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A Review on Durability Properties of Densified Small Particles based Concrete

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Abstract— The most widely used construction material is Concrete because of its good workability and ability to be moulded to any shape. Concrete is a major part of development and plays a very important role in the infrastructural development especially in a developing country like India. Normal cement concrete possesses very low tensile strength, lesser ductility and less resistance to cracking. Normal concrete shows the brittle behaviour and fails to handle the tensile loading hence leads to internal micro cracks responsible for brittle failure of concrete. The concrete durability crisis forced the engineers to think about the performance of concrete, proper design mix and careful construction by using the best available materials and technologies are necessary to achieve quality concrete structures. High performance concrete appears to be a better choice for a strong and durable structure. A huge amount of by products or wastes like silica fume, fly ash, copper slag etc are produced by industries, dumping and disposal of such wastes causes various environmental and health issues. In the recent past, considerable attempts has been there for improving the properties of concrete by adding such by products or wastes with respect to strength and durability, especially in aggressive environments. Proper usage of silica fume along with fibres and superplasticizers in concrete improves both the mechanical & durability characteristics of the concrete. The present review paper mainly focuses on research papers carried in the field of fibre reinforced DSP concrete, which includes experimental studies, strength and durability properties, effect of fibres and the latest developments in fibre reinforced concrete.

Keywords— Concrete, Silica fume, Durability, DSP, Steel Fibres, Superplasticizer

I. INTRODUCTION

The concept of Densified small particles (DSP) materials was introduced by Bache in the 1980's, when the use of sub micron particles (microsilica) in cementitious materials was conceived. Densified small particles based concrete materials, including fibre reinforced DSP and Compact Reinforced Composites are obtained by using higher quantities of superplasticizers and higher volumes of microsilica. DSP cement paste consists of a mixture of Portland cement and microsilica, densified with a superplasticizer. The mechanism of obtaining DSP cement pastes is shown in figure. Normally, the micro-silica/binder ratio varies from 0.15 to 0.25, water/binder ratio varies from 0.15-0.20. Recent works on the freeze-thaw durability (also in the presence of de-icing salts) of fibre – reinforced DSP confirm the excellent behaviour in the expected long service life. Concrete made with silica fume is more cohesive and therefore less prone to segregation than concrete without silica fume. Due to the very high surface area of the silica fume and usually very low water content by using high range water reducing admixtures in the DSP concrete, there will be very little bleeding of the concrete.

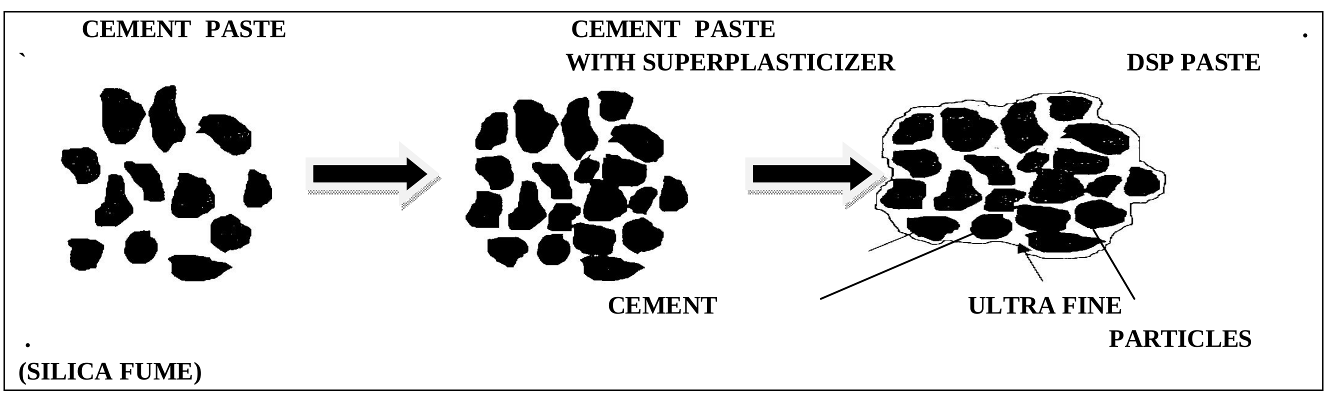

Figure: Mechanism for obtaining DSP paste

According to ACI Committee 201, durability is defined as the ability of concrete to resist weathering action, chemical attack, abrasion or any other process of deterioration. Durability of concrete is very important property of concrete which plays an important role in the service life of reinforced concrete structures. Durability can be enhanced by improving impermeability, resistance to chloride ion penetration, resistance to abrasion, acid and alkaline resistance. One of the ways to achieve this is by adding superplasticizers and supplementary cementitious materials. The addition of admixtures to the concrete mixtures increases the strength by pozzolanic action and filling the small voids which are created in cement particles. Durable concrete will retain its original quality and serviceability when exposed to environment.

