete .The high strength concrete shows remarkable resistance to the effects of elevated temperatures and chemical attacks .The high strength concrete is characterized by the decrease in the porosity and permeability and hence the chances of ingress and chemical attack are very rare or less.The use of nano materials in the high strength concrete helps in decreasing the water absorption of the concrete .The loss in mass and loss in compressive strength in high strength concrete due to the exposure to the elevated temperatures is less as compared to normal strength concrete .There is general decrease in the sorptivity of the concrete on the addition of nano particles .

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