IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 6.252
Volume 2, Issue 6, June 2022

A Review on Flexural Behaviour of RC Beam with Nano-Silica

Vasanth G[1] and Ramadevi K[2]
PG Student, Department of Civil Engineering[1]
Professor, Department of Civil Engineering[2]
Kumaraguru College of Technology Coimbatore, Tamil Nadu, India
vasanth.20mse@kct.ac.in[1] and ramadevi.k.ce@kct.ac.in[2]

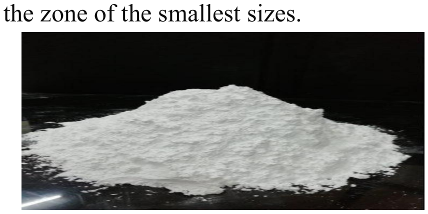
Abstract: *The partial replacement of cement with nanomaterials such as nano-silica(NS) particles in concrete improves its strength and other properties. In this study, the effect of NS as a partial replacement of cement for concrete mixes and concrete beams was examined. The studied response characteristics of reinforced concrete beams included compressive strength, failure mechanisms, load-carrying capacity, and load-deflection behavior. The results showed that compressive strength increased with an increase in NS content up to 2.0% replacement of cement weight. The rate of increase in compressive strength was no longer significant beyond 2.0% replacement, indeed there was a slight decrease in compressive strength for NS content of 3.0%. The effect of increased NS content on the flexural behavior of beams was also studied. Increased NS content led to increases in the first-cracking and ultimate loads and reductions in the deflection at cracking and ultimate load levels.*

Keywords: Nano-Silica, Steel Fibers, Mechanical Properties and Durability.

I. INTRODUCTION

Cement is characterized by small particle size. It thus not only works as a filler material in concrete but has a vital role in bonding all the structural elements of concrete. However, cement is a significant environmental pollutant due to its production process, which is energy-intensiveand emits large amounts of carbon dioxide. To address this issue and improve the performance of cement, different types of binding materials are currently being used. One of these materials is the amorphous powder nano-silica (NS). NS is an effective highly pozzolanic material with a small particle size and high surface area. The experimental study on the behavior of reinforced concrete (RC) beams containing micro silica (10%) and NS (0%, 0.5%, 1.0% or 1.5%). The concrete mixes had a fixed water/binder ratio of 0.53. The development of mechanical strength indicated that a cement replacement of10% micro silica and 0.5% NS was the optimal proportion. The current study evaluated the behaviour of RC beams containing different NS ratios (0%,1.0%, 2.0% and 3.0% by weight of cement (bwoc)). The study investigated the effect of experimental variables on the response characteristics of the beams and their related failure mechanisms, load-carrying capacity, and load-deflection behavior

Nano-Silica: Nano-silica, also called quartz dust or silica dust, is a material that, like SF, is characterized by **its high SiO_2 percentage, over 99%**. The use of nano-silica (crystalline SiO_2) reduces the volume of cement and completes the grading curve of the aggregate mix in the zone of the smallest sizes.



II. LITERATURE SURVEY

[1] B. Sabharinadh, et.al (2015)

"Flexural Behavior of High-Performance Reinforced Concrete Beams" High-performance concrete (HPC) is in the upper hand in all aspects of strength and mechanical properties than those over conventional concrete. The addition of silica fume in conventional concrete makes it more capable to perform. HPC has been primarily used in bridges, tunnels, nuclear power plants, and tall buildings for its strength, durability, and high modulus of elasticity. Beyond 30 to 40% replacement of GGBS, compressive strength and split tensile were decreased. There was a decrease in workability (slump) as the replacement level increased. The addition of silica fume is improving the bond strength of concrete and decreases its permeability of concrete. From the test results of cubes and cylinders, the percentage of water absorption of the HPC mixes containing silica fume was lower, when compared to controlled mixes (without silica fume).

[2] Gang Chen,et.al[2021]

"Study on flexural performance of concrete beam reinforced by steel fiber and nano-silica materials", the main objective of this paper is to investigate the flexural performance of beams through combined experimental and theoretical studies. The load vs. deflection curves of beams during the whole loading process were analyzed in detail. The failure mode was discussed in detail, and the specimens all behaved in a very ductile manner. Furthermore, the test results indicated that bending cracks and concrete crushing were formed in the compression zone of all specimens. With the increase in concrete strength and the volume fraction of steel fiber, both the cracking load and ultimate load of beams increased. Flexural specimens are considered to experience three stages until the failure-loading stage, cracking stage, Yield stage of steel bars, bending cracks, and concrete crushing are formed in the compression zone. Increasing the amount of nano-silica can reduce the crack spacing and increase the number of cracks.

