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Study on the Behaviour of Nano Concrete Columns Wrapped with Glass Fiber Reinforced Polymer under Axial Load

Deenadhayalan R[1], Lavanya G[2]
[1]Department of structural engineering, Anna University Regional Campus, Madurai, Tamil Nadu, India
[2]Department of structural engineering, University College of Engineering, Ramanathapuram, Tamil Nadu, India

Abstract: An emerging field in materials science and engineering called nano science and technology is providing the framework for the creation of new technological materials. Numerous scientific and technical fields make use of nanotechnology. Concrete constructed from materials with nanoscale particle sizes is a unique type of concrete. A nanoscale has a range of 1 to 100 nanometers. A nanometer is one billionth of a meter. Fiber reinforced polymers have shown to be an effective substitute for modernizing and repairing damaged infrastructures. The failure trend may be caused by modifications to faulty design and construction practices. Glass fiber reinforced polymer wraps or laminates have shown to be a more effective solution for infrastructure applications. This study examined conventional columns, nano concrete columns, and nano concrete columns encased in glass fiber reinforced polymer under axial loads. In this study, three different kinds of concrete columns were utilized to evaluate the strength of concrete when various concentrations of nanosilica were applied. This experiment uses glass fiber reinforced polymer as its wrapping material.
Keywords: Column, Nano Silica, Nano Concrete, Glass Fiber Reinforced Polymer, Column under axial load, Epoxy resin, Sikacim pink.

I. INTRODUCTION

Nanotechnology is generally understood to be the knowledge, control, and reorganization of matter on the order of nanometers (i.e., less than 100nm) in order to generate materials with fundamentally new properties and functionalities. The meaning of "nanotechnology" differs by field and country.

Two sorts of nanotechnologies exist. Each has a top-down and bottom-up approach. The word "nano", which means "dwarf", is taken from ancient Greek. It stands for one billionth. Nanotechnology is the creation of new large scale materials using very small particles of materials. On the other side, a molecules size is crucial since, at the nanoscale 10 to 9 m length scale, materials characteristics undergo a significant change.

A nanometer is one billionth of meter. One billionth of meter is equivalent to one nanometer. The size range of the relevant particles is between 1 and 100 nanometers.

One nanometer (nm) is equivalent to 1 X 10^{-9} m. concrete can be improved by adding nanoparticles like nano silica, nano fibers and other nanomaterials to produce composites with better characteristics. The addition of nano silica (NS) to concrete and mortar improves the effectiveness of cement hydration.

Pozzolanic activity causes the additionally, this lessens the need for cement. If at least one dimension of group of substances is fewer than 100 nanomaterials, the group is referred to as nanomaterials. Because they display remarkable optical, magnetic, electrical, and other properties at such a small scale, nanomaterials are fascinating. The electronics, health and other fields could be greatly impacted by these emerging qualities. Concrete is made with nanomaterials such carbon nanotubes, nano silica and polycarboxylates.

II. MATERIALS AND METHODS

A. Cement

Cement is a cohesive and sticky bonding agent that may be used to join together diverse building materials to create compacted assemblies. The compressive strength of the mortar cube after 28 days is specified by the cement grade at 53 N/mm^2. Cement of the OPC 53 grade is utilized in this experiment.

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TABLE I
PROPERTIES OF CEMENT

Properties	Values
Colour	Dark Gray
Setting time • Initial • Final	 30 minutes 10 hours
Specific gravity	3.12
Fineness	2.5%

B. Coarse Aggregate

Aggregates are larger than 4.75mm or that has been retrained using a 4.75mm IS sieve is referred to as coarse aggregate. Tests will be performed in accordance with IS 383 – 1970 to identify the various physical properties of a coarse aggregate with a nominal size of 20mm. this experiment makes use of 20mm coarse aggregate.

TABLE II
PROPERTIES OF COARSE AGGREGATE

Properties	Values
Particle size	Angular
Specific Gravity	2.70
Water absorption	22.03%
Impact value	39%

C. Fine Aggregate

M-sand is a specially constructed, finely crushed aggregate made from the right raw materials. The parent rock has an impact on the sands chemical, mineral, texture and compositional characteristics. Sand that is manufactured has particles that are smaller than 4.75mm. M-sand is utilized as a fine aggregate in this experiment.

TABLE III
PROPERTIES OF FINE AGGREGATE

Properties	Values
Surface texture	Smooth
Zone type	Zone II
Specific gravity	2.62
Water absorption	10.15%

D. Water

Water usage is required for construction. Water used for construction and curing should be free of salts and solid debris. A pH of less than 6 should be present in water. Portable water was used throughout the experiment in compliance with IS 456: 2000 criteria.

