"EFFECT OF NANOSILICA ON FLEXURAL STRENGTH AND CORROSION RATE OF NANO-CONCRETE BEAMS"

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ABSTRACT

Nanotechnology has emerged as a transformative field in improving the performance of construction materials, particularly concrete. Conventional concrete suffers from limitations related to pore structure, durability, and long-term strength, which can be significantly enhanced through the incorporation of nanoparticles. This study focuses on nanoconcrete produced using nano-silica, nano–titanium dioxide (TiO_2), and carbon nanotubes (CNTs), along with superplasticizers, to refine microstructure and improve mechanical and durability characteristics. Nano-silica, with its high reactivity and fine particle size, enhances hydration, fills micro-pores, and substantially increases compressive and flexural strength. TiO_2 contributes to improved early-age strength and photocatalytic benefits, while CNTs improve tensile properties due to their exceptional strength and aspect ratio.

The objectives of the investigation include studying the fundamental properties of nanoconcrete, evaluating the flexural strength of reinforced nanoconcrete beams, and assessing durability against permeability, chemical attack, and environmental exposure. A detailed literature review reveals that incorporating nano-silica up to an optimal percentage significantly enhances strength and reduces permeability, whereas excessive dosage shows diminishing returns. Studies also confirm the combined benefits of nanoparticles in producing dense, durable, and high-performance concrete. Overall, this project emphasizes the potential of nanotechnology to advance sustainable, long-lasting, and high-strength structural concrete.

KEYWORDS: - . Nano-silica, TiO_2 , CNTs

CHAPTER-1

1.1 INTRODUCTION:

1.1 General

Nanotechnology is one of the most active research areas which has wide application in almost all the fields. As concrete is most usable material in construction industry it's been required to improve its quality.

Improving concrete properties by addition of nano particles have shown significant improvement than conventional concrete.

Nano concrete is defined as a concrete made by filling the pores in traditional concrete using nanoparticles of size <500 nano meters. There are some addition of nanosized material. Some of the applications of nanotechnology are:

- Cuore concrete- nano-silica
- Titanium dioxide
- Carbon nanotubes

1.2 Nano-silica

Silicon dioxide nanoparticles, also known as silica nanoparticles or nano-silica, in nature, silica makes up quartz and the sand. It is the first Nano product that replaced the micro silica. Advancement made by the study of concrete at Nano scale has proved Nano silica much better than silica used in conventional concrete.

Micro silica has been one of the world's most widely used additives in concrete for over 80 years. Its properties allows high compressive strength, durability and impermeability and they have been part of many important concrete structure. Its main disadvantages being its relatively high cost and contamination which adversely affects the environment and the health of the construction workers. Micro silica as a powder is one thousandth fold thinner than cigarette smoke. Hence, operators must take special precautions to avoid inhaling micro silica to prevent silicosis, a deadly diseases of the lungs. In the middle of 2003, a product which could replace micro silica was developed having better characteristics incurring a lower cost and also fulfilling environment regulation of ISO-14001. Using tools of physics, chemistry and recent nano technology, a revolutionary product cuore nano silica was developed which had superior advantages in comparison with micro silica. A litre bottle of nano silica was equivalent to a barrel full of micro silica, extra cement and super plasticizing admixtures.

Figure 1.1Nanosilica

Compressive strengths of 70 to100 N/mm^2 have been reported at 28 days. . Nano-silica addition to cement based materials can also control the degradation of the fundamental C-S-H (calcium-silicate hydrate) reaction of concrete caused by calcium leaching in water as well as block water penetration and therefore lead to improvements in durability. High workability with reduced water/concrete levels, for example: 0.2.

1.2.1 Properties of Nano-silica

- High compressive
- Strength concretes.
- High workability with reduced water/content ratio.
- Fills up all the micro pores and micro spaces.
- Cement saving up to 35-40%.

1.3NanoTio$_2$

Nano titanium dioxide is divided into two crystal forms of rutile and anatase. It has high purity, an average particle size of less than 100nm, great transparency and excellent UV absorption. It also has high thermal and chemical stability.

The anatase crystal form is used for production of photo-catalysts. Under illumination, it can help break down hazardous gases and organic pollutants via photo-catalysis. The anatase form can also be used in the decomposition of automobile exhaust and sewage treatment.

The rutile crystal form excels at UV absorption, under the joint action of UV rays and oxygen, the nano titanium dioxide has strong bactericidal powder. With its smaller particle size and high specific surface area, the rutile form provide a fine and smooth feel suitable for sunscreens and cosmetics. It is widely used in the production of cosmetics, sunscreen and high-grade plastics.

Figure 1.2 NanoTio$_2$

1.4 Carbon Nanotubes

A carbon nanotube is a tube-shaped material, made of carbon, having a diameter measuring on the nanometer scale. A nanometer is one-billionth of a meter, or about 10,000 times smaller than a human hair. CNT are unique because the bonding between the atoms is very strong and the tubes can have extreme aspect ratios. Carbon nanotubes are molecular-scale tubes of graphitic carbon with outstanding properties. They can be several millimetres in length and can have one “layer” or wall (single walled nanotube) or more than one wall (multi walled nanotube). Carbon nanotubes can be visualized as a modified form of graphite. Graphite is formed from many layers of carbon atoms that are bonded in a hexagonal pattern in fiat sheets, with weak bonds between the sheets and strong bonds within them. A CNT can be thought of as a sheet or sheets of graphite that have been rolled up into a tube structure. CNT can be single walled nanotubes (SWNT), as if a single sheet had been rolled up, or multiwalled (MWNT), similar in appearance to a number of sheets rolled together.

1.5 Superplasticizer

Superplasticizer is also known as high rang water reducers, are chemical admixtures used where well dispersed particles suspension is required. The new generation of this kind of admixtures is represented by polycarboxylate ether based superplasticizers (PCEs). With a relatively low dosage (0.15-0.30% by cement weight) they allow a water reduction up to 40%, due to their chemical structure which enables good particle dispersion.

1.6 Durability

Durability of concrete may be defined as the ability of concrete to resist weathering action, chemical attack, and abrasion while maintaining its desired engineering properties. Different concrete requires different degrees of durability depending on the exposure environment and properties desired. For example, concrete exposed to tidal seawater will have different requirements than an indoor concrete floor. The design service life of most building is often 30 years, although buildings often 50 to 100 years or longer. Because of their durability, most concrete and masonry buildings are demolished due to functional obsolescence rather than deterioration.

CHAPTER-2

2.0.OBJECTIVES OF THE INVESTIGATION

- To study the properties of nanoconcrete.
- To investigate the flexural strength of nanoconcrete reinforcement beam.
- To investigate the durability of nanoconcrete reinforcement beam.

CHAPTER-3

LITERATURE REVIEW

3.1 GENERAL

The literature review was carried out under strength and durability of nanoconcrete.

3.2 LITERATURE REVIEW

Vandhiyan et al. (2024) conducted an extensive experimental investigation to evaluate the influence of nano-silica incorporation on the corrosion resistance and bond strength characteristics of reinforced concrete. In this study, nano-silica was used as a partial replacement of cement at varying percentages ranging from 0% to 3% by weight. Mechanical properties including compressive strength, split tensile strength, and flexural strength were evaluated alongside accelerated corrosion testing using electrochemical methods such as corrosion current density measurements. The results demonstrated that specimens containing 1–2% nano-silica exhibited significant improvement in flexural strength compared to conventional concrete. The enhancement was primarily attributed to the nano-filler effect and pozzolanic reactivity of nano-silica, which led to the formation of additional calcium silicate hydrate (C-S-H) gel and densification of the interfacial transition zone (ITZ). Furthermore, corrosion testing indicated reduced crack formation, lower mass loss of reinforcement, and decreased chloride ion permeability. The study concluded that nano-silica effectively improves both mechanical strength and durability performance, making it particularly beneficial for reinforced concrete beams exposed to aggressive chloride environments.

Zhang et al. (2025) explored the application of nano-silica in geopolymer concrete with the objective of enhancing corrosion resistance and mechanical properties under simulated marine conditions. The study focused on evaluating chloride ion penetration, reinforcement corrosion rate, and flexural strength development. Nano-silica was incorporated in small dosages to improve microstructural compactness and promote better geopolymeric reactions. Experimental findings revealed that nano-silica significantly reduced chloride permeability and enhanced resistance against aggressive salt exposure. Flexural strength showed noticeable improvement due to enhanced bonding between aggregates and matrix, as well as improved gel formation within the geopolymer system. Electrochemical impedance spectroscopy indicated reduced corrosion current density in nano-modified specimens compared to control samples. Microstructural analysis confirmed pore refinement and reduced capillary voids. The authors emphasized that nano-silica acts as both a filler and nucleation agent, accelerating geopolymerization and improving matrix homogeneity. The research demonstrated that nano-silica incorporation enhances durability and structural reliability of reinforced concrete beams subjected to harsh environmental conditions.

Li et al. (2023) conducted a detailed experimental investigation to evaluate the mechanical performance of nano-silica modified concrete. The research incorporated nano-silica at replacement levels of 0%, 1%, 2%, and 3% and examined compressive strength, split tensile strength, and flexural strength at various curing ages. The study found that 2% nano-silica replacement yielded optimum results, significantly improving flexural strength compared to conventional concrete. The improvement was mainly attributed to accelerated hydration reactions and the formation of additional C-S-H gel, which refined the pore structure and enhanced bonding within the cement matrix. Scanning electron microscopy (SEM) analysis confirmed a denser microstructure and reduced microcracking in nano-modified specimens. However, higher percentages of nano-silica slightly reduced workability and caused particle agglomeration, which affected uniform dispersion. The authors concluded that nano-silica enhances both early-age and long-term mechanical performance while also improving crack resistance and durability characteristics. The study supports the application of nano-silica in structural concrete beams requiring improved flexural strength and long-term performance.

Kumar and Rao (2025) investigated the combined effects of nano-silica and nano-vanadium additives on the mechanical and durability properties of concrete. The study aimed to evaluate compressive, tensile, and flexural strength along with permeability, water absorption, and chloride penetration resistance. Experimental results showed that nano-silica significantly enhanced flexural strength due to improved matrix densification and microstructural refinement. The presence of nano-silica promoted additional pozzolanic reactions, leading to increased formation of C-S-H gel and reduction in pore connectivity. Durability tests indicated reduced water absorption and lower chloride ion penetration in nano-modified specimens, suggesting improved corrosion resistance of embedded reinforcement. The combined nano additives demonstrated synergistic effects in enhancing both strength and durability. The authors emphasized that optimum nano-silica dosage is critical to prevent agglomeration and ensure uniform dispersion. The study concluded that nano-silica incorporation enhances structural performance and durability of reinforced concrete beams exposed to aggressive environmental conditions.

