A Study on The Influence of Nano Silica on The Strength Parameters of Rubberised Concrete

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Abstract- *Disposal of different waste materials is now becoming a major problem to the environmentalists. The situation of environmental pollution has become alarming and it is the foremost task to think regarding the disposal of waste materials which are generated along with the main product before finalizing any project. The generation, handling and disposal of solid wastes are now a grave concern in the country. We're living in a world of cars, It is estimated that approximately 290 million old tires are disposed of every year and almost 20% of them are illegally dumped in landfills. In these circumstances, there is a need to explore the possibility of utilization of these waste materials in bulk. The use of nano silica as an supplementary cementitious material is one of the prominent method of reducing the pollution problems and conservation of resources, since it reduces the use of cement and also use of nano materials into the concrete can lead to strength improvements and life of concrete. In addition, nano silica is used in combination with crumb rubber to make concrete structures more durable. The present experimental study has been taken up to make use of the industrial wastes in the best possible way. The use of alternatives for the coarse aggregate is now becoming importance due to scarcity of natural aggregate and high cost of artificial aggregate. In this study crumb rubber has been used as a replacement for fine aggregate and nano silica as the partial replacement of cement. M30 Grade of concrete is considered in this investigation by replacing the cement with Nano silica by volume fraction at 0%, 10%, 20%, 30%, 40% and 50% and replacing fine aggregate with crumb rubber by 20%, 40%, 60%, 80% and 100%. Properties of rubberized concrete such as compressive strength, split tensile strength and flexure strength are determined and compared with the normal mix.*

Keywords- Carbon Dioxide (CO2) gas emissions, Nano silica, crumb rubber, compressive, flexural, split tensile strength test.

I. INTRODUCTION

Disposal of waste tyres has become an environmental issue now a days. With the increasing demand of vehicles, use of rubber tyre is increasing. Consequently, disposal of waste tyres is becoming a major environmental issue. There is lot of requirements of natural aggregates in construction industry. Due to huge demands of natural aggregates in construction industry, lot of environmental problem are being faced worldwide. Hence, there is need to protect the environment by using the waste material like rubber tyre, silica fumes, fly ash etc. as an alternate construction material.

Cement is the most important ingredient of the concrete which produces carbon dioxide which is May harmful. So it is a main concern to reduce the usage of cement. Creation of cement isn't just making ecological contamination moreover that the creation of cement requires tremendous measure of crude materials. Because of the overabundance utilization of crude materials they may confront a risk of getting removed in the close by future.

Concrete is the most widely used man-made construction materials in the world. Slightly more than a ton of concrete is produced each year for every human being on the planet. Fundamentally, concrete is economical, strong, and durable. Although concrete technology across the industry continues to rise to the demands of a changing market place. The construction industry recognizes that considerable improvements are essential in productivity, product performance, energy efficiency and environmental performance. The industry will need to face and overcome a number of institutional competitive and technical challenges. One of the major challenges with the environmental awareness and scarcity of space for land-filling is the wastes/byproducts utilization as an alternative to disposal. Throughout the industrial sector, including the concrete industry, the cost of environmental compliance is high. Use of industrial by-products such as foundry sand, fly ash, bottom ash and slag can result in significant improvements in overall industry energy efficiency and environmental performance.

The use of scrap tyre rubber from vehicles as partial aggregate in concrete has great potential to positively affect the properties of concrete in a wide spectrum. Concrete is one of the most popular construction materials. Due to this fact, the construction industry is always trying to increase its uses and applications and improving its properties, while reducing

cost. These limitations such as low tensile strength, low ductility and low energy absorption are constantly being tested with hopes of improvement by the introduction of new admixtures and aggregates used in the mix.

One such is the introduction of rubber is introduced to the concrete mix. It is a perfect way to modify the properties of concrete and scrap rubber tyres at the same time. The objective of this research is to test the properties of concrete when rubber chips from automotive tyres is used as a partial aggregate.

