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EXPERIMENTAL STUDY ON RIGID PAVEMENT BY USING NANO CONCRETE

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Abstract - - Now day construction of highway, bridges and where strength is major issue there Nano concrete are used because Nano concrete is new emerging material which improve all qualities of concrete and also this is chemical resistance concrete and very durable concrete. pavement design require the bending strength, of the concrete as a primary design input In this paper is on comparative study of conventional concrete and Nano concrete pavement we take indirect test like compression test, split tensile test, flexure test, and durability test is studied by experiments because of direct test on specimen is very difficult. Nano concrete is prepared by mixing Nano silica and Graphene in high performance concrete (M40). A finite element model of conventional and Nano concrete pavement is established for static loads in ANSYS workbench 19.2. By interchanging properties of concrete to Nano concrete deformation stress distribution of pavement is determined, it is experimentally observed that Nano concrete has is higher capacity in tension, compression, flexure as compared to conventional concrete. Results of Finite Element Model showed performance of Nano concrete pavement is better than conventional concrete pavement

Key Words: Nano concrete; Industrial Graphene; Nano-silica; Nano-concrete Pavement; Finite Element Modelling.

1. INTRODUCTION

Nano material is a new emergent material in market .Which mix in concrete to improve all mechanical properties like flexure strength, tensile strength, porosity etc. The country like India where climatic condition are very harsh and very high traffic volume then there required very durable and high strength concrete. Hence, Nano concrete, which is, alter the all properties of concrete like workability, permeability, abrasion resistance etc. Rigid pavement means they do not flex and it take wheel load safely and uniformly distribute to subgrade soil.

Nano particle(silica and Graphene) having size is less than 500μm this particle fills voids in cement and concrete is became more dense and also improve bond strength Between aggregate .Dr. C.B.POLSir and A. BIRAJDAR give suitable Nano silica and Graphene content percentage.

From several literature it is seen that they take Nano material as Nano silica, Nano clay, carbon Nano tubs, Nano Titanium, Graphene and graphene oxide etc. and they check their strengths and durability but in my present study we take silica with graphene with suitable percentage form Nano concrete and these tested under strength and durability test and also compare their economy.

2. OBJECTIVE OF WORK

In modern days, roads are always important for progress of nation wealth. The rigid pavement require high strength and durability, also economical that's why Nano concrete is enhance mechanical strength, and durability is verifying this research paper. The comparative study of conventional and Nano concrete pavement under static load in FEM in ANSYS software and We take indirect test like compression test, split tensile test, flexure test, and durability test is studied by experiments because of direct test on specimen is very difficult and there is used M_{40} grade of concrete.

3. LITERATURE REVIEW

Gonzalez, de Oliveira Lima, and Tighe (2014): In this paper, high-quality concrete is credited with improving both abrasion and macro texture durability under moving loads. By affecting the deterioration mechanism at the molecular level, a micro texture change using nanotechnology improves the friction response in stiff pavements and increases the longevity of concrete materials. The findings suggest that Nano silica has a positive impact on the environment.

Anwar M. Mohamed (2014): In this research, we investigated how using Nano particles can improve flexure strength by up to 4% and 8% at 90 days for NS and NC, respectively, due to the filler activity of Nano particles, which increases the link between the aggregate and the cement. N's moist mixture.

Muhammad Atiq Orakzai (2020): The influence of a binary combination of Nano-alumina (nano-Al2O3) and Nano-titanium dioxide (nano-TiO2) on the mechanical characteristics of concrete y is investigated in this work. The compressive, splitting tensile and flexural strength increase by 42 percent, 34 percent, and 28 percent, respectively, when compared to the control sample. SEM and XRD tests were used to make this decision.

Guruvignesh.N,Lavanya.G2 (2020): In this study, the pavement thickness is optimized using IRC58 based on the various experimental findings. The static response analysis of a concrete pavement lying on a liquid foundation is

included in this work. The ANSYS programme was utilized for three-dimensional modelling of the pavement, and the results were compared to Westergaard's research. The research reveals that the finite element tool is trustworthy.