Ahmed et al. (2023) examined the mechanical strength and durability characteristics of nano-silica modified concrete subjected to aggressive chloride environments. The study incorporated nano-silica in proportions ranging from 0% to 3% and evaluated compressive strength, flexural strength, and rapid chloride permeability. Results demonstrated that specimens containing 1–2% nano-silica exhibited substantial improvement in flexural strength compared to control concrete. The enhancement was attributed to the nano-filler effect, improved particle packing density, and increased pozzolanic activity. Rapid chloride penetration tests revealed significantly reduced ion permeability, indicating enhanced resistance to reinforcement corrosion. Microstructural observations confirmed refined pore structure and improved interfacial bonding between cement paste and aggregates. The authors concluded that nano-silica effectively enhances both structural performance and durability of reinforced concrete beams, particularly in marine and chloride-rich environments where corrosion is a primary concern.

Singh et al. (2024) conducted an experimental study to evaluate the influence of nano-silica on the mechanical and durability properties of conventional concrete. The investigation incorporated nano-silica at different replacement levels ranging from 0% to 3% by weight of cement. Mechanical tests including compressive, split tensile, and flexural strength were carried out at 7 and 28 days of curing. The results demonstrated a noticeable increase in flexural strength at 1–2% nano-silica replacement, with improvements attributed to enhanced hydration kinetics and microstructural refinement. The study highlighted that nano-silica acts as a nucleation site, accelerating cement hydration and producing additional calcium silicate hydrate (C-S-H) gel. Durability assessment through rapid chloride permeability tests and water absorption tests indicated a significant reduction in permeability and pore connectivity. Microstructural examination confirmed densification of the cement matrix and improvement in the interfacial transition zone (ITZ). The authors concluded that nano-silica incorporation improves crack resistance, load-carrying capacity, and corrosion resistance potential of reinforced concrete beams exposed to aggressive environments.

Hassan and Ibrahim (2023) investigated the performance of sustainable concrete incorporating nano-silica as a supplementary cementitious material. The research aimed to enhance mechanical strength while maintaining environmental sustainability through reduced cement usage. Nano-silica was incorporated at controlled percentages, and mechanical properties such as compressive strength and flexural strength were evaluated. The results indicated that nano-silica significantly improved flexural strength due to improved particle packing and refined pore distribution. The study also examined crack development and propagation under loading conditions, observing narrower crack widths in nano-modified specimens. Durability tests revealed reduced water absorption and enhanced resistance to chloride ion penetration. The improved performance was attributed to the high surface area and reactivity of nano-silica, which enhanced pozzolanic activity and strengthened the cement matrix. The authors concluded that nano-silica contributes to improved long-term durability and structural integrity of reinforced concrete beams, especially in environments susceptible to corrosion.

Patel et al. (2023) examined the effects of nano-silica incorporation in fly ash blended concrete subjected to salt exposure cycles. The objective of the study was to assess mechanical strength and resistance to chloride-induced deterioration. Nano-silica was added in small percentages to enhance the performance of fly ash concrete. Flexural strength testing revealed significant improvement in nano-modified specimens compared to control samples. The improvement was mainly attributed to refined pore structure and improved interfacial bonding between cement paste and aggregates. Rapid chloride penetration tests and salt exposure cycles demonstrated reduced chloride ion ingress and improved durability. Microstructural analysis showed reduced microcracking and enhanced densification of the matrix. The study concluded that nano-silica effectively compensates for potential weaknesses in fly ash concrete and enhances flexural strength and corrosion resistance, making it suitable for reinforced concrete beams exposed to marine and coastal environments.

Chen et al. (2025) investigated the mechanical and durability performance of self-compacting concrete (SCC) modified with nano-silica. The study focused on evaluating workability, compressive strength, and flexural strength along with permeability characteristics. Nano-silica was incorporated in controlled proportions, and appropriate dispersion techniques were adopted to prevent agglomeration. The results indicated improved flexural strength at optimum nano-silica dosage due to enhanced microstructural compactness and improved bonding between aggregates and cement paste. Durability assessments showed reduced permeability and lower chloride ion diffusion rates in nano-modified SCC specimens. The study emphasized the importance of proper dispersion of nano-silica to maximize its benefits. The authors concluded that nano-silica incorporation enhances structural performance and corrosion resistance of self-compacting concrete beams, making it a promising material for high-performance structural applications.

Ramesh et al. (2024) conducted a comprehensive experimental study to evaluate the influence of nano-silica on the mechanical properties of cement concrete. The research incorporated nano-silica at replacement levels ranging from 0% to 4% and evaluated compressive, tensile, and flexural strength. The results revealed that 2% nano-silica replacement provided optimum flexural strength enhancement. The improvement was primarily attributed to increased pozzolanic reaction and densification of the cement matrix. Microstructural observations confirmed reduced pore diameter and improved interfacial bonding. However, higher nano-silica content resulted in reduced workability and slight strength reduction due to particle agglomeration. Durability evaluation indicated lower permeability and enhanced resistance to chloride penetration. The study concluded that nano-silica significantly enhances both strength and durability characteristics, thereby improving the structural and corrosion performance of reinforced concrete beams.

Oliveira et al. (2024) presented a comprehensive review examining the influence of nano-silica on cement hydration, microstructural development, and durability performance of concrete. The study synthesized findings from multiple experimental investigations to explain the mechanisms through which nano-silica enhances mechanical properties and corrosion resistance. According to the review, nano-silica acts as a highly reactive pozzolanic material that accelerates hydration reactions and promotes the formation of additional calcium silicate hydrate (C-S-H) gel. This results in pore refinement, reduced capillary porosity, and densification of the interfacial transition zone (ITZ). The review further emphasized that nano-silica significantly reduces chloride ion permeability and water absorption, which are critical factors influencing reinforcement corrosion. Improvements in flexural strength were consistently reported across various studies due to enhanced matrix compactness and crack resistance. The authors concluded that nano-silica incorporation leads to superior long-term durability and structural reliability, making it a promising material for reinforced concrete beams exposed to aggressive environmental conditions.

Garcia et al. (2024) investigated the potential of nano-silica to enhance the mechanical and durability performance of recycled aggregate concrete (RAC). Recycled aggregates typically exhibit higher porosity and weaker interfacial bonding, which can negatively affect flexural strength and durability. In this study, nano-silica was incorporated as a partial cement replacement to compensate for these deficiencies. Mechanical testing revealed significant improvements in flexural strength and compressive strength at optimum nano-silica content. The enhancement was attributed to the filler effect and pozzolanic reaction of nano-silica, which improved bonding at the aggregate–paste interface. Durability assessments demonstrated reduced permeability and enhanced resistance to chloride ion penetration. Microstructural analysis confirmed that nano-silica reduced microcracks and improved matrix densification. The authors concluded that nano-silica effectively enhances structural performance and durability of recycled aggregate concrete, thereby supporting its application in reinforced concrete beams requiring improved flexural behavior and corrosion resistance.

Wang et al. (2024) conducted a comparative experimental study evaluating the performance of micro-silica and nano-silica in cement-based composites. The research aimed to determine the relative effectiveness of these supplementary materials in enhancing mechanical strength and durability. Flexural strength tests demonstrated that nano-silica provided superior performance compared to micro-silica, primarily due to its significantly higher surface area and enhanced pozzolanic reactivity. The nano-scale particles improved particle packing density and refined pore structure more effectively than micro-silica. Chloride penetration and permeability tests revealed lower ion diffusion rates in nano-silica modified specimens, indicating improved resistance to reinforcement corrosion. However, the study also emphasized the importance of proper dispersion techniques to prevent agglomeration. The authors concluded that nano-silica is more effective in improving flexural strength, matrix compactness, and durability performance, making it highly suitable for reinforced concrete beams exposed to corrosive environments.

Ibrahim et al. (2022) examined the durability performance of nano-silica blended concrete subjected to aggressive environmental conditions, including chloride exposure and wet–dry cycles. The study incorporated nano-silica at varying replacement levels and evaluated compressive strength, flexural strength, and permeability characteristics. Results indicated that nano-silica significantly improved flexural strength due to enhanced hydration and densification of the cement matrix. Rapid chloride permeability tests demonstrated substantial reduction in chloride ion penetration compared to conventional concrete. The microstructural analysis confirmed refined pore structure and improved interfacial bonding between cement paste and aggregates. The study also observed delayed crack formation and improved resistance to microcracking under cyclic exposure conditions. The authors concluded that nano-silica enhances both structural performance and durability of reinforced concrete elements, particularly in environments prone to corrosion and chemical attack.

Park et al. (2025) investigated the combined effect of nano-silica and steel fibers on the flexural toughness and crack resistance of concrete. The study aimed to enhance structural performance by integrating nano-scale and macro-scale reinforcement mechanisms. Nano-silica was incorporated as a cement replacement, while steel fibers were added to improve tensile and flexural behavior. Experimental results demonstrated significant improvement in flexural strength and post-cracking behavior compared to conventional concrete. The presence of nano-silica enhanced matrix densification and improved bonding between fibers and cement paste. Durability tests indicated reduced permeability and improved resistance to chloride penetration, suggesting enhanced corrosion resistance of embedded reinforcement. The authors concluded that the synergistic effect of nano-silica and steel fibers significantly enhances load-carrying capacity, crack control, and durability performance of reinforced concrete beams, particularly under aggressive environmental conditions.

Singh et al. (2023) investigated the influence of nano-silica incorporation on the mechanical and durability performance of high-performance concrete (HPC). The study examined various nano-silica replacement levels to determine the optimum dosage for structural applications. Experimental results indicated that the inclusion of nano-silica significantly improved flexural strength, compressive strength, and tensile strength compared to conventional HPC. The enhancement was primarily attributed to the pozzolanic reactivity of nano-silica, which accelerates hydration and promotes the formation of additional C-S-H gel. Microstructural observations revealed a refined pore structure and reduced microcracking due to improved interfacial bonding. Durability tests, including water absorption and rapid chloride permeability, demonstrated substantial reduction in permeability, thereby enhancing corrosion resistance. The authors concluded that nano-silica improves both mechanical strength and long-term durability, making it highly suitable for reinforced concrete beams exposed to aggressive environmental conditions.

Al-Mahmoud et al. (2024) conducted an experimental investigation into the corrosion behavior of reinforced concrete containing nano-silica under simulated marine conditions. The study evaluated corrosion rate using electrochemical techniques such as half-cell potential and linear polarization resistance. Results showed that nano-silica significantly reduced chloride ion penetration and delayed corrosion initiation in embedded steel reinforcement. The improved corrosion resistance was attributed to the densification of the cement matrix and refinement of pore structure. Flexural strength tests indicated enhanced structural performance in nano-silica modified beams compared to control specimens. The authors emphasized that nano-silica incorporation leads to increased durability in marine environments, where chloride-induced corrosion is a major concern. The findings suggest that nano-silica concrete beams offer superior long-term structural reliability in coastal infrastructure applications.