OBJECTIVES OF THE STUDY

Therefore in this investigation, it is attempted to conduct a study on a properties of concrete using nano silica and crumb rubber. In this research, M30 grade concrete mix is designed and used in casting specimens (cubes, cylinders and beams). Also, compressive strength, split tensile strength, and flexural strength tests are conducted. The test results are detailed and reported in chapter 5. The primary objectives of the primary research work are

- To study the compressive, split tensile and flexural behaviour of silica fume and crumb rubber concrete and to compare the same with conventional concrete
- To ascertain the proper percentage required for the manufacturing of concrete with optimum silica fume and crumb rubber variation to improve its hardened properties.
- To faster the compressive strength without sacrificing the ductility, a strategy adopted is to add nano silica and crumb rubber as replacement in concrete
- An extensive research programme was undertaken to evaluate the enhanced properties of replaced materials and more specifically to verify the strength of concrete after being partially replaced by nano silica and crumb rubber.
- To find the optimum percentage of Nano silica & Crumb rubber with cement and fine aggregate respectively at which maximum strength is obtained.
- Improvement of concrete strength properties reduce landfill problem.

II. REVIEW OF LITERATURE

In the present construction world, the solid waste is increasing day by day from the demolitions of constructions. There are some researchers are also going on solid waste from construction to reuse them again in the construction to reduce the solid waste and to preserve the natural basic aggregates. These researches promotes to use the recycled aggregates in the concrete mix and they got good result when adding some extent percentages of recycled aggregates in place of natural coarse aggregate.

This research is supported with the related reading material previous research about the silica fume and crumb rubbberr material which had been done as the references to describe more and explain the characteristic and application of waste ash as partial replacement in the concrete production

- According to MalekK.Batayneh, Iqbal Marie, Ibrahim Asi (2007) ,in their research focused on using crumb tires as a replacement for a percentage of the local fine aggregates used in the concrete mixes .. The mechanical strength values of the concrete have decreased compare to control mix. So it was recommended not to use in high strength structures.
- Khalid B.Najim, Matthew R.Hall (2010) in his study, the mechanical and dynamic properties of Self-Compacting Rubberised Concrete were experimentally investigated. scraptyres crumb rubber was used as a partial replacement for Coarse Aggregate (CA) ,Fine Aggregate (FA),and combined Fine and Coarse Aggregate (FCA) at 5, 10, and 15 wt. The Dynamic Modulus and Ultrasonic Pulse Velocity decreased as the proportion of rubber substitution was increased.
- Eshmaiel, Ganjian,Morteza,Ali Akbar (2008) showed the performance of concrete mixtures incorporating 5%, 7.5% and 10% of discarded tyre rubberas aggregate and cement replacements was investigated.. In the first set, different percentages by weight of chipped rubber were replaced for coarse aggregates and in the second set crumb rubber as a filler was replaced for cement. The mechanical tests included compressive strength, tensile strength; flexural strength and modulus of elasticity are conducted. The durability tests included permeability and water absorption.
- According to PitiSukontasukkul (2008), the thermal and sound properties of crumb rubber concrete panel were investigated. The rubber from used tires, produced in a local recycling plant, was used to replace fine aggregate at ratios of 10%, 20% and 30%. Properties such as thermal resistivity, heat transfer thermal conductivity, sound absorption, conductance value at different frequency and noise reduction were investigated.
- Zheng, X. Sharon Huo, Y. Yuan (2007); For vibration reduction damping ratio is one of the main parameter.. Simply supported beams were tested

using a free vibration method to determine the relationships between damping ratio in rubberized concrete. Elastic wave method and beam element method to test the dynamic modulus for rubberized concrete.