The main reason for deterioration of concrete structures in the past is too much emphasis given to compressive strength of concrete rather than on the performance of concrete. The deterioration of RCC structures usually includes the transport of aggressive substances from the surrounding environment followed by physical and chemical actions in its internal structure. The transport of aggressive gases and liquids into the concrete depends on its permeation characteristics as the permeation of concrete decreases its durability performance, in terms of physio-chemical degradation, increases. High resistance to chloride penetration can be directly related low permeability that reduces the deterioration process in concrete structures; the resistance to chloride penetration is one of the simplest measures to determine the durability of concrete. The strength, durability and other characteristics of concrete depends on its ingredients, mix proportions, the method of compaction and curing. To enhance these properties attempts have been made to enhance the durability properties by introducing micro steel fibres in concrete. Sulphate attack, acid attack and corrosion of steel are common problems which are related to durability of concrete and therefore, in recent years more emphasis has been put on the durability issue of concrete.

II. LITERATURE REVIEW

Guerrini (2000) explained that advanced composites and the fundamental understanding of their behaviour is a rapidly expanding branch within the field of civil engineering materials. In particular, fiber-reinforced cement based materials had a great evolution in these years, so that they are more and more utilized in the building sector. Besides, large efforts have been made to develop high-performance cements and concretes showing further performance improvements. High-performance fiber-reinforced cement composites include, for example, materials such as SIFCON (Slurry Infiltrated Fiber concrete), fiber-reinforced DSP (Densified Small Particles), and fiber-reinforced MDF (Macro-Defect- Free) cements. Developments of these materials were possible due to: (a) the introduction of new reinforcement systems; (b) the development of high-performance cement-based matrices, which present greatly improved microstructural properties in terms of strength and durability; (c) the development of adequate processing techniques (including controlling chemical reactions) which allow us to obtain composite materia1s with surprising toughness properties.

Vinayagam (2012) formulates a simplified mix design procedure for HPC by combining BIS and ACI code methods of mix design and available literature on HPC. Based on the above procedure M80 and M100 mixes are arrived at. These HPC mixes are tested experimentally for compression, split tension, flexure and workability. The performances of the design mixes are very good and the results are reported are in this paper. The durability characteristics of HPC are under progress. He evaluated that the concrete mixes containing silica fume showed less value of pH as compared to concrete mix without silica fume. The optimum percentage of cement replacement by SF is 10% for achieving maximum compressive, split tensile and flexural strength and elastic modulus. The 7 days to 28 days compressive strength ratio of HPC is 0.75 -0.8. From the test results, it is observed that the percentage of saturated water absorption of the HPC mixes containing silica fume was lower when compared with that of HPC mixes without silica fume.

Reddy; et al (2012) reported that concrete has today very demanding performance requirements. The concrete durability crisis which started to attract public attention forced the engineers to think about the performance of concrete proper mix design and careful construction using the best available materials and technologies are necessary to achieve quality concrete structures. The February 2007 report issued by the International Panel on Climate Change (IPCC) has started in no uncertain terms that global warming is no longer an issue that has to be debated. According to the report, global warming is here, and drastic actions are needed for the long term sustainability of our environment. It is in this context that this paper discusses the role of supplementing cementing materials as partial replacement for cement in concrete in reducing green house gas emissions. In the last decade the use of Supplementary Cementing Materials (SCM) has become an integral part of high strength and high performance concrete mix design. The addition of SCM to concrete reduces the heat of hydration and extends the service life in structures by improving both long term durability and strength. One of the important changes is the introduction of micro technology for concrete with ultrafine and various other micro sized and fine cementitious materials. It is now possible to achieve excellent particle packing and thereby comply with the demands for performance in concrete both in fresh and in the hardened state. Some of the commonly used SCMs are Fly ash, Silica fume, Blast furnace slag & Metakaoline. This paper presents the results of the durability characteristic properties of M40 grade of concrete with Super Plasticizer. The durability was evaluated using Rapid Chloride Permeability Test.