4. Material

4.1 Cement

The cement grade OPC 53 is used and they free from lumps and its specific gravity is 3.14, consistency is 30%, its initial and final setting time is 130min and 270 min respectively

4.2 Fine Aggregate

Fine aggregate (crush sand) is in zone two, which is locally available. Its specific gravity is 2.8 and maximum size is4.75mmm

4.3 Coarse Aggregate

Coarse aggregate is passing through 20mm Sieve and retained on 12.5mm sieve is used and its specific gravity is 2.98.

4.4 Nano Silica

The hydrolysis of tetra ethoxysilane in ethanol with ammonia as catalyst then Nano silica is form and having density is 2.7and pH is3.7 to 4.7.

4.5 Graphene

The extraction of carbon then Graphene Nano particle are obtain and having specific gravity 1.9,testless, odorless, Black in color,. They do not directly mix with concrete but it mix with water before one day casting

4.6 Superplasticizer

Currently available on the market Sulphonated naphthalene polymers are used as a water-reducing additive in Forsook to improve the workability of new concrete for specific quantities of constituents and its specific gravity and its dosage is 1.2 and 1.2% of cement respectively

4.7 Water

Water used to make concrete should be clean and free of dangerous contaminants such as oil, alkali, acid, and other chemicals. Casting and pH are done with locally available potable tap water is seven.

5. Mix Design

The process of selecting appropriate ingredients for concrete and determining their relative proportions with the goal of achieving a particular maximum strength as minimum economy as possible is known as mix design. For concrete, a design technique was developed that adhered to Indian standards (IS 10262-2019). Mix design for standard M40 concrete with graphene and Nano silica added to form Nano concrete.

Table 1: Proportion of Mix Design oi Nano and Conventional Concrete

Ingredient($\frac{kg}{m^3}$)	Conventional Concrete Mix(M40)	Nano Concrete
Cement	450	450
Fine Aggregate	585	585
Coarse Aggregate	1305	1305
Superplasticizer	3	3
W/C ratio	0.4	0.4
Graphene	0	0.2
Nano silica	0	6.75
Water	148.8	148.8

6. FINITE ELEMENT MODEL

For FEM analysis of pavement is in ANSYS Workbench 19.2. In the present work, we have taken 3500mm x 4500mm; Lane of rigid pavement M40 grade of concrete is used

6.1. Material Properties

Table 2: Material properties of Nano and Conventional Concrete

Properties	Conventional Concrete Pavement	Nano Concrete pavement
Young's Modulus Of Elasticity	31622.747 Mpa	37080.99 Mpa
Poisson's Ratio	0.16	0.15
Coefficient Of Thermal Expansion	1.19×10^{-5} /°C	1.2×10^{-5} /°C
Ultimate Compressive Strength	40 Mpa	55Mpa
Density	$23KN/m^2$	$24KN/m^2$

6.2. Boundary Condition

Generally, rigid pavement is resting on soil means it is the elastic foundation and having a stiffness is 24 KN/mm3, the transverse direction of two ends of pavement, is supported because of its continuity, while the longitudinal direction of pavement is free.

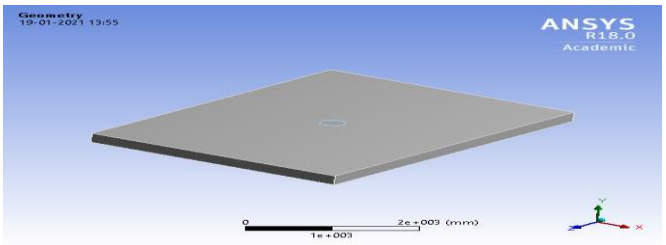

Fig 1: Plane of Rigid Pavement

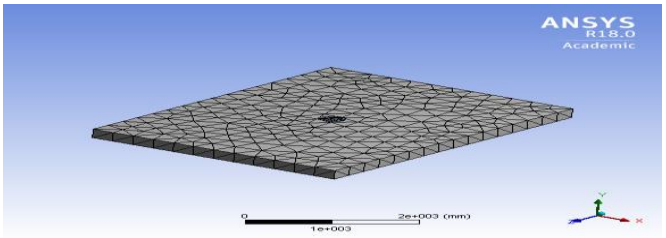

Fig 2: Meshing

6.3. Loading condition

The pavement design is based on an equivalent single axle load as per IRC recommended is less than 10000 kg; in this model, we apply static single wheel load at the center of the lane