- Piti Sukontasukkul, Chalermphol Chaikaew (2005), showed the use of rubber to replace coarse and fine aggregates by 10% &20%in concrete pedestrian block. The rubber block also performed quite well in both skid and abrasion resistance tests. Production process was found to be economical.
- RafatSiddique and TarunR.Naik (2004) present an overview of some of the research regarding the use of scrap-tires in Portland cement concrete. Sodium hydroxide used as a pre-treatment work which increases adhesion between cement paste and rubber particle which in turn increases compressive strength. The paper details the likely uses of rubberized concrete in vibration damping foundations, as sound insulator, thermal insulator. It also discusses the toughness, post crack strength, workability& density.
- Ren-JwoTsay, Huynh Nguyen, Nhat L-Am(2007) investigated rubberized concrete slab behavior under dynamic loading. They found the ductility response for more rubber replacement. The increased ratio is more than 80% than normal concrete RC slab. They found stiffness and energy absorbing capacities in the test &suggested method to decrease the dynamic vibration response on the RC slab.
- Eshmaiel Ganjian, Morteza Khorami, Ali Akbar Maghsoudi(2008) investigated different percentages by chipped rubber were replaced for coarse aggregates. The mechanical tests included compressive strength, tensile strength, flexural strength and modulus of elasticity. The durability tests included permeability and water absorption.

III. MATERIALS AND METHODS

The experimental investigation work is started with various tests on the constituent materials. The constituent materials are given below.

1. Cement
2. Fine aggregate
3. Coarse aggregate
4. Water
5. Silica fume
6. Crumb rubber

Cement

Ordinary Portland Cement (OPC) was used in the experimental work which is conforming to I.S 4031-1988.The O.P.C is classified into three grades, those are 33grade, 43grade and 53 grade, depending upon the strength of the cement in this experiment 43grade cement is used.

Fine Aggregate

Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970.

Coarse Aggregate

The crushed aggregates used were of 20mm nominal maximum size.Aggregate most of which is retained on 4.75-mmIS Sieve and containing only so much finer material as is permitted for the various types described in this standard.

Nano Silica

Nano silica or silica fume, also known as micro silica is an amorphous (noncrystalline) polymorph of silicon dioxide. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production. It is extremely fine with particles size less than 1 micron and with an average diameter of about 0.1 microns, about 100 times smaller than average cement particles. Its behaviour is related to the high content of amorphous silica (> 90%).The reduction of high-purity quartz to silicon at temperatures up to 2,000^{o}C produces SiO_2 vapours, which oxidizes and condenses in the low temperature zone to tiny particles consisting of non-crystalline silica.

Silica Fume (SF) and fly ash individually or in combination are indispensable in production of high strength concrete for practical application. The use of silica fume as a pozzolana has increased worldwide attention over the recent years because when properly used it as certain percent, it can enhance various properties of concrete both in the fresh as well as in hardened states like cohesiveness, strength, permeability and durability.

Crumb rubber

Crumb rubber with the particle size (2–4 mm) specially used to pave a rubber runway was selected as the replacement material, as shown in Figure. The specific gravity was 1.2. Corresponding studies indicated that the concrete containing 2–4 mm crumb rubber had superior properties. The geometric configuration of crumb rubber was an uneven prism, which could enhance the bonding between rubber

particles and cement paste. Hardness and elasticity were also better than general rubber. Modifiers for the pretreatment of crumb rubber, including emulsion, ethoxyline resin, synthetic resin, amino-acrylate (contact glue), chloroprene adhesive and unsaturated resins (marble glue), were commonly used in decoration and construction engineering.

IV. MIX DESIGN

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. M30 grade of concrete is used for the present study.

V. TESTS ON FRESH CONCRETE

WORKABILITY OF CONCRETE

The vertical settlement of unsupported fresh concrete, flowing to the sides and sinking in height is known as slump. Slump is a measure indicating the consistency or workability of cement concrete. It gives an idea of water content needed for concrete to be used for different works. A concrete is said to be workable if it can be easily mixed, placed, compacted and finished. A workable concrete should not show any segregation or bleeding.