Reddy; et al (2013) addressed that by using mixture-optimized, High Performance Concrete (HPC), significant reductions in CO2 contributions can be realized fur concrete construction-in conventional buildings, as well as in major projects. There is a growing awareness all over the world about the extensive damages being caused to the environment due to accumulation of waste material in the form of pulverized fuel ash from thermal power plants, silica fume, blast furnace slag etc. Worldwide efforts are being made to utilize these industrial wastes as an alternative material for both in building industry and fur road construction. The paper presents experimental studies conducted on HPC mix of M70 grade using mineral and chemical admixtures in various proportions. The main purpose of this investigation is to develop confidence among user agencies in India to use mineral and chemical admixtures in a desirable proportion in most of the construction works. Overall, the paper highlights the usage of admixtures to achieve high strength concrete mixes and from the experimental investigation it is clear that mineral admixtures contribute effectively a lot not only for achieving durability, also high strength.

Shah; et al (2013) reported that research is underway to increase the strength of concrete with the addition of chemical and mineral admixtures. The use of High Range Water Reducers (HRWR) has been increased many times in the last two decades. In this research the effect of two types of commercially available HRWR (Superplasticizers) are studied on the properties of concrete in fresh and hardened state. The strength development characteristics of concrete have been studied with the addition of the HRWR. The research has shown the selection of appropriate HRWR for the desired results of concrete in fresh and hardened state is a critical decision for the performance of the HRWR. The increase in compressive strength, flexural strength and cylinder tensile strength is relatively greater in the case of Polycarboxylates group (SP-2). Substantial reduction in water demand has been observed with use of SP. With Polycarboxylates group (SP-2), more than 40% strength (14MPa) can be obtained after 3 days which makes it very suitable for Very Early Strength (VES) Concrete. The 28 days compressive strength of SP added concrete with Polycarboxylates group (SP-2), gives High Strength Concrete (HSC) having 28 days compressive strength in excess of 75 MPa. Further research is required for cost optimization of the HRWR concrete.

Mehsana (2013) investigates the performance of concrete mixture in terms of Compressive strength, Chloride Attack tests, Sea water test and Accelerated corrosion test at age of 28 and 56 days. In addition find out the optimum dosage of Alccofine and fly ash from given mix proportion. Result show that concrete incorporating Alccofine and fly ash have higher compressive strength and Alccofine enhanced the durability of concretes and reduced the chloride diffusion. An exponential relationship between chloride permeability and compressive strength of concrete is exhibited. From the results obtained in this study, it is concluded that compressive strength achieved by using Alccofine (8%) + Fly Ash (20%) is 54.89Mpa and 72.97 Mpa at 28 and 56 days respectively. The minimum loss of weight and loss of compressive strength of concrete in Chloride Resistance test and Sea water test due to addition of Alccofine. Due to its more compactness and less permeability of concrete effect of Chloride Attack is reducing. This is converts leachable calcium hydroxide into insoluble non- leachable cementanious product. This pozzolanic action is responsible for impermeability of concrete. Secondly, the removal of calcium hydroxide reduces the susceptibility of concrete to attack by Chloride. It is possible to make M70 grade of concrete having RCPT value lower than 500 coulombs. It is observed that in Alccofine, RCPT value is less due to its pore filling and pore refining of particle. It is observed that in Accelerated Electrolytic Corrosion test weight loss of the steel in the Alccofine is less, so in Alccofine normal cover is sufficient to prevent steel from corrosion due to its pores filling and pore refining of particle.