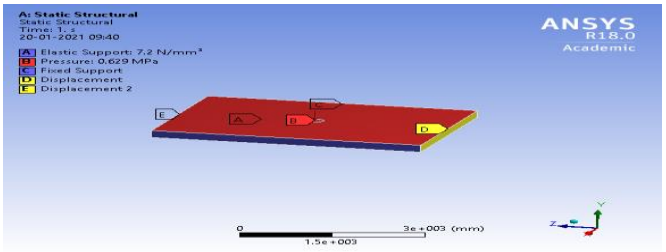

Fig 3: Loading condition diagram Of Pavement.

6.3. Static Stress Analysis result

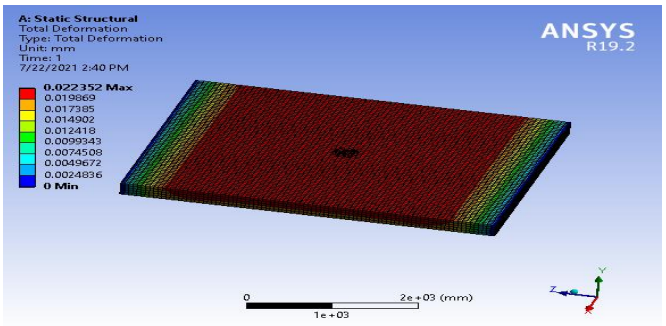

Fig 4: Deflection Diagrams of CCP

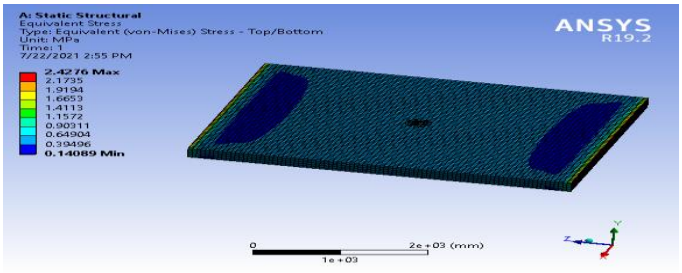

Fig 5: Stress Diagram of CCP

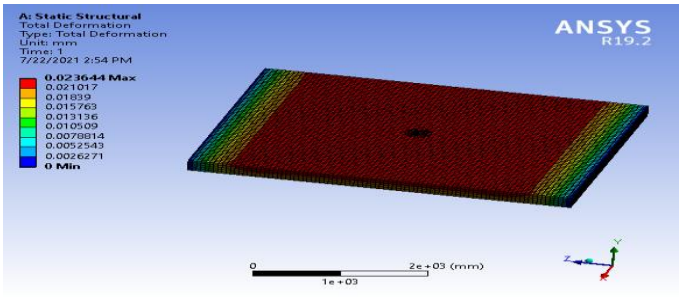

Fig 6: Deflection Diagrams of NCP

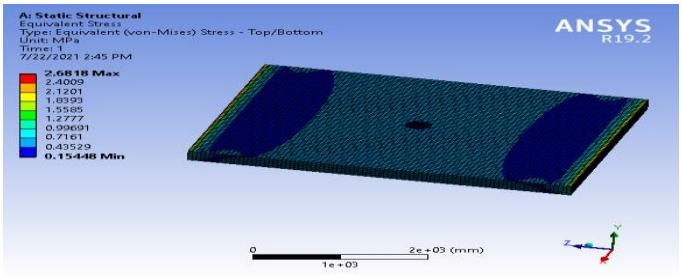

Fig 5: Stress Diagram of NCP

From the above analysis, we conclude that Nano concrete will reduce the deflection due to its high strength. Nano concrete pavement (NCP) will reduce thickness as compared to conventional concrete pavement (CCP).