Chen et al. (2022) explored the microstructural evolution and strength characteristics of concrete incorporating nano-silica. The study utilized scanning electron microscopy (SEM) and X-ray diffraction (XRD) analysis to understand hydration mechanisms. Results indicated that nano-silica accelerates cement hydration and enhances C-S-H gel formation, leading to improved matrix densification. Flexural strength measurements showed significant improvement at optimum nano-silica dosage due to enhanced bonding between aggregates and cement paste. Additionally, reduced porosity and refined microstructure contributed to lower permeability and improved resistance to aggressive agents. The authors highlighted that excessive nano-silica content may lead to agglomeration, which can negatively impact performance. Overall, the study concluded that nano-silica effectively enhances both mechanical properties and durability of concrete, particularly in reinforced beam applications.

Hassan et al. (2023) examined the influence of nano-silica on chloride diffusion and durability performance of reinforced concrete. The experimental program included rapid chloride permeability tests, water absorption tests, and corrosion rate measurements. Findings demonstrated that nano-silica incorporation significantly reduced chloride diffusion coefficients, thereby delaying corrosion initiation in steel reinforcement. Flexural strength tests revealed consistent improvements compared to conventional concrete, particularly at 2–3% nano-silica replacement levels. The enhanced performance was attributed to the filler effect and pozzolanic reaction, which refined pore structure and reduced connectivity of capillary pores. The study emphasized that nano-silica not only enhances mechanical performance but also improves long-term durability by limiting aggressive ion penetration. The authors concluded that nano-silica modified concrete is highly suitable for structural beams exposed to chloride-rich environments.

Kumar et al. (2025) evaluated the mechanical and corrosion resistance performance of sustainable nano-concrete incorporating nano-silica. The research focused on optimizing nano-silica dosage to achieve improved flexural strength and durability while maintaining sustainability objectives. Experimental results indicated that nano-silica significantly enhanced flexural strength due to improved hydration kinetics and matrix densification. Corrosion rate measurements using electrochemical methods showed delayed corrosion initiation and reduced steel mass loss in nano-silica specimens. The study also reported lower water absorption and improved resistance to chloride ion penetration. The authors concluded that nano-silica enhances both structural performance and service life of reinforced concrete beams. Furthermore, the incorporation of nano-silica contributes to sustainable construction practices by improving durability and reducing maintenance requirements over the structure’s lifespan.

PranayLanjewar et al (2017) Nanotechnology is one of the most active research, Nano-Silica is used as a partial replacement for cement in the range of 1%, 1.5%, 2%, 3.5% and 4% for M_{25} mix. This study summarizes the influence of nano-silica on strength and durability of M_{25} grades of concrete with the used of nano-silica as a replacement of cement. The replacement of cement with nano-silica more than 3.5% results in the reduction of compressive strength of nano-concrete. From the experimental results, it can also be concluded that the permeability of concrete decreases with increase in the percentage of nano-silica up to 3.5 %.

Vasanthi et al (2017) Studies have shown that concrete containing nano particles has demonstrated increased strength, durability and reduction of pores in the concrete due to the pore filling properties of the nano materials. The nano materials are useful to improve the life of the building. The use of large quantity of cement produces increasing CO2 emissions. Nano Silica produces high compressive strength concrete. It also provides high workability with reduced water cement ratio.

Sakthivel et al (2017) The influence of Nano-Silica on various properties of concrete is obtained by replacing the cement with various percentages of Nano-Silica and natural hybrid fibres. Nano-Silica is used as a partial replacement for cement in the range of 2%, 2.5%, 3%, 3.5%, 4% and hybrid fibre (coir fiber & human hair) of percentage 0.5%, 1%, 1.5%, 2% and 2.5% for M25 mix. Specimens are casted using Nano-Silica concrete. Laboratory tests were conducted to determine the strength of Nano-Silica concrete at the age of 28 days. The replacement of cement with Nano-Silica results in higher strength and reduction in the permeability than the controlled concrete. The replacement of cement with Nano-Silica more than 3% results in the reduction of various properties of Nano-Silica concrete.

Namdev Bapu Rajguruet al (2017) This paper shows the partial replacement of cement with the Nano silica with different dosses like 1%, 1.5%, and 2% by weight and increase the strength property of concrete and also shows that the comparative study between the concrete without addition of Nano silica and with addition of Nano silica. The result of this paper gives the increase in compressive strength of concrete by the application of Nano silica Average percentage increase in strength of concrete after 3 days, 7 days, and 28s days is 10.3%, 15%, and 19.43% with respect to dosses.

Rahini et al (2017) This study concern with the use of titanium dioxide (TiO2) to increase the strength of concrete. An experimental investigation has been carried out by replacing the cement with titanium dioxide (TiO2) of 0.5%, 1%, 1.5% by water ratio. This test conducted on it shows a considerable increase in early age compressive strength and also improves the overall compressive strength of concrete. The strength increase was observed with the increase in the percentage of nano silica.

Namdev Rajguruet al (2017) This paper shows that the partial replacement of cement by Nano silica powder (1 %, 1.5%, 2%) by the weight of cement .After that replacement to do the comparative study of compressive strength of concrete with addition of Nano silica and without addition of Nano silica. Nano silica is suitable to reduce the environmental pollution by reduction of CO2 emission in atmosphere. This paper also shows that improvement in permeability of concrete.

Ramachandran et al (2017) In this paper the behavior of RC slab structures by using Natural hybrid Fiber (coir and hair) and Nano silica reinforced Concrete (NHFRC) was determined. The various percentages of fibers ranging from 0.5% to 2.5% by weight of cement were used in the investigations and the various percentages of Nano silica ranging from 0.2% to 4.5% by weight of cement were used in the investigations. The test results shown that use of NHFRC with Nano silica improves loading performance of slab under static loading. It was found that slab with 1.5% NHFRC with 3% Nano silica slab specimen shows an increase of 73.33% in ultimate load and 56.97% in deflection when compared to that of control slab.

Balasundaram et al (2016) The influence of Nano-Silica on various properties of concrete is obtained by replacing the cement with various percentages of Nano-Silica. Nano-Silica is used as a partial replacement for cement in the range of 2.5%, 3%, and 3.5% for M25 mix. Specimens are casted using Nano-Silica concrete. Laboratory tests were conducted to determine the compressive strength, split tensile and flexural strength of Nano-Silica concrete at the age of 7 and 28 days. Results indicate that the concrete, by using Nano-Silica powder, was able to increase its compressive strength. That the compressive strength of concrete initially increased up to 3% of Nano-Silica and with further increase in the Nano-Silica content the compressive strength of concrete decreases.

Rajkumar et al (2016) In this paper an attempt has been made to improve the strength characteristics of concrete with the addition of Nano-silica which not only acts as a filter to improve the microstructure but also as an activator to promote pozzolanic reaction there by resulting in the enhancement of the mechanical properties of the concrete mix. The replacement of nano silica range 1.5%of cement. The results obtained from water absorption test suggest that nS concrete is more durable than conventional concrete. The percentage increase in strength of nano silica concrete after 28 days was found out to be 35 Mpa for compression and 45 Mpa for tensile strength for m20 mix

Umesh Pendharkaret al (2016) In this reviews of recent developments and present state of the application of nano alumina, nano titanium dioxide, nano zinc oxide and nano-silica for sustainable development of concrete industry The cement was replaced by Nano-materials at various percentages (2%, 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18% and 20%) for M20, M30, M40 and M50 grades. The replacement of Nano partial's more than 3.5% the result reduced

Arun Nishchal Guleriaet al (2016) In this review paper we will study the effect of MS and NS in the concrete properties with their different percentages in the different grades of concrete. The strength of concrete with the varying percentage ratio of nano silica at 0, 1, 1.5, 2 & 2.5 percent (%) with the partial replacement of cement. The max increase in compressive strength with nano silica was at 10% both on 7th And 28th days. On 7th day at 10% the strength was 38.7 MPa and 28th day it was 58.5 MPa.

Mohamedet al (2016) The presented research aims to study the bond performance of concrete containing relatively high volume nano silica (up to 4.5%) exposed to corrosive conditions. Adding 4.5% nano silica in concrete increased the residual bond strength to reach 79% instead of 27% only as compared to control mix (0%W) before the subjection of the corrosive environment. From the conducted study we can conclude that the Nano silica proved to be a significant pore blocker material.

Renu Tiwaret al (2016) The research mainly focusing on the use of nano materials in concrete. Further researchers are continuing to improve the durability and sustainability of concrete and have realized significant increment in mechanical properties of concrete by incorporating nano-silica. The review paper summarizes the effect of nano-silica addition compressive strength on concrete 2% NS reduces initial and final setting time and compressive strength increases by 22% and 18% at 3 days and 7 days

Mohammad Reza et al (2016) In this study, the effect of combined nanosilica (nS) and microsilica (mS) on sulfate resistance of Portland cement (PC) mortars was evaluated against all cement control mortars and mixtures with equivalent contents of only one form of silica. Silica contained mortars had 6% cement replacement of either nS, mS, or 3% of each. The mortars in this study were subjected to a 1.5 year period of full submersion sulfate attack in a 5% sodium sulfate (Na_2SO_4) solution. The results most of the beneficial contribution from the cement replacement with the combination mixtures could be attributed to the mS proportion given that the combination mixtures' expansion performance was comparable to that of the 3% mS only mortars

Mainak Ghosalet al (2015) This paper deals with the fact that nano materials (like nano-SiO_2 & nano-TiO_2) when added in optimized proportions to a standard M-40 Grade concrete improves its both fresh and hardened properties (both short term &long term).The results simply corroborated the fact that for nano concrete the workability increased by more than 90% w.r.to controlled M-40 Grade concrete. The compressive strength of nano concrete with nano-SiO_2 gave a strength gain of more than 24% at 28 days and more than 18% at 90 days while that of & nano-TiO_2 gave a strength gain of more than 9% at 28 days and more than 6% at 90 days all under ordinary curing conditions. However, under exposure to $MgSO_4$ &$MgCl_2$ the standard concrete specimens gave a greater crushing strength when compared with both the nano concretes

Malek Mohammad Ranjbaret al (2015) This paper investigates the hardened properties of HPC incorporating nanoTiO_2 (NT) and Fly Ash (FA). TiO_2 nanoparticles at the rates of 1, 2 and 3% and low-calcium fly ash at the rate of 30% of the binder by weight were considered. The durability performance was assessed by means of water absorption by capillarity, ultrasonic pulse velocity, chloride diffusion and resistance to sulphuric acid attack. The results showed significant improvement in the properties of the samples incorporating the replacement of cement with a combination of 1% TiO_2 nanoparticles and 30% FA.