Eldin; et al (2014) explained that it is possible to produce UHPFRC using available local materials that if they are carefully selected. Such concretes can be produced with ordinary Portland cement, silica fume, steel fibers, super plasticizer, fine sand and basalt with ratio as discussed before. From the experimental study and analytical analysis the following conclusions can be drawn: It is observed that compressive strength, modulus of elasticity, splitting tensile strength and flexural strength are on higher side for 3% steel fibers volume fraction as compared to that produced from 0%, 1% and 2% fibers volume fraction. All the strength properties are observed to be on higher side for aspect ratio of 50 as compared to those for aspect ratio 30. It is observed that compressive strength increases from 4.10% for (UHPFRC) with steel fiber volume fraction equals 1% comparing with (UHPC) without steel fibers to 18.0 % for (UHPFRC) with steel fiber volume fraction equals 3% comparing with (UHPC) without steel fibers. It is observed that modulus of elasticity increases from 6.0% for (UHPFRC) with steel fiber volume fraction equals 1% comparing with (UHPC) without steel fibers to 13.0 % for (UHPFRC) with steel fiber volume fraction equals 3% comparing with (UHPC) without steel fibers. It is observed that Poisson's Ratio had a little effect with steel fiber and can be used equal 0.20 for UHPFRC. It is observed that flexural strength increases from 15% for (UHPFRC) with steel fiber volume fraction equals 1% comparing with (UHPC) without steel fibers to 40.0 % for (UHPFRC) with steel fiber volume fraction equals 3% comparing with (UHPC) without steel fibers. It is observed that splitting tensile strength increases from 34% for (UHPFRC) with steel fiber volume fraction equals 1% comparing with (UHPC) without steel fibers to 67.0 % for (UHPFRC) with steel fiber.

Swar; et al (2015) reported that inadequate transverse reinforcement is considered as the main reason for the beam column joint shear failure observed during recent earthquakes. DSP matrix consists of cement and high content of micro-silica with low water to cement ratio while the aggregates are graded quartz sand. Steel fibres with high tensile yield strength of smaller diameter and short length in different fibre volume percentage and aspect ratio will be utilized to improve the performance by reducing the brittleness of matrix material. In the case of High Performance Densified Small Particles Concrete (HPDSPC), concrete is dense at the microstructure level, tensile strain would be much higher than that of conventional SFRC, SIFCON & SIMCON. Studies were conducted to investigate multiple cracking behavior of fibre reinforced small particle densified concrete containing high volume fraction (higher than 3%) of fine and short steel fibres. It was observed that by increasing fibres volume fraction, crack localization did not occur during multiple cracking. Various international codes of practices have been undergoing periodic revisions to incorporate the research findings into practice. The structural applications of HPDSPC, because of extremely high strength, will reduce dead load significantly as compared to normal weight concrete thereby offering substantial cost saving and by providing improved seismic response, longer spans, and thinner sections, less reinforcing steel and lower foundation cost.

Lekhya; et al (2015) reported that at present a large scale production of cement is useful for construction which causes global warming on one side and depletion of natural resources on other side. So that different pozzolanic materials like silica fume, Fly ash, are used in concrete as admixtures. The present study was to evaluate the mechanical and durability properties of M60 grade concrete by replacing 10%, 15% of silica fume and 10%, 20%, 30% of fly ash to cement. 0.5% steel hook fibers are used by volume fraction as admixture for all proportions of HSFRC. The main objective of the present work is to develop M60 grade concrete and to find the effective dosage of silica fume and fly ash. This paper presents the detailed experimental study on compressive strength at different ages i.e. 3 days, 7 days, 28 days, 56 days, 90 days and split tensile test and flexural strength at the age of 28 days. Durability tests like Rapid Chloride Permeability test and Water Absorption test were conducted on casted specimens. Based on the results obtained, she evaluated that by the addition of steel hook fibers in concrete leads to increase in compressive strength and makes concrete into ductile. In split tensile and flexural tests, it is noticed that crack width reduced due to the presence of steel fibers when compared with conventional specimen. When the cement is replaced with 10% silica fume and 20% fly ash gives the optimum compressive strength, split tensile strength and flexural strength. At 10% silica fume and 20% fly ash replacement to cement, compressive strength were increased up to 20.34% when compared with conventional concrete for 28 days. At 10% silica fume and 20% fly ash replacement to cement, split tensile strength were increased up to 60.85% when compared with conventional concrete for 28 days. At 10% silica fume and 20% fly ash replacement to cement, flexural strength were increased up to 38.74% when compared with conventional concrete for 28 days. The addition of silica fume and fly ash as replacement to cement results in its normal consistency and initial setting time increases with increase in percentage and final setting time decreases with increase in percentage.