7. EXPERIMENTAL WORK

we take an indirect test like compression test, split tensile test, flexure test, and durability test is studied by experiments because of direct test on the specimen is very difficult, and there is used M_{40} grade of concrete and comparison the result

7.1. Compression Test

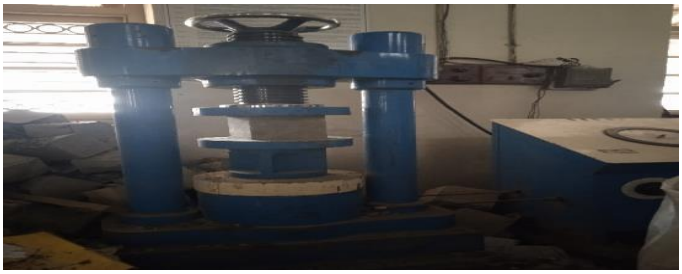

Fig 8 : Copressive Testing Machine

This test having 150mm*150mm*150 cube mold test is taken on CTM of M40 grade of concrete and load is applied gradually at the rate 140kg/cm^2 and the concrete strength is tested after 7days and 28 days curing.

Table 3: Compression test result

Mix Design	Graphene (%)	Nano Silica (%)	Average 7Days Strength	Average 28 Days Strength
Conventional concrete	0	0	30.77	47.2
Nano Concrete	0.05	1.5	39.14	60.03

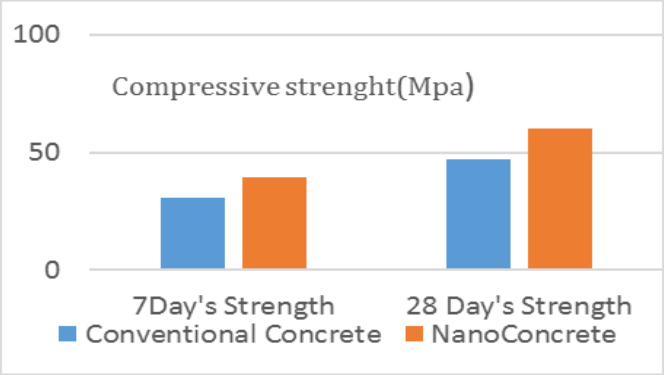

Fig 9: Comparison compressive strength result

It is seen that, compressive strength of Nano concrete is much more than conventional concrete because of Nano material improve rate of pozzolanic reaction due to large surface area and Nano silica acting as packing material.

7.2. Split Tensile Test

It is an indirect tensile strength test of concrete and it is called true tensile strength of concrete. In this test cylindrical mold having, size 100mm Diameter and 200mm length and load is applied on cylindrical specimen is compressible but failure of concrete is in tension and loading rate is 1.2 to 2.4N/mm^2/min.

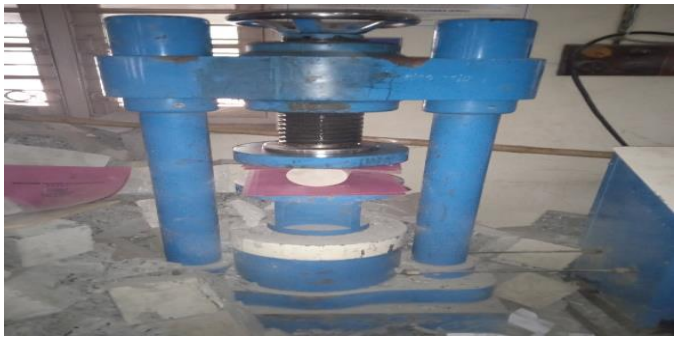

Fig 10 : Copressive Testing Machine

Table 4: Split Tensile Test Result

Mix Design	Graphene (%)	Nano Silica (%)	Average 7 Days Strength	Average 28 Days Strength
Conventional Concrete	0	0	3.06	4.710
Nano Concrete	0.05	1.5	4.356	6.702

From the above result we conclude that, Nano concrete enhance tensile strength than Conventional concrete Because of Nano Material fill the micropoures in the cement past and reduse the porocity