E. Nano Silica

Amorphous silica powder with a high purity is used to create the white, fluffy powder known as nano silica. The amount of micro silica that must be provided is extremely small. Nano silica functions as a versatile additive. When nano silica is added to the slurry, the thickening period is shortened, the compressive strength is raised, the cements porosity and permeability are decreased, and the amount of fluid lost is decreased. The inclusion of nano silica ensures the integrity of the wall and optimal cementation. Nano silica reduces the amount of time needed to wait for cement, which lowers the overall capital cost. Specific gravity of nano silica is 2.30

TABLE IV
PROPERTIES OF NANO SILICA

Properties	Values
Colour	white
Form	amorphous
Particle size	17nm

Fig. 1 Nano Silica

F. Glass Fiber Reinforced Polymer

Glass fiber reinforced polymer sheets are placed externally by attaching them to concrete surfaces. Fiber reinforced polymers are finished products created by incorporating fibers into a resin. One uses epoxy resin, outstanding chemical, water and heat resistance are all present. Epoxy resists temperature changes and has a good binding strength. Glass fiber of the E-glass type is utilized in this experiment. It uses this kind of glass fiber. Good impact and tensile strength as well as high chemical resistance are all characteristics of these glass fibers.

TABLE V
PROPERTIES OF GLASS FIBER REINFORCED POLYMER SHEETS

Properties	Values
Density of fiber	2.5 g/cm^3
Thickness of fiber	2 mm
Tensile strength of GFRP	3450 N/mm^2
Modulus of Elasticity	72400 N/mm^2

Fig. 2 Glass Fiber Reinforced Polymer Sheets

Fig. 3 Epoxy Resin

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G. Super Plasticizer

In this experiment a super plasticizer called sikacim pink is employed. Without adding more water, it makes things easier to work with. Super plasticizer sikacim pink is based on polycarboxylate ether.

TABLE VI
PROPERTIES OF SUPER PLASTICIZER

Properties	Values
Colour	Pink
Appearance	Hazy liquid
Density	1.21 at 25^0C
pH value	7

Fig. 4 Super Plasticizer (Sikacim Pink)

H. Mix Design

The mix design was developed using the ACI methodology. In this experiment, concrete of the M50 grade is employed. Cement: M-sand: Coarse aggregate: super plasticizer: water (1: 1.66: 2.47: 0.01: 0.34). The fresh concretes slump value is 100mm, and the water to cement ratio is 0.34.

TABLE VII
MIX DESIGN

Cement	446.50 kg/m^3
Water	151.81 kg/m^3
Fine aggregate	742.47 kg/m^3
Coarse aggregate	1100.76 kg/m^3
Super plasticizer	4.47g/m^3

III. EXPERIMENTAL INVESTIGATION

In this experiment, three distinct kinds of columns are cast and tested. These columns come in three different varieties, regular column, nano silica column and nano silica columns wrap with glass fiber reinforced polymer. This column is 750mm X 150mm X 150mm in size and is intended as a column with 4 No's of 12mmϕ steel bars and 8mmϕ rinks spaced @ 150mm apart. The columns were made using concrete of grade M50, steel of grade Fe500, cement of grade OPC 53, grade of sand is M-sand and coarse aggregate of size 20mm. For longitudinal reinforcement, high yield strength deformed (12mmϕ) bars are used, whereas 8mm bars are used for rinks.

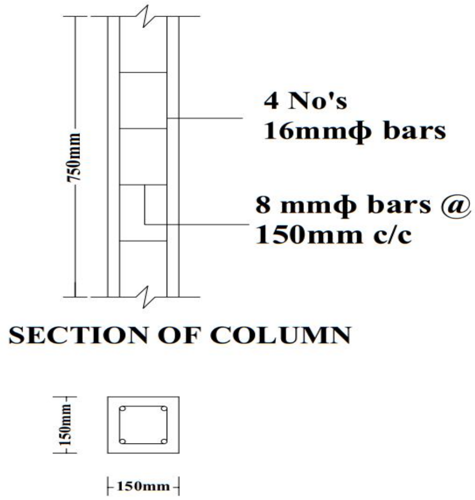

Fig. 5 Plan and Section of column


Fig. 6 Mix of concrete


Fig. 7 compacting and curing of concrete


Fig. 8 Reinforcement Work of Column

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IV. RESULTS AND DISCUSSION

A. *Compressive Strength of Concrete*

A concrete cube measuring 150mm X 150mm X 150mm was produced using a mix ratio of 1: 1.66: 2.47 and water cement ratio of 0.34, with 0.5 percent, 1 percent and 1.5 percent of nano silica replacing the cement, OPC 53 grade cement is employed. After 24 hours, the specimens were taken from the mould and allowed to cure in water for 28 days. During the moulding process, the cube was damping rod vibrating are employed for compaction purposes. A compression testing machine with a 2000kN capability was used to assess the specimen's concrete compressive strength after curing.