Haininet al (2014) The objective of this paper is to review the use and performance of nano silica in porous concrete pavement and previous laboratory study on porous concrete pavement .To improve the strength of the porous concrete, various additives have been studied as a part of porous concrete mix and yet, the optimum condition to produce good porous concrete has still not been established. Using the standard Proctor hammer (2.5 kg) and pneumatic press (70 kPa compaction effort).

Arkadeep Mitraet al (2014) Ground and Unground micro-silica with concrete in 5, 10, and 15% as a partial substitute to cement and result were compared with conventional concrete. Concrete specimens were cast in the laboratory and tested for compressive and tensile strength at different age of concrete. The morphology of the ground and unground micro-silica for different time duration were studied using scanning electro microscope, more irregular shapes were observed after 6 hrs of grinding .Result was observed that the specimens cast with microsilica with 6hrs grindind and 5% of replacement of cement showed improvement in strength of 30%. Resistance to permeability was also higher in concrete specimens.

Esmaeili et al (2013) The effects of adding Nano-Silica particles on the compressive strength and water permeability of concrete and its comparison with that of Micro-Silica were investigated in this work. The effect of combination of Nano- silica and Micro-silica were also studied in this work, which resulted in an increase in compressive strength of concrete in comparison with other concrete specimens tested in this study. The XRD analysis showed that the $Ca(OH)_2$ amount of such samples is considerably less than that of the control sample.

Iyer et al (2013) Nano-scale silica or nano silica is a material at level of individual atoms and molecules in the range of 0.1 to 100 nano meter (10-6 mm). Adding nano-scale silicafume into concrete mixes improves durability of concrete structures. Understand in that takes place in the cement particle at a nano-scale level can lead to improved industry standard for mixing and curing concrete. Material of nanotechnology product enables self-consolidating concrete (SCC) achieve consolidation without the need for vibration and to saving up 50% labour costs. The construction sector can benefit from this new construction material with ultra-high strength, ductility, and high durability, such as concrete. The research showed that2.5% - 10% percentage weight nano silica to cement's as partial cement substitution increases the mechanics and physics properties of concrete.

Georgene Geary et al (2013) Multiwall carbon nanotube (CNT) effects on strength characteristics and durability of concrete. Sonication process is carried out by adding MWCNT with surfactants (super plasticizers – poly carboxylate 8H), 0.25% by weight of cement and also with water. 36 Specimens with MWCNTs of 0.015%, 0.03% and 0.045% of cement (by weight) were tested after 28 days of curing. Results show an increase in compressive and splitting-tensile strengths of the samples with increasing MWCNT. 0.045% of MWCNT has improved the 28 days compressive strength by 27 % while the split tensile strength increased by 45%. Crack propagation was reduced and water absorption decreased by 17% at 28 days curing.

Reshmaet al (2013) The combination of partial replacement of fly ash and Nano Silica are used in the present project in order to determine the compressive strength, split tensile strength, flexural strength and young's modulus of elasticity and that should be compared to controlled concrete. In the present study, the cement is replaced by 20%and 30% of fly ash and Nano silica 1.5%, 3% and 4.5% by weight is determined with M20 grade. from the tests conducted it has been concluded that the concrete prepared with 20% Fly ash and 3% Nano silica combination possess improved properties compared to controlled concrete

Vijaya Sekhar Reddy et al (2013) Pozzalonic materials are widely used in concrete and mortars for various reasons, particularly for reducing the amount of cement required for making concrete and mortar which lead to a reduction in construction cost. In the new millennium, concrete incorporating self-curing agents will represent a new trend in the concrete construction. Curing of concrete plays a major role in developing the concrete microstructure and pore structure, and hence improves its durability and performance. Due to the high alkalinity of concrete it has always been susceptible to acid attack. Hence, in this investigation an attempt was made in order to know the behavior of standard concrete of M40 grade specimens curing with acids such as HCL, Alkaline such as NaOH and sulphate solution MgSO4 and Na2SO4. In the last decade the use of Supplementary Cementing Materials (SCMs) 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. Some of the commonly used SCMs are Flyash, Silica fume and Metakaoline. This paper presents results of the durability characteristic properties of M40 grade of with and without SCMs.

Yuvaraj et al (2012) This paper reviews to reduce the carbon emission due to the cement manufacturing the fly ash is partially replaced in ordinary Portland cement and termed as Portland pozzolana cement (PPC) it not only reduces the environmental impact, improves the workability, corrosion strength and long term strength of concrete but this replacement of fly ash in the ordinary Portland cement deviating its strength consequently. Hence here we added Nano silica as an additive to fill up the deviation, the range of nano silica 2.5 %Corrosion resistance property of the nS added concrete is comparatively higher than ordinary fly ash concrete. Finally the compressive strength of 28 days cured Nano concrete possess an incremental strength by 23% than the ordinary fly ash replaced concrete.

Partha Ghoshet al (2012) The objectives of the present research is to appreciate the effect of %Na2O and %SiO2 on apparent porosity and sorptivity of fly ash based geopolymermortar. The study revealed that the apparent porosity and sorptivity as well as microstructure depended basically on alkali content and silica content. Strong alkali solutions are needed to dissolve fly ash during the process of geopolymerisation. There is no direct relationship between compressive strength and sorptivity. However, generally there is decrease in water sorptivity and water absorption with increase in compressive strength and bulk density.

Rupasinghe et al (2010) One of the most interesting research fields of recent time is the study of reaction mechanism of nano embedment in cement composites. Cement composites prepared with river sand as per Indian standards with and without Nanoparticles showed an increase of 31% in compressive strength at 7 days & 32% at 28 days & 59% at 90 days respectively. Similarly, Nano Carbon tube embedment showed a decrease of 16% at 7 days, 37% increase at 28 days, 14% increase at 90 days & 3% increase at 180 days when compared to ordinary controlled cement composite after dispersion in Super.

Flores et al (2008) Nano science and technology is a new field of emergence in materials science and engineering, which forms the basis for evolution of novel technological materials. Nano technology finds application in various fields of science and technology. A critical review of the literature on the influence of nano silica in concrete and its application for the development of sustainable materials in the construction industry and to study the pour filling effect and its pozzolanic activity with cement towards improvement of mechanical properties and durability aspects. Thus, there is a scope for development of crack free concrete towards sustainable construction.

3.3 SUMMARY OF LITERATURE REVIEW

- The above papers shows partial replacement nano materials like nanosilica which improves the strength of concrete
- The tests conducted on cubes, cylinders and prism which shows compressive, split tensile and flexural strength increased.
- The effects of different ratios of Nano-Silica to cement content were well investigated, and the optimum ratio of 3% was reported.
- Resistance to permeability was also higher in concrete. Corrosion resistance property of the nS added concrete is comparatively higher than ordinary fly ash concrete.

- Concrete mixtures including fly ash show a higher mass loss after sulphuric acid attack exposure
- Workability of concrete decreases with the increase in the percentage of silica fume.
- Tension cracks were formed in the NHFRC beams with nS under the loaded area.
- It can also be concluded that the permeability of concrete decreases with the increase in the percentage of Nano-Silica up to 3% due to the effect of Nano-Silica filling the voids in concrete.
- The results obtained from water absorption test suggest that nS concrete is more durable than conventional concrete.
- Nano Silica produces high compressive strength concrete. It also provides high workability with reduced water cement ratio.
- The replacement of cement with Nano-Silica more than 3% results in the reduction of various properties of Nano-Silica concrete.
- The percentage increase in strength of nano silica concrete after 28 days was found out to be 35 Mpa for compression and 45 Mpa for tensile strength for M_{20} mix
- However, under exposure to $MgSO_4$ &$MgCl_2$ the standard concrete specimens gave a greater crushing strength when compared with both the nano concretes.
- The research showed that 2.5% - 10% percentage weight nano silica to cement's as partial cement substitution increases the mechanics and physics properties of concrete.
- The review paper summarizes the effect of nano-silica addition compressive strength on concrete 2% NS reduces initial and final setting time and compressive strength increases by 22% and 18% at 3 days and 7 days.
- From the conducted study we can conclude that the Nano silica proved to be a significant pore blocker material.
- From the comprehensive review of recent studies, it is evident that nano-silica plays a significant role in enhancing both the mechanical and durability performance of concrete. Most researchers reported considerable improvement in flexural strength due to the pozzolanic reactivity and filler effect of nano-silica, which accelerates cement hydration and promotes additional formation of calcium silicate hydrate (C–S–H) gel. The incorporation of nano-silica refines pore structure, reduces capillary porosity, and improves the interfacial transition zone between aggregates and cement paste, leading to increased load-carrying capacity and crack resistance in concrete beams.
- Furthermore, numerous studies demonstrated that nano-silica significantly decreases chloride ion permeability and water absorption, thereby reducing corrosion rate of embedded steel reinforcement. Electrochemical investigations confirmed delayed corrosion initiation and improved long-term durability in aggressive environments such as marine and chloride-exposed conditions. However, several authors emphasized the importance of optimal dosage and proper dispersion techniques to prevent particle agglomeration, which may negatively affect performance.
- Overall, the literature indicates that nano-silica is a highly effective nanomaterial for improving flexural strength and corrosion resistance of reinforced concrete beams. Nevertheless, further experimental research is required to determine the optimum percentage of nano-silica and its combined effect on structural performance and corrosion behavior under real-time exposure conditions.