7.3. Flexure Test

Flexural strength is nothing but resistance of concrete against bending. It also called indirect tensile strength of concrete. This test on unreinforced concrete beam of size 100mmx100mmx500mm.It is measure resistance of concrete under bending. Load is applied on beam is two point load 1/3rd of length from each end and simply supported at two end

Fig 11: Universal Testing Machine

Table 5: Flexural Test Result

Mix Design	Graphene (%)	Nano Silica (%)	Average Strength 28 Days (Mpa)
Conventional concrete	0	0	4.81
Nano Concrete	0.05	1.5	6.94

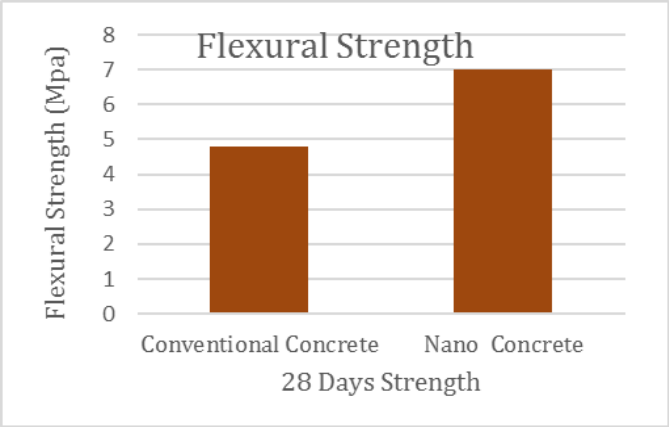

Fig 12: Comparison Flexural strength result

7.4. Abrasion Test

Abrasion is the resistance of surface against wearing action of contact surface. Grinding path of abrasion testing machine shall be evenly strewn with 20 gm of standard abrasive powder aluminum oxide and centrally loaded with 294 N. Grinding disk is rotating at 30 rpm, for 1 cycle, grinding disk revolve 22 revolution, and after 1cycle pavement block is rotating at 90 degree in horizontal plane. This test are repeated with 16 cycle then loss of volume is determine.

Fig 11: Abrasion Testing Machine.

Table 6: Abrasion Test Result

Mix Design	Graphene (%)	Nano Silica (%)	Abrasion loss(cm3)
Conventional Concrete	0	0	44.6
Nano Concrete	0.05	1.5	32.78

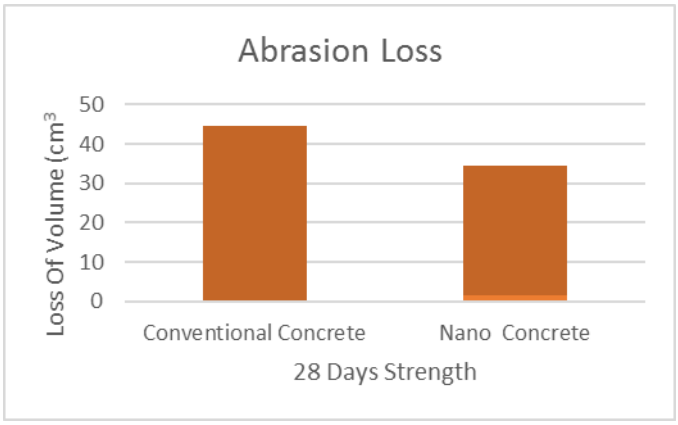

Fig 12: Comparison Abrasion strength result

CONCLUSIONS

1. From the test, result Nano concrete more better strength in compression, tension and flexural strength than conventional concrete by 27.18%, 42.29%, 44.28% respectively. Moreover, Nano Concrete reduce loss volume in abrasion test by 26.5% because due to pozzolanic reaction with calcium hydroxide, the amount of C-S-H gel is increase. Resulting higher densify the matrix. Hence for design of pavement strength and durability is very essential then there we use Nano concrete
2. From ANSYS FEM Analysis Nano concrete pavement reduce the deflection by 9.98% than conventional concrete pavement and also reduce the thickness of pavement Ultimately we save concrete material
3. The initial Cost of Nano concrete is high but this cost is overcome in life of structure because Nano concrete is very durable

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