TABLE VII
COMPRESSIVE STRENGTH OF CONCRETE

Replacement of nano silica (%)	Average compressive strength of concrete at 7 days (N/mm^2)	Average compressive strength of concrete at 28 days (N/mm^2)
0	34.44	51.33
0.5	33.85	52.30
1	35.56	53.48
1.5	34.15	52.37

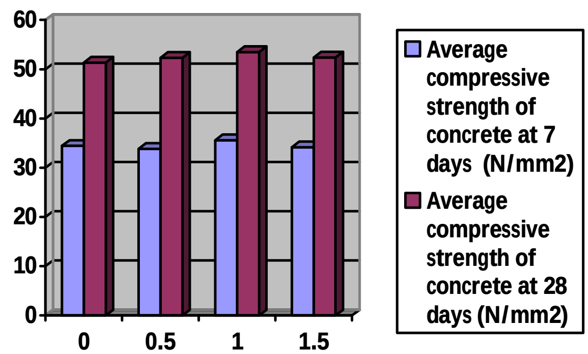

Fig. 9 Compressive Strength of Concrete

Fig. 10 Compressive Strength of Concrete Test

B. Split Tensile Strength of Concrete

The diameter of the cylinder mould is 150mm and its length is 300mm. In this test, compressive live loads were applied in a vertical, symmetrical plane, dividing the specimens that had been cast for split tensile strength. Three specimens were tested, and the average split tensile finding was obtained. The samples were assessed for 400kN capacity universal testing equipment.

TABLE IIX
SPLIT TENSILE STRENGTH OF CONCRETE

Replacement of nano silica (%)	Average split tensile strength of concrete at 7 days (N/mm^2)	Average split tensile strength of concrete at 28 days (N/mm^2)
0	3.28	5.50
0.5	3.45	5.73
1	3.85	6.25
1.5	3.62	5.99

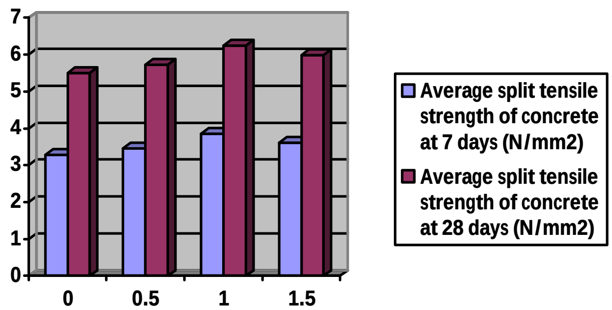

Fig. 11 Split Tensile Strength of Concrete

Fig. 12 Split Tensile Strength of Concrete Test

C. Compressive Strength of Column

Fe500 grade steel and M50 grade concrete were used to cast a 750mm X 150mm X 150mm concrete column. The column was produced utilising 4 No's 12mmϕ and 8mmϕ rinks spaced 230mm apart. Using a water cement ratio of mixing is 0.34 and a concrete mix ratio of 1: 1.66: 2.47. These specimens were created with OPC 53 grade cement, but 1% of the cement was used. The specimens in this column were removed from the mould after 24 hours and allowed to cure in water for 28 days. Damping rods were employed for compaction during the moulding process. A 2000kN capacity compression testing machine was used to gauge the sample concrete compressive strength after curing.

TABLE X
COMPRESSIVE STRENGTH OF COLUMN

Designation	Ultimate load on column (kN)
Conventional column	630
Nano silica column	680
Nano silica column wrap with GFRP	1260