Castro; et al (2016) reported that applying the particle packing concept in concrete mix design allowed the development of concretes with superior properties even when compared to other high performance concretes widely considered in researches focused on the design and implementation of special concretes in civil construction works. The water absorption coefficients of the new concrete (0.26), either by capillarity or by immersion, were much lower than the reference concrete (REF), indicating extremely low permeability for the material. The depth of chloride ions penetration also decreased after wetting and drying cycles in NaCl solution, constituting the new concrete (0.26) into a more efficient physical barrier for chloride ions penetration when compared with the high performance concrete studied (reference concrete – REF). Thus, the application of particle packing concept, in order to increase the density of the granular system in cementitious materials, shows as a key parameter for obtaining concrete with high mechanical and durability performance for the application in civil construction.

Krishna; et al (2016) addresses that concrete is the most versatile man-made construction material in the world and being extensively used in all types of construction activities. The strength, durability and other characteristics of concrete depend upon the properties of its ingredients, the mix proportions, the method of compaction and other controls during placing, compaction and curing. To enhance these properties, an attempt was made to study the durability property by introducing steel fibers in concrete. In this paper effect of steel fibers on the durability of concrete for M30 grade have been studied by varying percentage of steel fibers in concrete. Fiber dosages of 0.5%, 1%, and 1.5% by volume of concrete were used in the experimental study. Concrete cubes of size 150mm x 150mm x 150mm were tested for compressive strength, Resistance to Acid Attack for 28 days, 56 days curing period. Hooked end steel fibers were randomly dispersed in concrete. The results indicated that increasing the volume fraction of fiber showed decrease in compressive strength after subjected to acid attack. High volume SFRC was shown to be more vulnerable to acid attack.

Patel; et al (2016) reported that the scientists are mainly concentrating to develop the specialized concretes, to enhance the service life of the buildings and to provide satisfactory performance under aggressive environments. With the powerful dispersion capability and flexibility in molecular design, PC admixtures enable the production of concrete at low water–cement ratio with high workability. The durability problems of reinforced cement–concrete structures and the increasing use of concrete in exposure like sea water and acidic environment are creating new demands on the concrete material. This research work intended to develop M70 grade structural concrete using chemical admixture only. M70 grade structural concrete was casted, cured and tested by performing experiments like compression test (150-mmdiameter and 300-mm-height cylinders and on 150 mm x 150 mm x 150 mm size cubes), ultrasonic pulse velocity test and flexural strength test (150 mm x 150 mm x 700 mm size beams), split tensile test (150 mm diameter x 300 mm height cylinders), sorptivity test (100-mm-diameter, 50-mm-thickness specimen), sea water and acid attack test (150 mm x 150 mm x 150 mm size cubes) and accelerated corrosion test (100-mm-diameter and 200-mm-height cylinders). Results showed that M70 grade structural concrete possesses better durability properties and can be better improved by suitable addition of mineral admixture/ admixtures.

Patel; et al (2017) carried out research that concrete is considered to be the most widely used and versatile material of construction all over the world. Durability and strength are two most important criteria for the design of reinforced concrete structures. These are the two requirements for the long term performance of concrete structures. In chemical industry, concrete is affected by different chemical like chloride, sulphate, carbonation of concrete etc. In this work, the characteristic strength for M30 grade of concrete and for micro concrete is checked. The cubes after 28 days of curing in water is immersed in 5% H_2SO_4 and 5% HCL of the total volume of water; separately for 28 and 56 days to evaluate the decrement in the strength as compared to normal condition. It is concluded that result of M30 Grade of concrete and Micro concrete after 28 days of curing in chemical; Compressive strength of M30 grade of concrete is 32.7 N/mm^2 in HCL and 30.98 N/mm^2 in H_2SO_4. After 28 days of curing in chemical, Compressive strength of Micro concrete is 45.26 N/mm^2 in HCL and 41.94 N/mm^2 in H_2SO_4. After 56 days of curing in chemical, Compressive strength of M30 grade of concrete is 23.13 N/mm^2 in HCL and 20.8 N/mm^2 in H_2SO_4. After 56 days of curing in chemical, Compressive strength of Micro concrete is 36.14 N/mm^2 in HCL and 30.93 N/mm^2 in H_2SO_4. The compressive strength is reduced slightly more at immersing in H_2SO_4 as compared to HCL.