[3] K. Kowsari, et.al (2015)

"Investigation of Mechanical and Durability Properties of Concrete Influenced by Hybrid Nano Silica and Micro Zeolite", concrete is the most widely used construction material in the world, cement is major component of concrete. Consuming energy in cement industry is very high and CO2 emissions generated during the production of Portland cement has serious environmental threatens. The optimized mixture for achieving high quality of durability is incorporation of 2% nano silica and 8% micro zeolite. The concrete contained 8% micro zeolite has high resistance for penetration chloride ion. The compressive strengths of concretes containing additives were lower than the concrete without supplementary replacement at all ages. However, the percentages of reduction were lower for high ageing times, which can be attributed to lump in transition zone. Decrease rate of tensile strength is less than compressive strength in all ages. Also effectiveness of additives on strengths for mixtures with 0.45 W/C is less than 0.4 W/C, probably because of the lack of water, strength have been decreased.

[4] Nanthakumar N , et.al (2017)

"Behaviour of Reinforced Concrete Beam Containing Micro Silica and Nano Silica" Silica fume is one of the most popular pozzolanas, whose addition to concrete mixtures results in lower porosity, and permeability and bleeding. The aim of this study is to examine the mechanical properties of cement concrete with and without silica fume and Nano silica particles. The work focused on concrete mixes having a fixed water/binder ratio of 0.53. The percentages of silica fume that replaced cement in this research were: 10% and nano-silica added were 0%, 0.5%, 1.0%, and 1.5%. Development of mechanical strength indicates that replacement of 10 % micro silica and addition of 0.5% of nano-silica as an optimal proportion.

[5] Mahmoud A. El-Mandouh, et.al (2022)

"Shear Strength of Nano Silica High-Strength Reinforced Concrete Beams" In this study, the shear strength of sixteen full-scale over-reinforced concrete beams with and without nano silica (NS), constructed from high-strength concrete (HSC), was investigated both experimentally and analytically. Nano silica was used as a partial replacement for Portland cement. According to the NS ratio, the tested beams were divided into four groups: 0%, 1%, 2%, and 3%. Shear span to effective depth (a/d) ratios of 1.5 and 2.5 were used in each group, and two different stirrups ratios (ρv) were employed

IJARSCT

ISSN (Online) 2581-9429

IJARSCT
Impact Factor: 6.252

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Volume 2, Issue 6, June 2022

as 0% and 0.38%. n. For specimens without stirrups and with an (a/d) of 1.5, raising NS from 0% to 1%, 2%, and 3% increased the ultimate load by 13%, 30%, and 39%, respectively, whereas for specimens with an (a/d) of 2.5, the ultimate load increased with approximately the same increase as that in beams with an (a/d) of 1.5 due to using NS. The finite element program ABAQUS may be successfully used to predict the shear strength of NS concrete beams.

[6] Eisa, Ahmed S, et.al (2021)

"Improving the flexural toughness behavior of R.C beams using micro/nano-silica and steel fibers" Experimental investigation has been conducted to study the effect of using Micro/Nano Silica in presence of steel fibers on improving the static response of reinforced concrete beams. Twenty-one mixtures were prepared with micro silica (MS), Nano Silica (NS), and steel fibers (SFs) at different percentages. Cement was replaced by 10% and 15% of Micro silica and 1%, 2%, and 3% of Nano silica in the presence of steel fibers at different volume fractions of 0%, 1%, and 2%. The first stage was to investigate the mechanical properties of the prepared mixtures. The second stage was to study the static behavior of R.C beams, using the designed concrete mixtures, under a four-point flexural test. The results showed that replacing cement with (10% MS and 1% NS) produces the optimum mix with a significant improvement in the mechanical properties and the response of R.C beams under static loads. In addition, incorporating steel fibers at different volume fractions has a considerable effect on the flexural toughness of concrete mixes.

[7] R. Sakthivel, et.al (2017)

"Behaviour of Nano Silica Powder and Hybrid Fiber Reinforced Concrete Beams with Cyclic Loading" the various properties of concrete are influence by nano-silica is obtained by replacing the cement with various percentages of nano-silica and with natural hybrid fibres. Nano-Silica powder is used for a partial replacement of cement, the range of 2%, 2.5%, 3%, 3.5%, 4% and hybrid fibre range of 0.5%, 1%, 1.5%, 2% and 2.5% for M25 grade of concrete Mix. Specimens are casted by using Nano-Silica concrete and NHFRC. Laboratory works were conducted to find the ductility strength of concrete at the age of 28 days. Moreover, the density of concrete is reduced when compared to control concrete. Thus, the results of partial replacement of cement with Nano-Silica & NHFRC are higher strength and reduction in the permeability when compared to controlled concrete. The partial replacement of Nano-Silica is more than3% & 1.5% of NHFRC. Determine the results in the reduction of various physical and mechanical properties of Nano-Silica concrete.