CHAPTER-4
METHODOLOGY

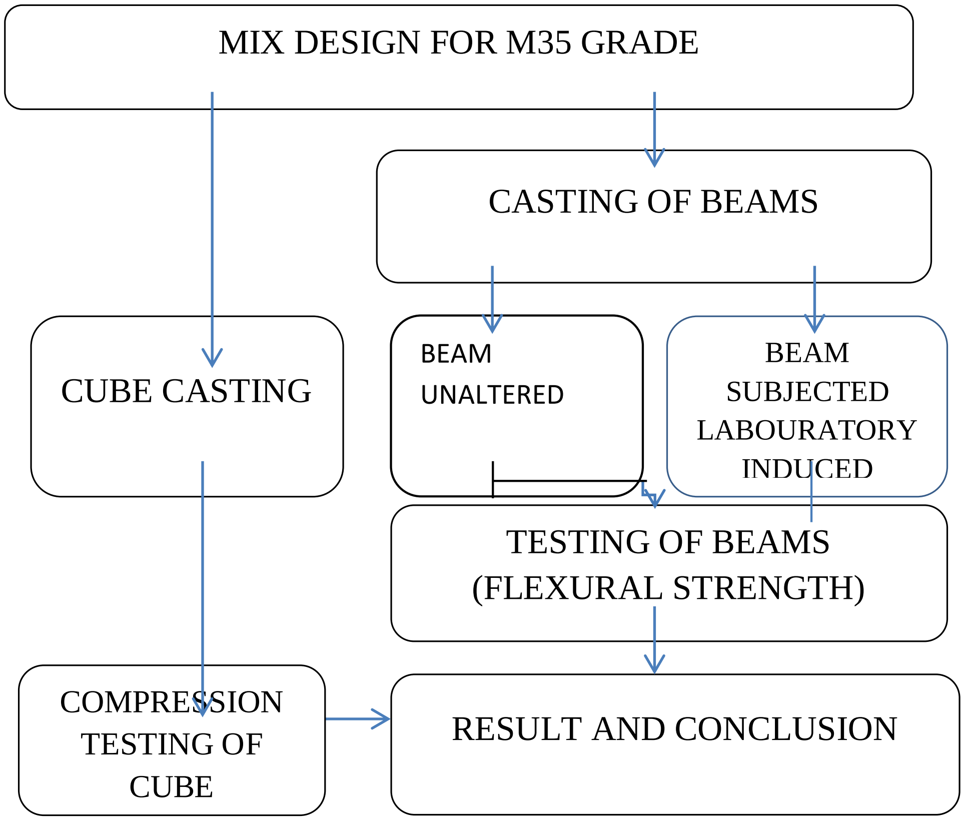

Figure 3.1 Methodology

CHAPTER 5

EXPERIMENTAL PROGRAM

5.1 MATERIALS USED

5.1.1 CEMENT:

Ordinary Portland cement conform to IS 10262-2009 penna cement 53 grade was used. The specific gravity of the cement is 3.11.

5.1.2 FINE AGGREGATE:

Locally available river sand was used as fine aggregate which passes through 4.75mm as per IS 383-1978. The specific gravity of the fine aggregate is 2.67. Zone 3was used. The fineness modulus of aggregate was 2.69.

5.1.3 COARSE AGGREGATE:

Locally available coarse aggregate brought from hosur, 20mm size aggregate was used. The specific gravity of the coarse aggregate is 2.72.

5.1.4 WATER:

Potable water which is available in laboratory is used for casting and curing of specimen as per IS 456-200.

5.1.5 NANO-SILICA (SOURCE ASTRA CHEMICALS, CHENNAI)

Nano-silica in the construction industry, extensive is going on to improve the performance of various building materials and development of durable and sustainable concrete. Among all the nano-materials is most widely used materials in the cement and concrete to improve the performance because of its pozzolanic reactivity besides the pore-filling effect.

Table 5.1 Properties of nanosilica

Test items	Standard Requirements	Test Results
Specific surface area (m2/g)	200+20	202
Ph value	3.7-4.5	4.12
Loss on drying @105 deg.c(5)	<1.5	0.47
Loss on ignition @1000deg. C (%)	<2.0	0.66
Sieve residue (5)	<0.04	0.02
Temped density g/l	40-60	44
Sio_2(%)	>99.8	99.88
Carbon content (%)	<0.15	0.06
Al_2o_3	<0.03	0.005
Tio_2	<0.02	0.004
Fe_2o_3	<0.003	0.001

5.1.6 CONCRETE MIX PROPOTION:

Mix proportion of M35 grade concrete was designed as per IS 10262-2009 and IS 456-2000. The proportion and w/c ratio for M35 is 1:1.6:2.67, 0.40 & 3% of nanosillica as cement.

5.2 REINFORCEMENT DETAILS:

The experimental investigation includes casting and testing of six beams of dimension (1000 mm length, 100 mm width and 100 mm depth). A view of longitudinal section and cross section of a typical beam specimen is shown fig.5.1. Six beams were casted with nano-silica with reinforcement. HYSD 4nos of 8 mm diameter was used as top and bottom reinforcement, for shear 6mm diameter stirrups were used at 90mm c/c. Bottom and top side concrete clear cover of 15 mm was maintained for all beams. Reinforcement details shown below Fig 5.1

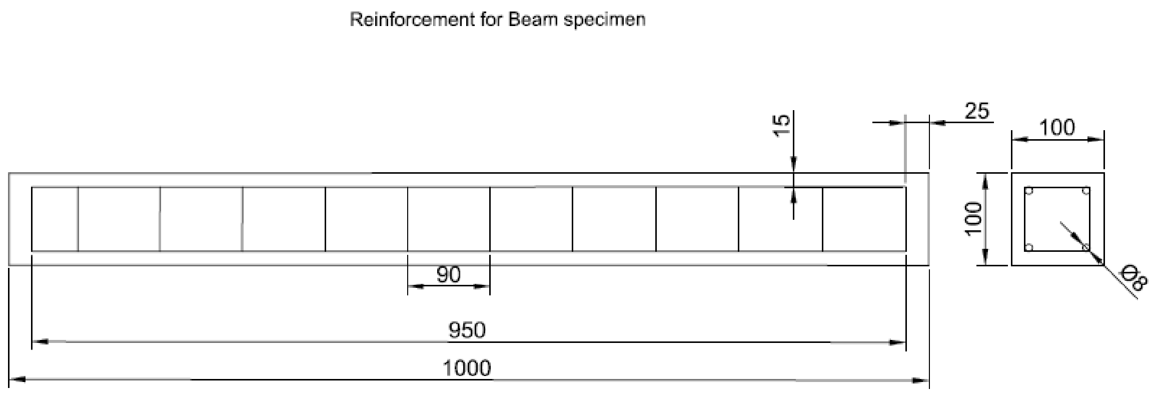

Figure 5.1 Reinforcement details of beam

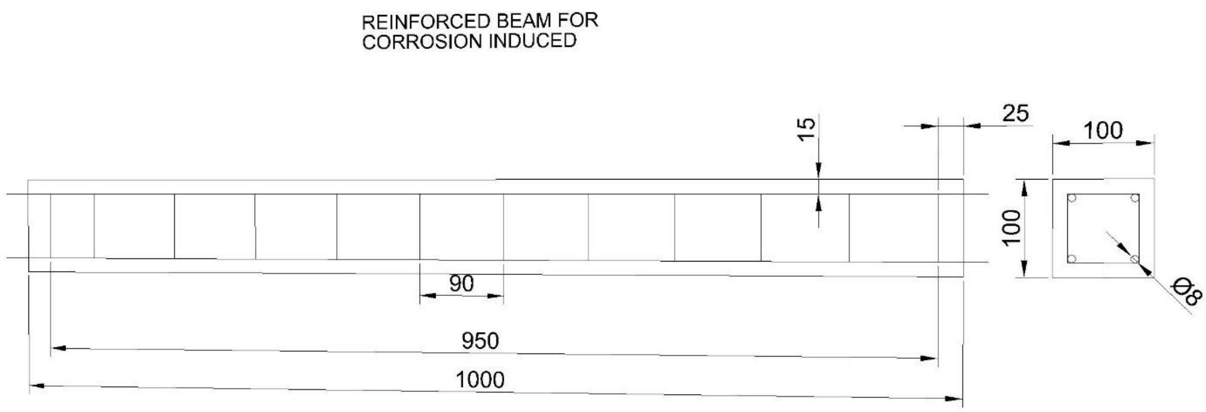

Figure 5.2 Reinforcement details of corrosion induced beam

5.3 CASTING AND CURING

Compressive strength of nano companion specimen were casted as follows. 3 numbers of 150mm x 150mm x 150mm cube and 150mm x 300mm cylinders were casted and tested for compressive and split tensile strength of concrete. Specimens are shown below Fig, 5.3, 5.4 & 5.5.

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Figure 5.3 Casting of Cube

Figure 5.4 Casting of Cylinder

Figure 5.5 Casting of Beams

5.4 TEST PROGRAMME

The test setup involves a two point loading system by using a spread beam and two rollers. Totally one 100mm LVDT and one 50mm Dial gauge was used to measure deflection placed at the mid span of beam along the tension side. The LVTD and dial gauge were placed under two point loading to measure the deflection. Pellets were placed as shown in Fig 5.5 at mid span across cross section of beam to measure concrete strain. The point loads acts at a distance of 200mm from the mid span along the compression side of the beam.

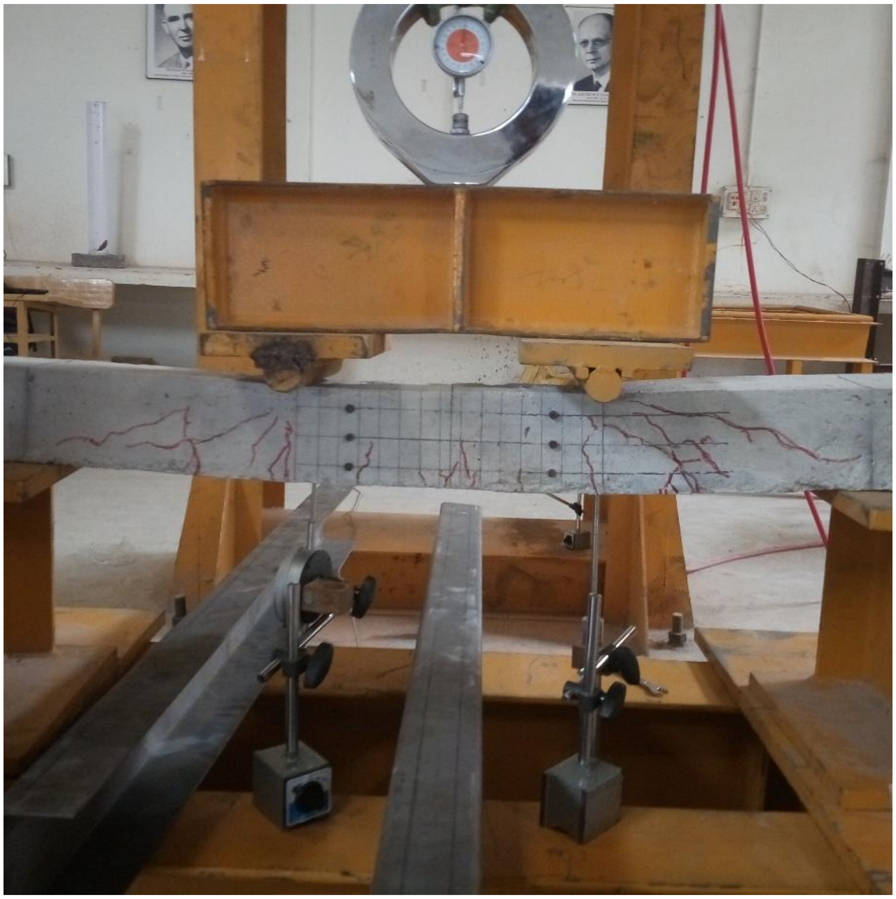
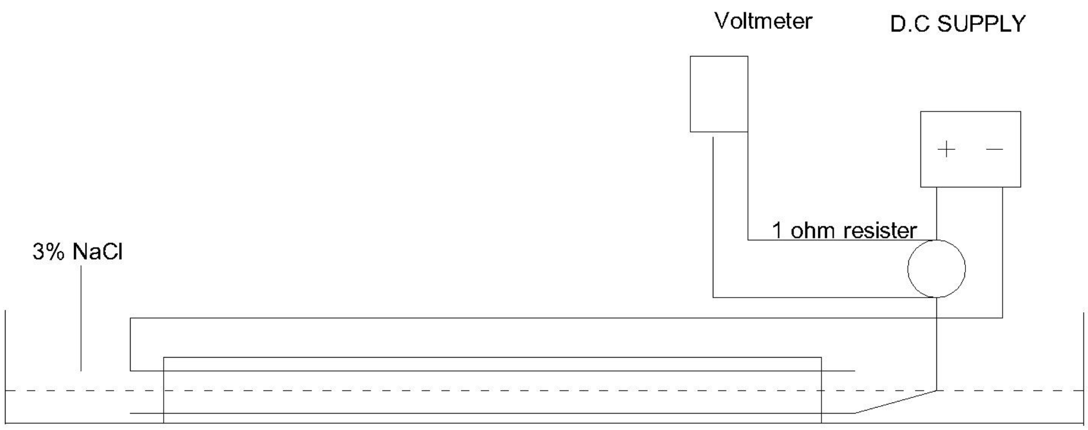