Singh; et al (2017) reported that the experiment on silica was done which stated that no strength is lost in silica-fume concretes. The experiment comprises four levels of silica-fume at the rate of 0%, 5.5%, 8.0%, 9.5% and 11.0% which results high strength concrete. The amount of water required for normal consistency of cementations material increases with the increase of' micro-silica percentage. Initial and final setting time of cementations material decrease with increase of micro-silica percentage. With the partial replacement of cement by micro-silica, it is found that the strength of cementitious material decreases with increase in content of micro-silica upto 28 days. However this difference reduces with age. The expansion of cementitious material slightly increases with addition of 9.5% and 11.0% micro-silica. However it needs further investigation. The workability of concrete decreases with increase of the content of micro-silica. The compressive strength of concrete increases with increase of micro-silica, but after certain percentage the gain in strength starts decreasing. The 28 days, 60 days and 90 days strength of concrete are maximum at 9.5% micro-silica content, whereas 7 days strength is maximum at 8.0% micro-silica content. The flexural strength of concrete with 8.0% micro-silica at 28 days and 90 days gives the maximum strength. Water absorption decreases with increase of micro-silica in concrete. The colour of groundmass changes with addition of micro-silica and it become dark in colour and confirm the increase in binding property of cementitious material. Reaction rim develops in case of cement with micro-silica. Binding material is more uniform in case of concrete with micro-silica than the concrete without micro-silica. The addition of micro-silica gives high strength, more durable and uniformly distributed binders in concrete.

Rao; et al studied the durability properties of steel fibre reinforced Metakaolin blended concrete, when it is exposed to certain types of chemicals. Metakaolin is a thermally structured, ultra fine pozzolona, which replaces industrial byproducts such as silica fume, fly ash, etc., An experimental investigation has been carried out to evaluate the durability in terms of Chemical Resistance and weight loss of steel fibre reinforced concrete with and without Metakaolin for concrete of M20 grade. In this investigation an attempt is made with chemicals like H_2SO_4 and HCl. Crimped Steel fibres with 60 as aspect ratio at 0, 0.5%, 1.0% and 1.5% of volume of concrete are used.The results show that the percentage of weight loss is reduced and compressive strength is increased in the case of Steel fibre reinforced concrete and concrete containing 10% Metakaolin replaced concrete when compared to the normal concrete. Also the less percentage weight loss is noticed in the case of HCl and severe in the case of H_2SO_4.

III.GAPS IDENTIFIED FROM THE LITERATURE

A. Studies has been conducted on conventional fibre reinforced concrete by using maximum fibre volume fraction of about 2%. The effect of higher fibre volume fraction has not been studied.
B. The effect of steel fibres on the durability properties of high performance densified small particle concrete has not been studied and only few investigators have studied the effect of steel fibres on HPDSPC.
C. Limited work has been reported on densified small particle concrete with or without steel fibres. Hence, it is necessary to design and develop HPDSPC.
D. Effect of microsilica and HRWR on the strength and durability properties of concrete has been reported very less.

E. In most of studies, fibres used by investigators are straight or hooked steel fibres.

Studies have shown that it is possible to produce HPFRC using available local materials such as OPC, silica fume, steel fibres, superplasticizer, fine sand etc if they are carefully selected.