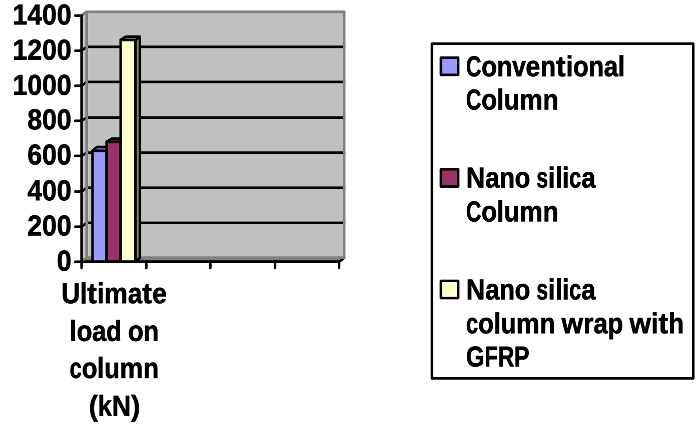

Fig. 13 Compressive Strength of Column

Fig. 14 Compressive Strength of Column Test

V. CONCLUSIONS

The experiment led me to conclude that nano silica may effectively replace cement in construction projects. When cements nano silica is partially replaced, 1% is the best proportion of replaced nano silica in M50 grade concrete. The maximum compressive strength of concrete with a 1% nano silica replacement reaches its peak after 28 days of curing. 53.48 N/mm^2 is the compressive strength of concrete after 28 days. The maximum split tensile strength of concrete with 1% nano silica substitution reaches its peak after 28 days of curing. Concrete has a 6.25 N/mm^2 split tensile strength. The highest compressive strength of the column with 1% of nano silica replacement column wrap with GFRP exhibits the optimal percentage in 28 days of curing time when compared to conventional column, nano silica column, and nano silica column wrap with GFRP. After 28 days, the compressive strength of a GFRP column wrapped in 1 percent nano silica is 1260 N/mm^2.

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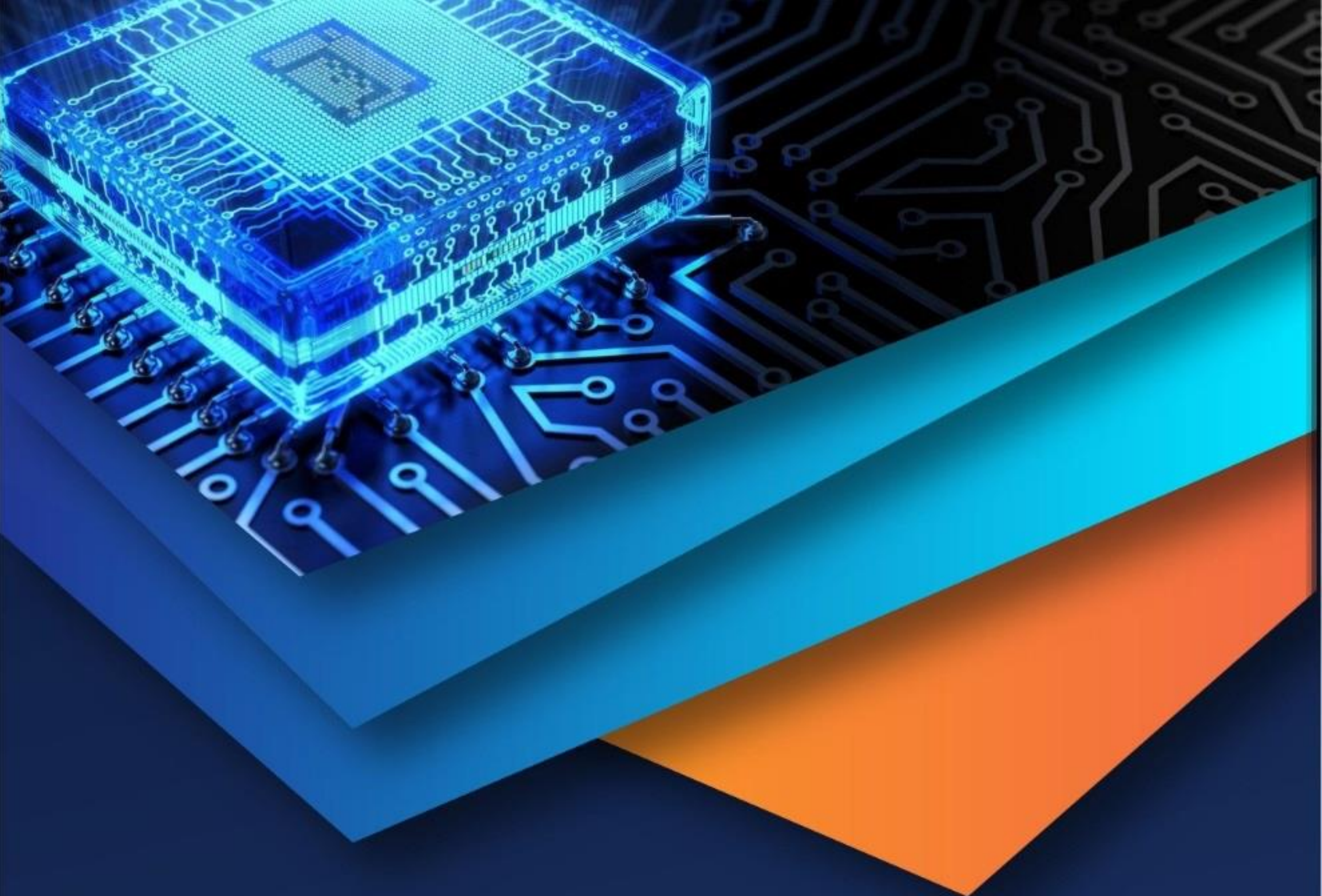

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