Figure 5.6 Testing Setup

5.5 ACCELERATED CORROSION SETUP

The set up for accelerating reinforcement corrosion was (100×100×1000 mm) reinforced nano concrete beam having 8 mm diameter reinforcement bar is provided. The effective cover of the column was 15 mm. 6 mm ties are provided with the spacing of 100mm throughout the length of the bar. The electrical wires were connected to the reinforcement bars after placing the concrete in the beams. Copper wires are connected to the reinforcement for monitoring the corrosion rate. The beams are immersed partially in water. The water containing the 3% of NaCl solution.one steel bar act as the anode and the other end steel bar act as cathode. The DC supply of 9volts was used as power source. The positive end of wire is connected to one end of the beam, the negative end of the wire is connected to another end of beam to the 1 ohm resister using the resister the voltage and current were monitored daily once using multimeter. The corrosion produced in the bar can be found by applying current in the reinforced structure. The rate of corrosion induced in the reinforcement was found by Faradays law. The set up for accelerating reinforcement was shown in Figure 5.6



Figure; 5.7 Accelerated corrosion setup

Figure; 5.8 Specimen partially immersion in 3% of NaCl

CHAPTER 6

RESULT AND DISCUSSION

6.1 CUBE TEST RESULT

Compressive strength is the maximum compressive stress that, under a gradually applied load, given solid material can sustain without fracture. Compressive strength is calculated by dividing the maximum load by the original cross section area of the specimen in compression test. Cube test result mentioned below in table 6.1.

Table 6.1 Compressive Strength

Specimen .No	Load in Kn	Compressive Strength in N/mm^2
1	1077	48
2	1061	47.155
3	1045	46.44

Avg=47N/mm^2

6.2 CYLINDER TEST RESULT

The tensile strength of concrete is not able to measure directly. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. 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. Cylinder test result are mentioned below in table 6.2.

Table 6.2 Split Tensile Strength

Specimen .No.	Load in kN	Split Tensile Strength in N/mm^2
1	282	3.99
2	249	3.54
3	251	3.55

Avg=3.7N/mm^2

6.3 LOAD CARRYING CAPACITY OF WITHOUT CORROSION INDUCED

A beam is a structural element that primarily resists loads applied laterally to the beam's axis. Its mode of deflection is primarily by bending.

Table 6.3 Test results of Load Carrying Capacity

Specimen. No.	Ultimate load carrying capacity kN
1	12.2
2	11.4
3	12.4

6.4 LOAD VERSUS DEFLECTION CHARACTERISTICS

In this LVDTs was placed to measure middle deflection of beam specimen.

FOR SPECIMEN 1

Table 6.4 Load Vs Deflection for specimen 1

Load in kN	Deflection in mm
0	0
1.2	0.6
2.6	1.25
3.8	2.78
5	3.7

6.4	4.87
8.2	5.83
9.6	7.2
10.8	10
12.2	11.95

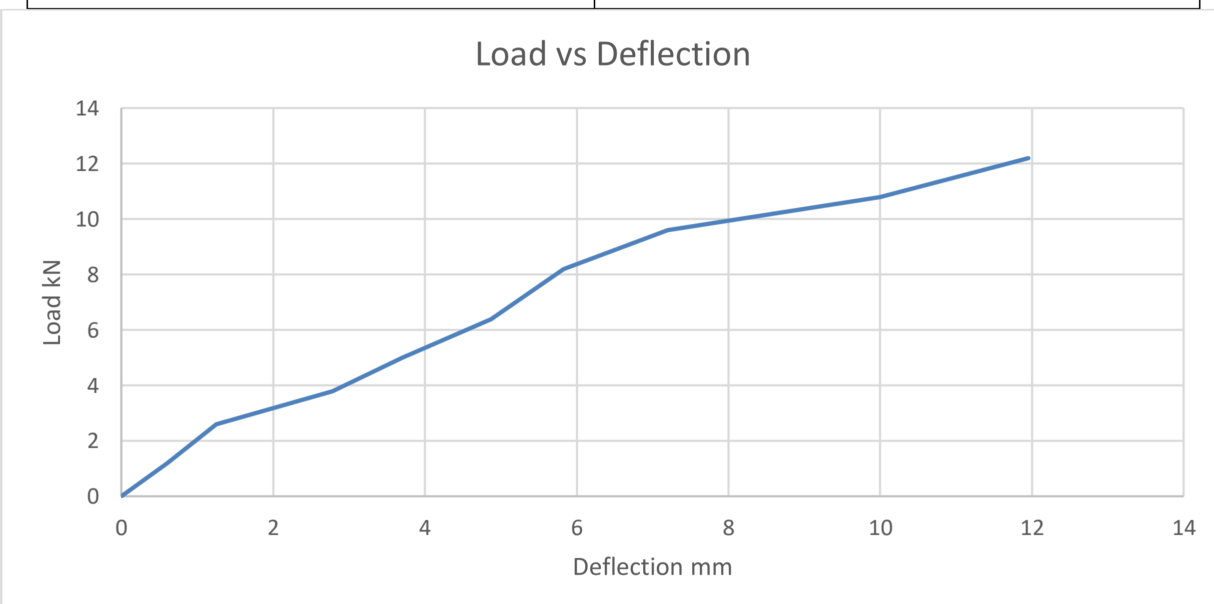


Figure 6.1 Load vs Deflection for specimen 1

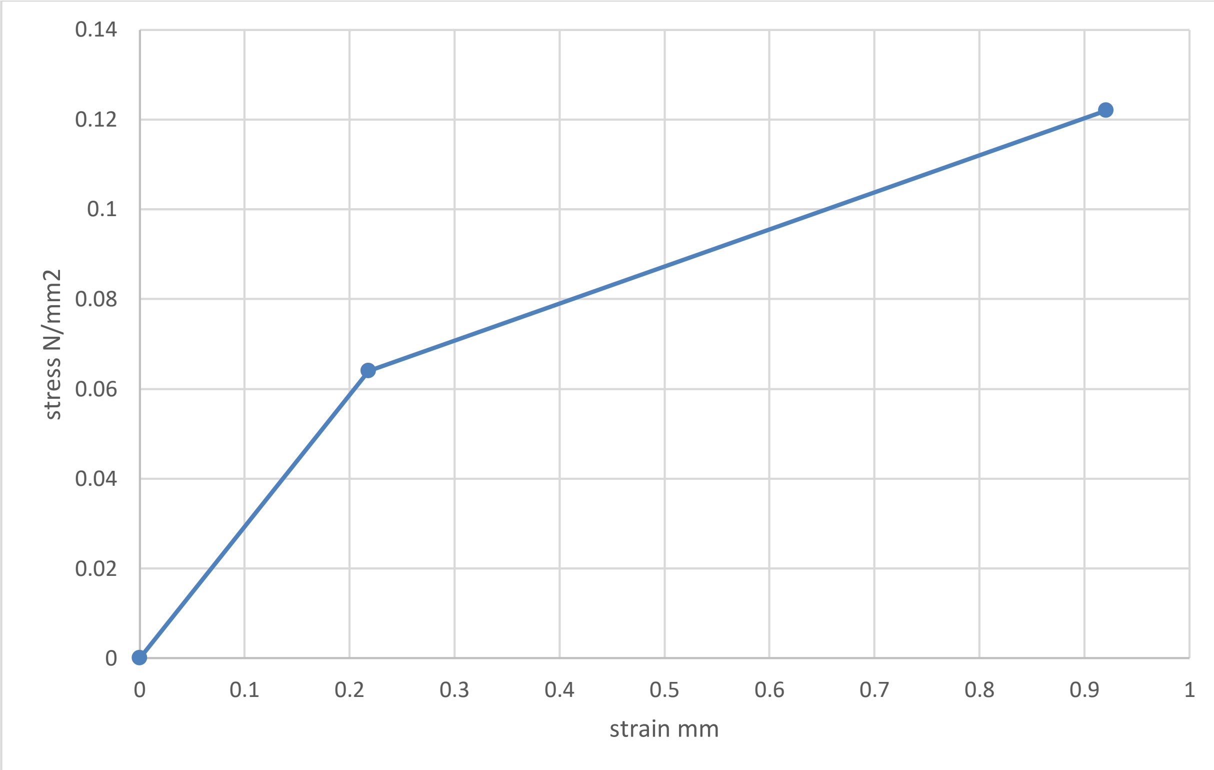


Figure 6.2 stress strain curve for specimen 1

FOR SPECIMEN 2

Table 6.5 Load Vs Deflection for specimen 2

Load in kN	Deflection in mm
0	0
1	0.08
1.4	0.42
2	1.08
2.6	1.82
3.2	2.42
4.8	2.82
5	3.39