IV. CONCLUSION

Author & paper name	Conclusion
Vinayagam.P;"Experimental Investigation on High Performance Concrete Using Silica Fume and Superplasticizer"	• Optimum %age of cement replacement by SF for achieving maximum compressive strength, split tensile & flexural strength & elastic modulus. • 7 days to 28 days compressive strength ratio of HPC is 0.75-0.8
Reddy M.Vijaya Sekhar, Reddy LV. Ramana, Murthy N.Krishna; "Durability of Standard Concrete Incorporating Supplementry Cementing Materials Using Rapid Chloride Permeability Test"	• M40 grade of concrete as the w/c ratio of 0.518 is insufficient to provide the good workability, hence superplasticizer is necessary. • RCPT resilts reveals that the total charge passed in coulombs is low for replacement of 10% SF. But the total charge passed in Coulombs for conventional concrete is slightly higher than the concrete replaced with SCMs.
Reddy M.Vijaya Sekhar, Reddy LV. Ramana, Murthy N.Krishna; "Predicting the Strength Properties of High Performance Concrete using Mineral and Chemical Admixtures"	• • Maximum %age loss in weight and %ge reduction in compressive strength due to acids for M70 concrete are 2.23%, 15.14% with replacement of 20% fly ash & 10% metakaoline and the minimum %age loss in weight & strength are 1.4%, 15.5% with replacement of 15% fly ash & 10% SF, due to alkalinity the maximum %age loss in weight & %age reduction in compressive strength are 3.30%, 19.20% with replacement of 20% fly ash & 10% metakaoline and the minimum %age loss in weight & strength are 2.10%, 17.20% with replacement of 20% fly ash and 10% SF. • Due to sulphates, the maximum reduction in weight & compressive strength is 11.70% with replacement of 20% fly ash & 10% SF and the minimum %age reduction in strength is 11.65% with 20% fly ash & 10% metakaoline.
Mehsana; "Study on Durability of High Performance Concrete With Alcofine and Fly Ash"	• Compressive strength achieved by using alccofine (8%) + fly ash (20%) is 54.89 MPa & 72.97 MPa at 28 & 56 days respectively. • The minimum loss of weight & loss of compressive strength in RCPT & sea water test due to addition of alccofine due to its more compactness & lesser permeability.
Eldin Hamdy K.Shehab, Mohamed Heba A, Khater Mahmoud, Ahmed Sayed; " Mechanical Properties of Ultra-High Performance Fiber Reinforced Concrete"	• Compressive strength, modulus of elasticity, split tensile strength and flexural strength are higher for 3% steel fibres volume fraction as compared to that produced from 0%, 1% & 2% fibres fraction.
Patel Hiren, Jain Piyush, Engineer Kaizad and Kajalwala Mohammed Vasim M; "The Experimental Investigation of Durability Test on Concrete	• The results of M30 grade of concrete & micro concrete after 28 dayds of curing in chemical; compressive strength of M30 concrete is 32.7 N/mm^2 ibn HCL & 30.98 N/mm^2 in H_2SO_4 and of micro concrete is 45.26 N/mm^2 in HCL & 41.94 N/mm^2 in H_2SO_4. • After 56 days, compressive strength of M30 grade concrete is 23.13

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CUBES	N/MM^2 IN HCL & 20.8 N/MM^2 IN H_2SO_4 AND OF MICRO CONCRETE IS 36.14 N/MM^2 IN HCL & 30.93 N/MM^2 IN H_2SO_4.
RAO P. SRINIVASA, SRAVANA, RAHIM Z. ABDUL AND SEKHAR T. SESHADRI; "DURABILITY STUDIES ON STEEL FIBRE REINFORCED METAKAOLIN BLENDED CONCRETE"	• THE %AGE LOSS OF COMPRESSIVE STRENGTH & WEIGHT IN 5% H_2SO_4 SOLUTION IS HIGHER THAN 5% HCL SOLUTION. • THE %AGE LOSS OF COMPRESSIVE STRENGTH AND WEIGHT REDUCTION ARE INCREASING IN WITH THE TIME OF EXPOSURE TO ACID ATTACK. • THE METAKAOLINE CONCRETE SHOWED MORE RESISTANCE TO ACID ATTACK WHEN COMPARED TO OPCC MIX. • DURABILITY STUDIES REVEALED THAT 10% REPLACEMENT OF CEMENT WITH METAKAOLINE ALONG WITH CRIMPED STEEL FIBRES WITH HIGHER CONTENT IS MORE DURABLE WHEN COMPARED TO NORMAL CONCRETE AFTER EXPOSUE TO THE HCL & H_2SO_4 SOLUTION.

From the literature review it is clear that, densified small particles based high performance concrete have the properties that have the potential to change the scenario of construction activities. It was seen that it offers enhanced properties and efficient performance when compared to conventional reinforced cement concrete. From the literature research it is proposed that to improve strength and durability properties of structural concrete cementitious materials like silica fume, fly ash, etc have to be added in making concrete because the use of such materials resulted in reduction of porosity, improvement in microstructure and increase in compressive and flexural strength. Based on the results of the experimental investigations of literature, it is concluded that steel fibres were found to be effective to acid resistance and in high performance concrete mix design water cement ratio adopted is low, super plasticizer are necessary to maintain required workability. It is observed that the structural applications of High performance densified small particles based concrete, because of its extremely high strength, will reduce dead load significantly as compared to normal weight concrete thereby offering substantial cost saving by providing longer spans, thinner sections, less reinforcing steel and lower foundation cost.