[8] Rasha El-Mashery, et.al (2020).

"Influence of Nano Particles in the Flexural Behavior of High-Strength Reinforced Concrete Beams", High strength concrete (HSC) characterized by high compressive strength but lower ductility compared to normal strength concrete. This low ductility limits the benefit of using HSC in building safe structures. Nanomaterials have gained increased attention because of their improvement of mechanical properties of concrete. In this paper we present an experimental study of the flexural behavior of reinforced beams composed of high-strength concrete and nanomaterials. Eight simply supported rectangular beams were fabricated with identical geometries and reinforcements, and then tested under two third-point loads. The reduction in flexural ductility due to the use of higher-strength concrete can be compensated by adding nanomaterials. The percentage of concentration, concrete grade and the type of nanomaterials, could predominantly affect the flexural behavior of HSRC beams.

[9] R. Padmapriya, et.al (2022)

"Experimental and analytical study on flexural behavior of reinforced concrete beams using nano silica", Nano technology is an emerging field in material science. Hence this research has been conducted to examine the flexural behaviour of the Reinforced concrete beam with Nano Silica and the same is compared analytically using ABAQUS. The structural behaviour of Reinforced concrete beam which has been strengthened using nano silica of various proportion 1%, 2%, 3%, 4%, 5% along with various proportion of 25%,40%, 50%,75%,100% Manufactured sand (Msand) is investigated. Mix proportion of M40 and M50 grade of concrete was used for concrete mix design. This flexural behaviour of nano concrete is compared with the conventional concrete. Nano silica which has a large surface area eventually, strengthens the reinforced concrete beam which behaves as micro filler improving the microstructure and makes it more homogeneous, the pozzalonic reaction improves the microstructure and makes it more homogeneous. The effect of concrete strain, the cracking patterns, the mode of failure and deflection was examined.

[10] J. Sridhar, et. al. (2019)
"Mechanical and Flexural Behavior of High Performance Concrete Containing Nano Silica", This research work presents the role of nano silica (NS) on properties of high performance concrete. This study evaluates the influence of nano silica in three percentages (1%,2%, 3 %,) by weight of cement. Several tests including mechanical properties and flexural test were performed to understand the influence of nano silica on behavior of concrete. It was determined that Portland cement replaced with 3% by weight with nano silica could accelerate C-S-H gel structure at early stage of hydration. In return this increases water permeability resistance of concrete specimens and acts as filler material that enhances micro structure as well as activator to promote pozzolanic activity and this will pave the way for producing good quality concrete.

[11] Mustaqqim Abdul Rahim et. al. (2015)
"The Effect of Steel Fiber as Additional Reinforcement in the Reinforced Concrete Beam", Steel fiber reinforced concrete has been increasingly used in structural applications during the last four decades. It is generally accepted that addition of steel fibers significantly increases tensile toughness and ductility, also slightly enhances the flexural strength. Effects of steel fibers as addition reinforcement in reinforced concrete (RC) beams are the main objectives of this study. In order to accomplish this task, eighteen concrete beams with the same mix proportioning of concrete and different volume fractions of steel fiber (0.5 % and 0.75%) were prepared. Then, by determining the flexural strength and deflection of samples, it was concluded that the optimum volume fraction was 0.50 % (0.44 kg). In the next step,the flexural behavior and deflection of RC beams with the addition of steel fibers in concrete was considered.

[12] Shaishav R et. al. (2014)
"Comparative study of experimental and analytical results of FRP strengthened beams in flexure" discussed about the comparative study of experimental and analytical results of FRP strengthened beams in flexure. Two beams were modelled using ANSYS finite element program and in those two beams, one beam was without FRP and other beam was Glass Fibre Reinforced Polymer (GFRP) strengthened beams. The load deflection relationships, crack pattern, ultimate load was obtained and compared with the experimental results available in literature and obtained results shows good agreement with the experimental results.

[13] Santhakumar R et. al. (2014)
"Analysis of Retrofitted Reinforced Concrete Shear Beams using Carbon Fibre Composites", made the analysis of retrofitted reinforced concretes shear beams using carbon fibre composites. In this paper, a study on the unretrofitted RC beam designated as control beam, RC beams retrofitted with CFRP composites in uncracked and precracked beams were studied. The modeling was done in ANSYS and quarter of the beam modelled on the bases of symmetry. The results obtained was in good agreement with the experimental plots.