6.4	4.15
7.2	4.8
8	6.3
8.8	6.86
9.6	8.5
10	9.18
11.4	9.65

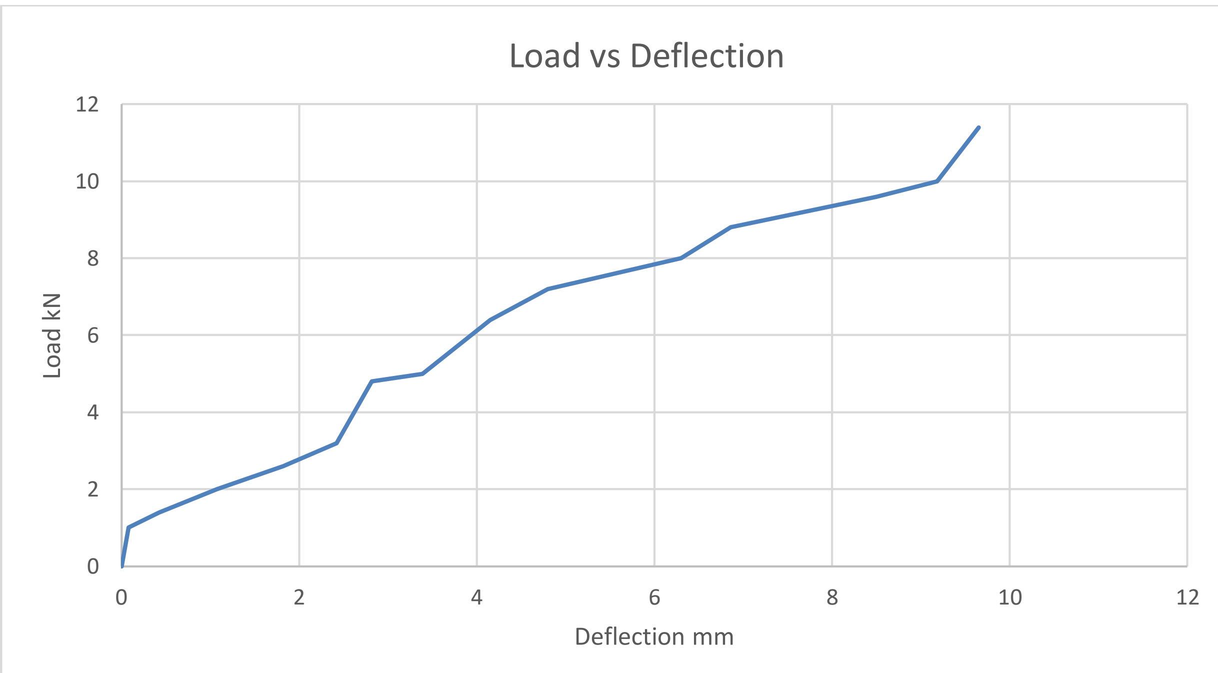


Figure 6.3 Load vs Deflection for specimen 2

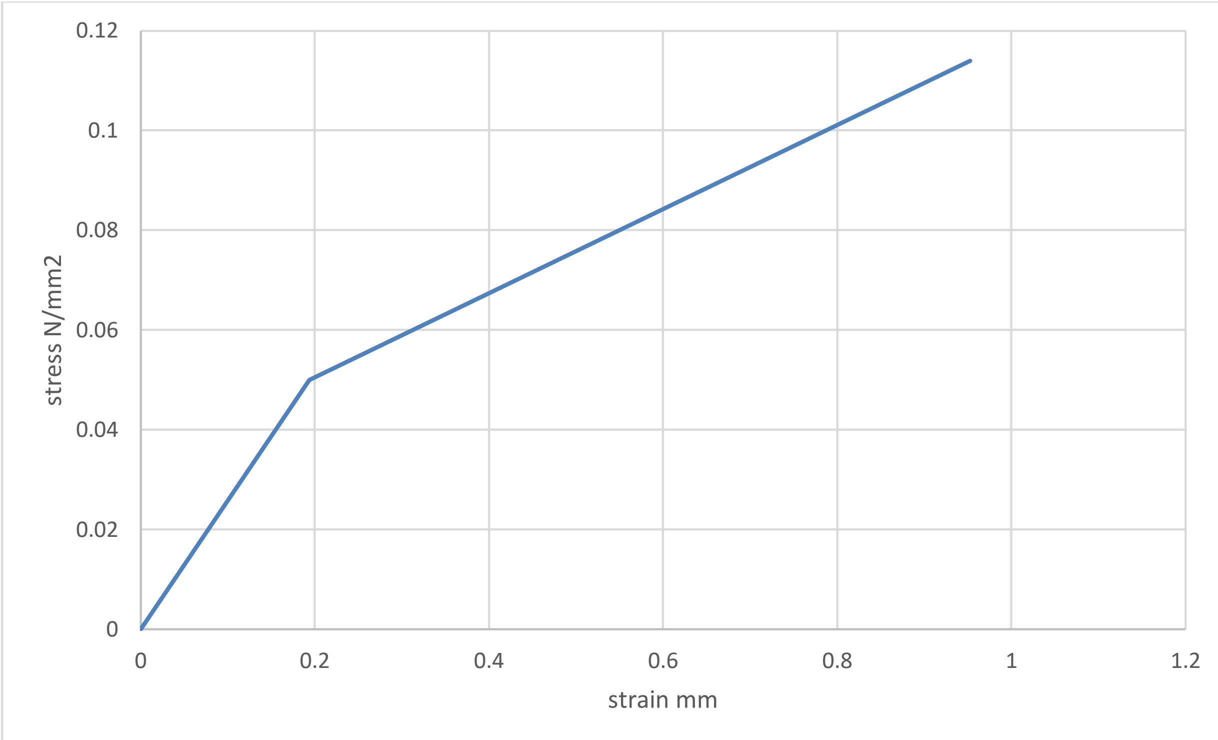


Figure 6.4 Stress strain curve for specimen 2

FOR SPECIMEN 3

Table 6.6 Load Vs Deflection for specimen 3

Load in kN	Deflection in mm
0	0
2	2.7
4.8	3.95
6.2	5.21
8	7
10.2	9.68
12.4	11.55

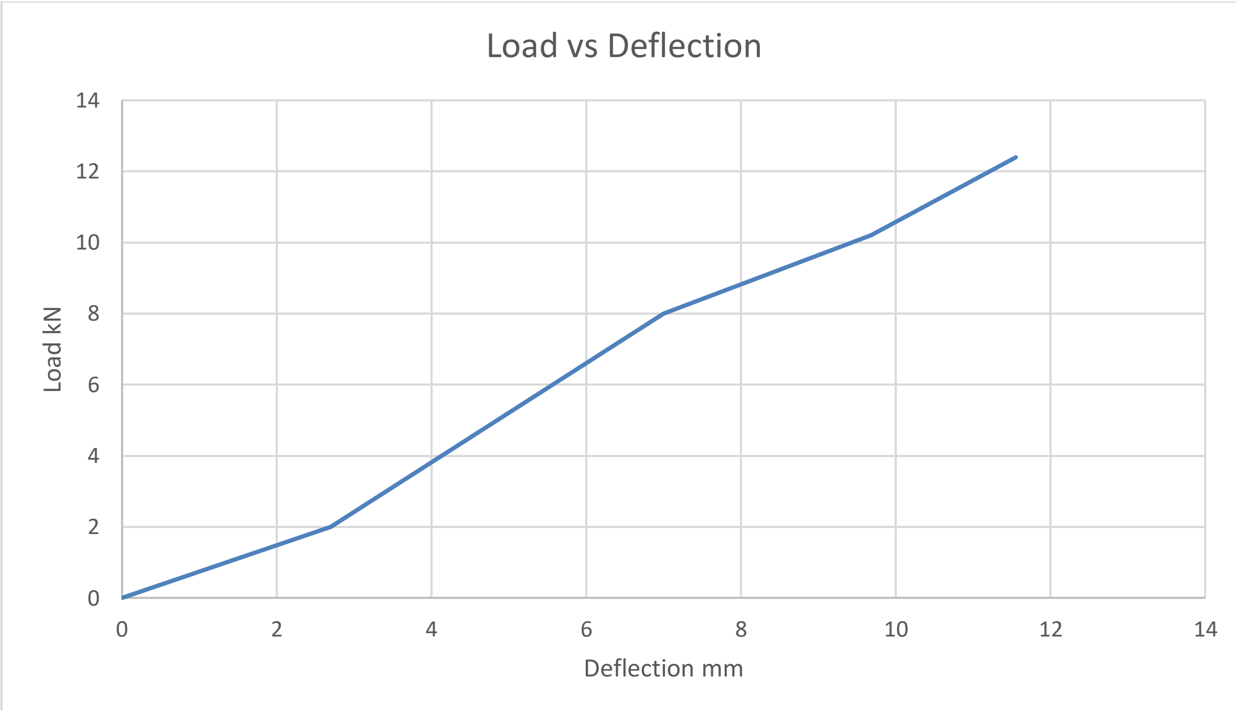


Figure 6.5 Load vs Deflection for specimen 3

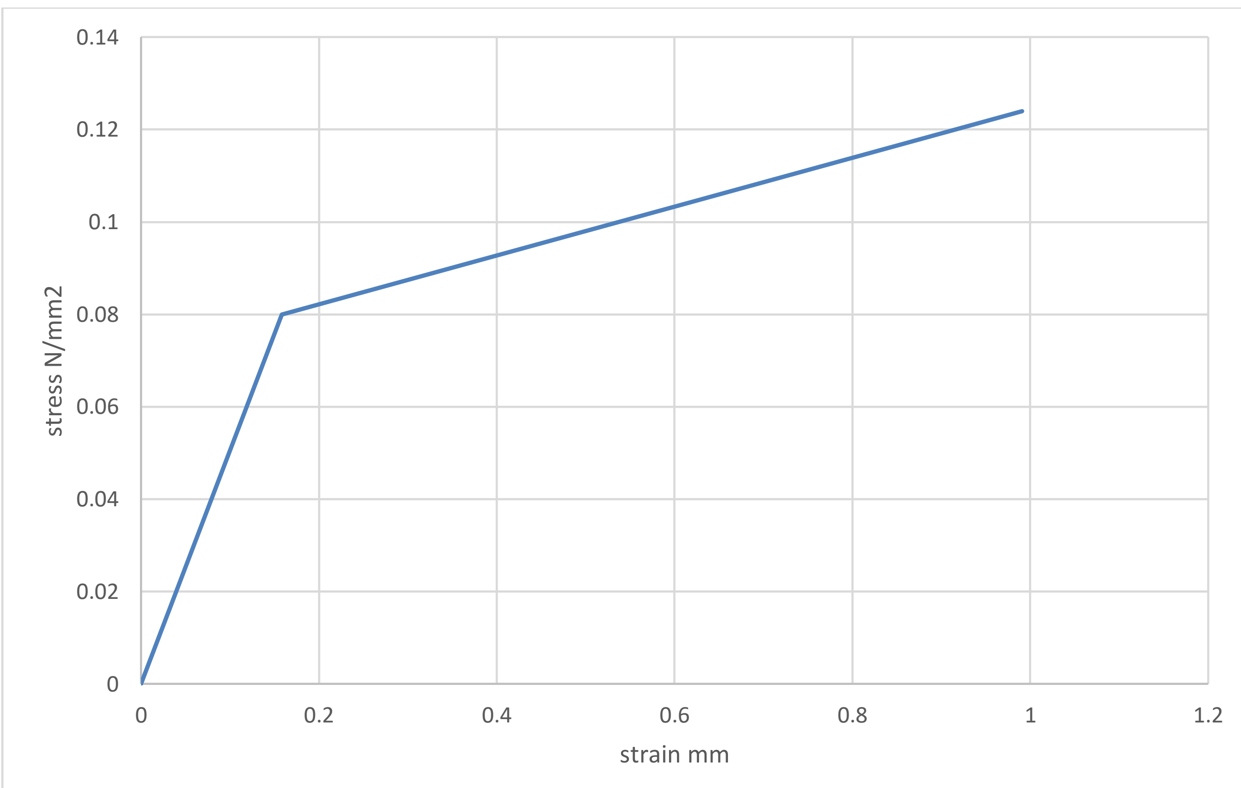


Figure 6.6 stress strain curve for specimen 3

6.5 TEST RESULTS OF BEAM AFTER CORROSION

Resistance, R (ohm)