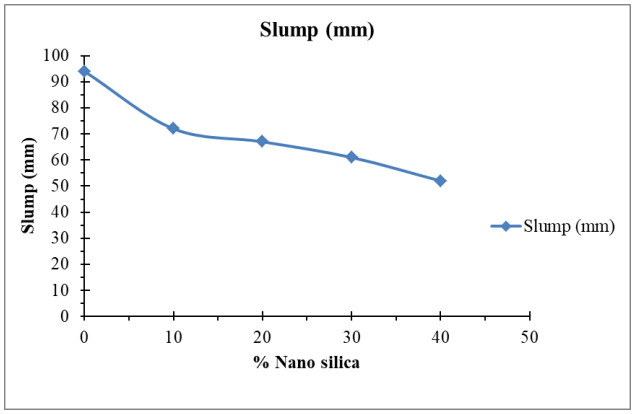

Fig 5.1 Slump values of M30 grade of concrete with % replacement of Nano silica

VI. TESTS ON HARDENED CONCRETE

6.1 COMPRESSIVE STRENGTH TEST

Concrete specimen cubes are used to determine compressive strength of concrete and were tested as per IS 516:1959. The compressive strength is usually obtained experimentally by means of a compressive test. 150x150x150 mm size mould is used for the casting of compressive test specimen, after the 24 hours of casting of specimens remove the cubes from moulds and the cubes are placed in curing tank up to one day before the testing. During testing on a UTM with a capacity of 300T, the load is delivered to the cubes at a continuous rate of 140kg/sq.cm/minute. The specimen is placed in the UTM with the cast faces facing the opposite to the observer. The specimen's ultimate load is defined as the load at which it fails. At the ages of seven, fourteen and twenty-eight days, this test was conducted. The average load of three specimens is used to calculate strength for each mix.

Cube compressive strength = load/area

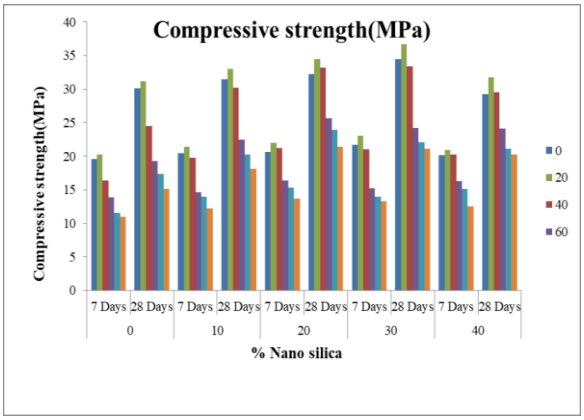

Fig 6.1shows the compressive strength of concrete for various replacements of nano silica and crumb rubber

6.2 SPLIT TENSILE STRENGTH

The cylinder specimen is of the size 150 mm diameters and 300mm height was cast to determine the split tensile strength of concrete. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of compression testing machine and the load is applied until failure of cylinder, along its longitudinal direction. The cylinder specimens are tested at 7 days and 28 days. The average of three specimens was reported as the split tensile strength provided the individual variation is not more than 15% of average value.

Split tensile strength $=2P/\pi DL$

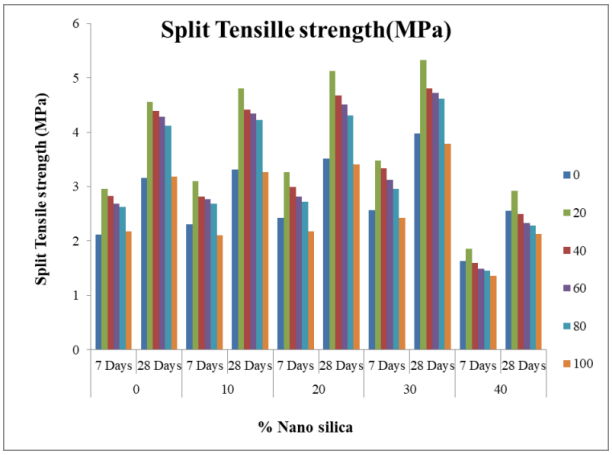

Fig 6.2 shows the split tensile strength of concrete for various replacements of nano silica and crumb rubber

6.3 FLEXURAL STRENGTH

The size of specimens 100 mm x 100 mm x 500 mm was used and the specimens were cured in water. Concrete specimen beams are used to determine flexural strength of concrete and were tested as per as per IS 516 (1959).

6.3.1 Effect of nano silica and crumb rubber on flexural strength of concrete

After 7 and 28 days curing, prismatic specimens are placed on flexural testing machine having a maximum of 100 KN and a constant rate of loading of 40 kg/m2 per minute is applied on the test specimen by placing the specimen in such a way that the two point loading should be placed at a distance of 13.3 cm from both the ends. Ultimate load at which the prismatic specimen fails is noted down from dial gauge reading.