[14] Lavate R, et. al. (2015)
"Dynamic Response Analysis of Fiber Reinforced Composite Beam", IOSR Journal of Mechanical and Civil Engineering", presented about dynamic response analysis of fibre reinforced composite beam. The dynamic analysis of the composite beam was studied and values of Young Modulus, Poisson's ratio and shear modulus were determined. The longitudinal and transverse vibrations were determined numerically and experimentally. These outputs were transferred to the graphs.

[15] Omran H.Y et. al. (2019)
"Finite element modelling of steel-concrete composite beams strengthened with prestressed CFRP plate", explained about finite element modelling of steel-concrete composite beams strengthened with prestressed CFRP plate. Beams strengthened with Carbon Fibre Reinforced Polymer and the beams were modelled using ANSYS. The obtained results was compared with the experimental one and was found to be in good agreement.

III. CONCLUSION

1. NS as a cement replacement material increased the compressive strength of the concrete specimens because of the pozzolanic and filling nature of the NS. The rate of increase in the compressive strength was no longer significant when the content of NS was more than2.0% bwoc.
2. Compared with control 0% NS, specimens with respectively 1.0%, 2.0%and 3.0% NS bwoc showed higher values of load-carrying capacities at first cracking load and ultimate load levels. An increase in NS replacement led to a slight increase in the strain associated with the ultimate load.
3. Increasing the NS content to 1.0%, 2.0% and 3.0% bwoc led to an increase in the ultimate load by5.5%, 11.5% and 19.2%, respectively, and a decrease in the ultimate deflection by 6.0%, 12.5% and 23.0% in comparison with (0% NS). When compared with the control beam, at the cracking load level, the first cracking load was increased by 11.8%, 17.8% and 20.3%for beams, respectively.
4. Generally, no major differences in the structural response parameters were observed for beams with partial replacements of NS concrete when compared with beam with full replacement of NS concrete.

REFERENCES

[1]. B. Sabharinadh, "Flexural Behavior of High-Performance Reinforced Concrete Beams", Magazine of Concrete Research, Volume 68 Issue 5, March 2015, Pages 229-236.

[2]. Gang Chen, "Study on flexural performance of concrete beam reinforced by steel fiber and nano-silica materials", Construction and Building Materials, Volume 278, 5 April 2021.

[3]. Koorosh Kowsaric, "Investigation of Mechanical and Durability Properties of Concrete Influenced by Hybrid Nano Silica and Micro Zeolite", Procedia Materials Science, Volume104, 2015.

[4]. Nanthakumar N, "Behaviour of Reinforced Concrete Beam Containing Micro Silica and Nano Silica", Materials Science, Volume 72, Issue 1, 2017.

[5]. Mahmoud A. El-Mandouh, "Shear Strength of Nano Silica High-Strength Reinforced Concrete Beams", Construction and Building Materials Volume 113, 15 June 2022, Pages 794-804.

[6]. Eisa, Ahmed, "Improving the flexural toughness behavior of R.C beams using micro/nano-silica and steel fibers", AIP Publishing 2021.

[7]. R. Sakthivel, "Behaviour of Nano Silica Powder and Hybrid Fiber Reinforced Concrete Beams with Cyclic Loading", International Journal of Modern Trends in Engineering and Research (IJMTER) Volume 2, Issue 7, 2017.

[8]. Rasha El-Mashery, "Influence of Nano Particles in the Flexural Behavior of High-Strength Reinforced Concrete Beams", Materials, Volume 14, Issue 22, 2020.

[9]. R. Padmapriya, "Experimental and analytical study on flexural behavior of reinforced concrete beams using nano silica", International Journal of Innovative Research in Technology, Volume 7, Issue 12, May 2022.

[10]. J. Sridhar, "Coupled effect of Nano-Silica and Steel fiber on fresh and hardened Concrete Properties", IJMER, Volume 5, Issue 7, 2019.

[11]. Mustaqqim Abdul Rahim, "The Effect of Steel Fiber as Additional Reinforcement in the Reinforced Concrete Beam", IJSER, Volume 8, Issue 5, May 2015.

[12]. Shaishav R, "Comparative study of experimental and analytical results of FRP strengthened beams in flexure", IRASE, Volume 12, Issue 1, 2014.

[13]. Santhakumar R, "Analysis of Retrofitted Reinforced Concrete Shear Beams using Carbon Fibre Composites", Nanotechnology Review, Volume 8, Issue 1, 2014.

[14]. Lavate R, "Dynamic Response Analysis of Fiber Reinforced Composite Beam", IOSR Journal of Mechanical and Civil Engineering ", Volume 221, Construction and Building Materials, 2015.

[15]. Omran H.Y, "Finite element modelling of steel-concrete composite beams strengthened with prestressed CFRP plate", Construction and Building Materials, Volume 94, 2019.