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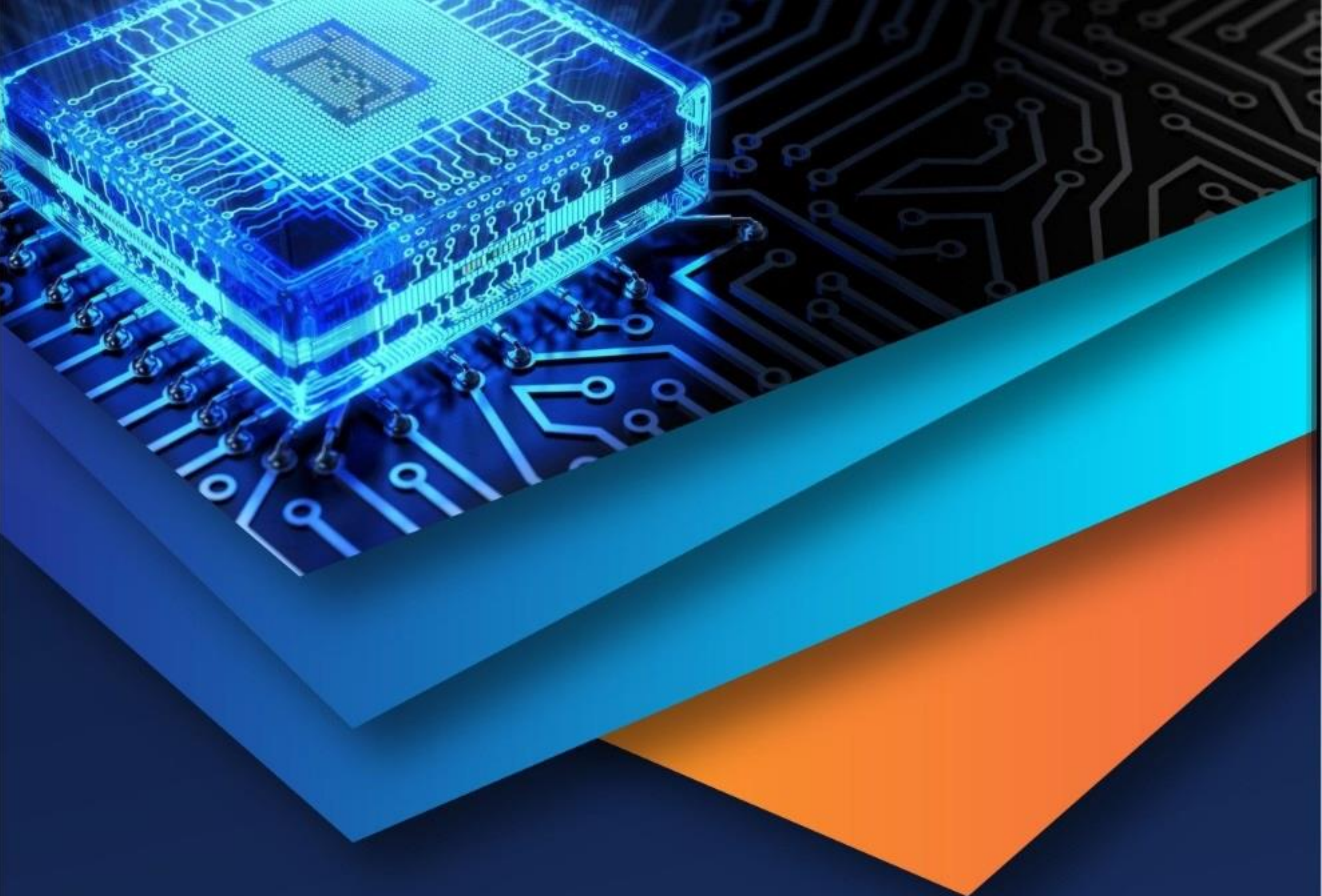

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