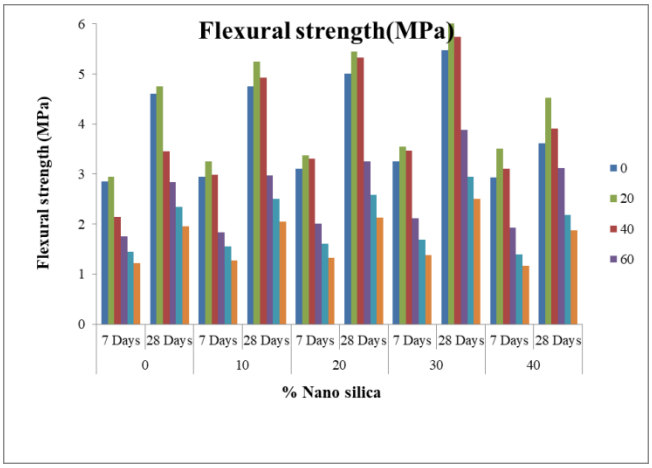

Fig 6.3 shows the flexural strength of concrete for various replacements of nano silica and crumb rubber

The Flexural strength of the concrete mix for M-30 with partial replacement of cement by Nano silica and fine aggregate with crumb rubber respectively showed higher Strength against Flexure after 7 and 28 days. The 7 days Flexural strength of mix with 30% partial replacement of Nano silica and 20% partial replacement of crumb rubber showed higher strength compared to other mixes.

VII. CONCLUSIONS

The purpose of this study was to investigate the use of Nano silica and crumb rubber in concrete as a waste material by assessing their effect in concrete specimens cured under normal water. The following conclusions are made based on the laboratory experiments carried out in this investigation.

- It has been observed that by the incorporation of nano silica and crumb rubber as partial replacement to cement and fine aggregates respectively in fresh and plain concrete decreases workability when compared to the workability with reference to concrete made without Nano silica.
- The significant improvements in strength characteristics were observed with Nano silica in concrete. It is evident from the present investigation that the addition Nano silica to concrete improves compressive strength of the mix.
- The strength of the M30 grade concrete decreases with the increment in the amount of crumb rubber used in the concrete. However, the optimal results were observed with the 20% crumb rubber sample by attaining approximate 80% of the standard strength of M30.
- Nano silica concrete performed better when compared to ordinary concrete at 30% replacement and will be the optimum nano silica mix.
- The optimum strength was observed at 30% of nano silica and 20% crumb rubber content for all type of strengths. The highest compressive strength obtained was 34.43 (30% replacement) and on further additions of nano silica and crumb rubber caused reduction in strength due to an increase of free water content in the mix.
- This increase in strength can be a result of good pozzolanic properties of nano silica or fineness of the particles.
- Nearly there is an increase of 62% in tensile strength for mix 30% nano silica+ 20% crumb rubber when compared to the nominal cement concrete.
- It was observed that the flexural strength (at 28 days) increased about 35.43% when compared with nominal cement concrete.

- Compressive, tensile and flexural strength values dropped for mix beyond 30% nano silica and 20% crumb rubber. Nevertheless, they are almost similar to the base mix.
- In all mixes there is acceleration in the increase in the later stages (i.e., after 14 days) as the pozzolanic activity gains momentum with the age of concrete.
- Thus nano silica and crumb rubber is a good alternative for replacing cement and fine aggregate by incorporating good mechanical properties into the blended cement.
- The mix with cement replacement of 30% Nano silica and fine aggregate replacement of 20% crumb rubber shows good strength properties like compressive and tensile and flexural strength.
- In this research it has been proposed the use of nano silica and crumb rubber in concrete to increase the strength of concrete. Finally it can be summarized that the nano silica and crumb rubber shown promising influence on the strength properties of concrete, thereby giving a two-fold advantage in improving the strength characteristics of concrete and also solving a problem of waste disposal.

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