$$R = \frac{V}{I}$$

V = Voltage in milli volts
I = Current in milli Ams

Initially v=592

I=520milli Ams

R=1.138ohm

Table 6.7 Results of Resistance

No. of Days	voltage(V)	current(I) milli ams	Resistance (ohm/cm^2)	Rate of corrosion mm
1	592	5.2	1.138	0
2	589	5.2	1.1327	0.003952
3	586	5.1	1.149	0.00408
5	582	5.1	1.1412	0.00408
6	579	5.1	1.135	0.00459
7	576	4.9	1.175	0.00459
8	570	4.7	1.21	0.004717
9	565	4.7	1.2	0.004717
10	558	4.6	1.21	0.004717
12	5.5	4.2	1.31	0.004717
13	5.38	4.1	1.312	0.004717
14	534	3.7	1.44	0.004717
15	532	3.7	1.44	0.004717
16	530	4.1	1.3	0.004717
17	527	4	1.32	0.004717
19	521	3.7	1.41	0.004845
20	518	3.8	1.363	0.004972
21	515	3.9	1.32	0.004972
22	501	3.9	1.28	0.004972
23	493	4	1.232	0.0051
24	487	4.2	1.16	0.0051
26	470	4.3	1.093	0.0051
27	463	4.1	1.13	0.0051
28	455	4	1.1375	0.005227

29	451	3.9	1.156	0.005227
30	444	3.7	1.2	0.005227
31	429	3.7	1.16	0.005355
33	425	3.7	1.148	0.005355
34	425	3.7	1.148	0.005355
35	418	3.6	1.161	0.005482
36	412	3.7	1.11	0.005865
37	409	3.7	1.105	0.005865
38	404	3.7	1.09	0.005992
40	390	3.7	1.054	0.005992

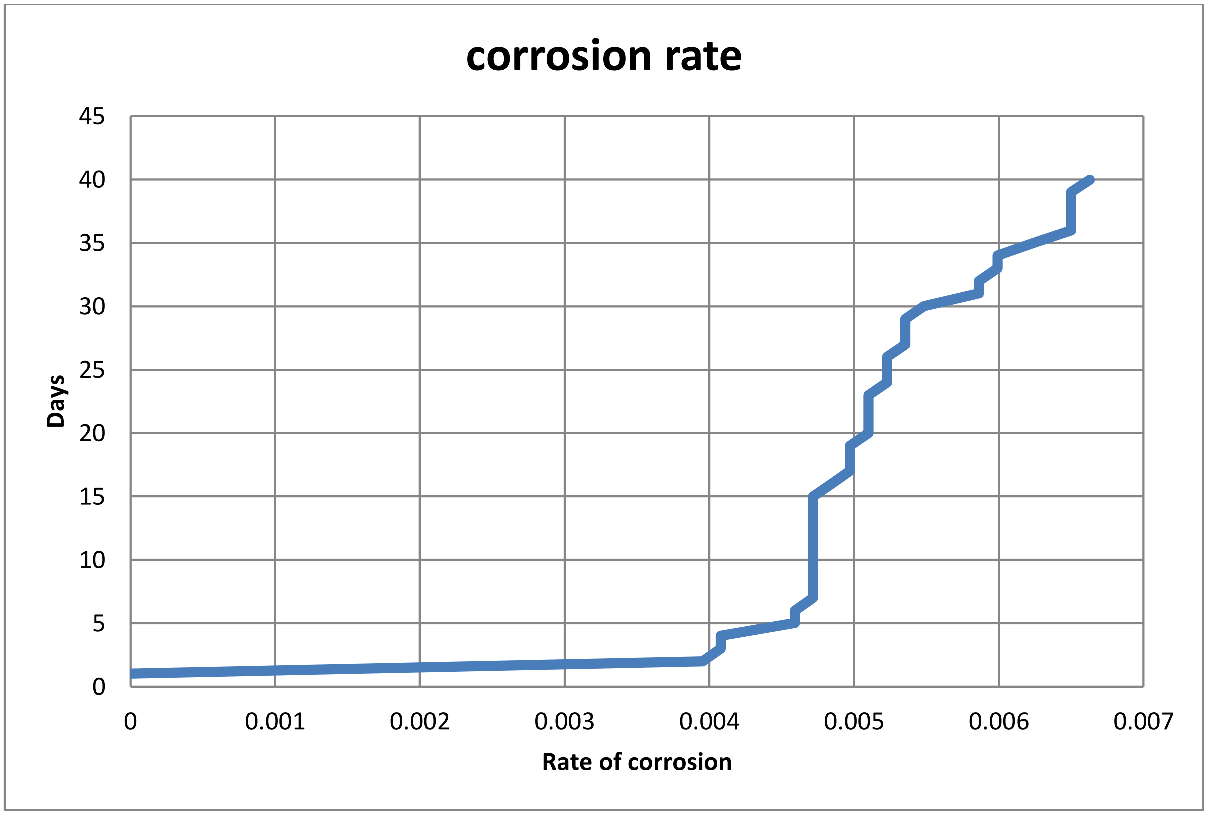


Figure 6.7 Rate of corrosion

6.5.1 LOAD CARRYING CAPACITY OF SPECIMEN AFTER CORROSION

The specimen tested after corrosion induced, the load carrying capacity of specimen are given below table.

Table 6.8 Result of specimen after corrosion induced

Specimen 1		**Specimen 2**		**Specimen 3**	
Load kN	Deflection mm	Load kN	Deflection mm	Load kN	Deflection mm
0	0	0	0	0	0
1.2	0.9	1.2	1.07	1.2	0.96
2.4	1.82	2.4	3.42	3.6	4.17
4.8	5.23	5.2	5.73	5.2	6.2
6.4	8.56	6.4	8.38	6.8	8.96
10.6	12.05	9.8	11.93	10.8	12.62

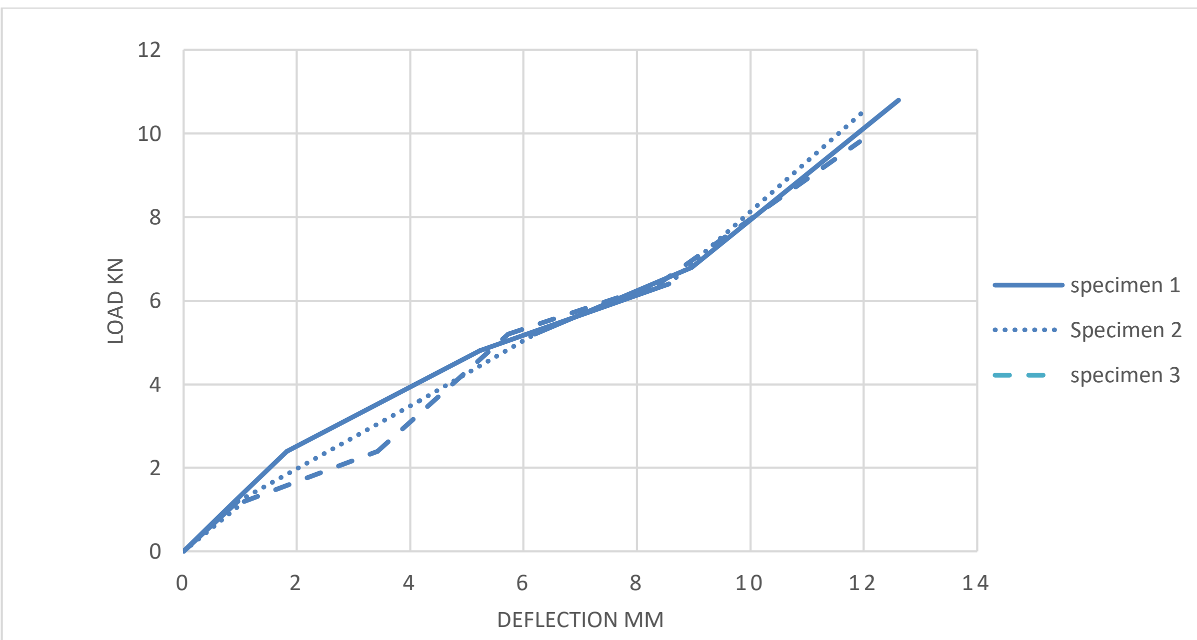


Figure 6.8 Load vs Deflection for corrosion induced specimen

6.5.2 CORROSION RATE

According to Faradays law the rate of corrosion has been calculated are given below.

Corrosion rate = $k1 * \frac{icurr}{p} * EW$

Where k_1 is 3.27×10^{-3}

i_{curr} is current in milli Ams

p is density of steel in g/cm^3

EW is equivalent weight

k1 = 3.27x10-3

I =5.20milli Ams

P =7.86 g/cm3

EW=55.84

$$icurr = \frac{\frac{5.20}{\pi}}{4} * 0.8^2$$

=10.62milli Ams/cm2

Corrosion rate = 3.27x10-3*10.62/7.86*55.845

= 2.13 mm/yr

Corrosion rate = 3.27x10-3*4.1176/7.86*55.45

= 0.8358

Final corrosion rate of nano-concrete beam = 2.13 - 0.8358

= 1.2942mm/yr

CHAPTER 7

CONCLUSION

- The effects of different ratios of Nano-Silica to cement content were well investigated, and the optimum ratio of 3% was reported
- The size of nanosilica particles are very less hence pore space in the concrete reduced.
- For the ultimate load, the beam have several number of minor cracks.
- The nano-concrete RC beam have maximum Deflection of 11.95mm for the ultimate load 12.4kN.
- The corrosion response of nano-concrete Beam after laboratory induced corrosion upto 40 days is 12.12%.
- The rate of corrosion has 1.294mm/yr
- The specimen tested after corrosion induced the load carrying capacity is reduced upto 21%.
- From the test result the nano-concrete beam more durable than the conventional concrete.

CHAPTER 8

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