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THEORETICAL MODELING OF POST-TENSIONED NANO-CONCRETE SLAB

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Abstract - *Post-Tensioning allows almost any shape of structure to be constructed, while reducing environmental impacts, construction time, material and costs. In this paper an attempt is made for theoretical modeling of Post-Tensioned Nano-concrete slab. Finite element analysis of Post-tensioned slab is carried out to compare load deflection characteristics of ordinary PT slab and Nano- concrete PT slab. By interchanging properties of concrete to Nano concrete deformation of PT nano concrete slab is determined and compared with PT concreteslab. From analytical results it is evident that Nano concrete PT slab has higher load carrying capacity compared to ordinary concrete PT slab. Results of Finite Element Model showed performance of Nano concrete PT slab is better than conventional PT slab.*

Key Words: Nano concrete; Industrial Graphene; Nano- silica; Post-tensioned nano-concrete slab; Finite Element Modeling.

1.INTRODUCTION

PT techniques are widely used in concrete to prevent cracking and minimize the deflection which is resulted by externally applied load. Stresses are transferred after concrete pouring and reach required hardening and strength. The tendons are placed inside ducts before pouring of concrete, after the hardening of concrete, stressing jacks must be used to stress each tendon to the required load. To ensure the initial-posttensioning forces, all tendons must be anchoraged at the member ends.

2. OBJECTIVE OF WORK

The objective of this work is to develop theoretical modeling of Post-tensioned Nano-concrete slab and compare the performance with conventional concrete Post-tensioned slab using ANSYS workbench 19.2

3. LITERATURE REVIEW

Abbas H. Mohammed et al. (2018) This paper investigates the structural behaviour of PT two-way concrete slabs. The main objective of this study involves a detailed flexural behavior analytical investigation of PT concrete two-way slab with the different bonded tendon layout. This will be achieved by non-linear Finite Element (FE) analysis programs method, to choose the most effective and optimum position of tendon layout with different number of tendons and applied load on the concrete two-way slab. A parametric study was conducted to investigate the effect of tendons layout on the overall behavior of post-tensioned twoway concrete slab. The result obtained from finite element analysis showed that the failure load in PT in both directions increased about 89 % as compared with slab PT in one direction.

Min Sook Kim and Young Hak Lee (2019): This paper discusses the experimental results on the flexural behavior and deflections of posttensioned concrete flat plates depending on tendon layout. One-way and two-way posttensioning layouts both showed similar maximum load. However, serviceability improved with two-way posttensioning layout compared to one-way posttensioning layout. Also, the yield-line theory was applied to predict the ultimate load for the posttensioned flat plates. The comparison between the test results and estimation by yield-line analysis generally showed good agreement.

Chen et al. (2018**)**: This paper evaluates shrinkage properties and mechanical behaviour of concrete containing graphene. Sample specimens were casted by addition of graphene oxide in various percentages. The results indicate that GO were increase compressive strength by 4.04–12.65%, 3.8–7.38%, and 3.92–10.97% at age of 28 days, flexural strength increase by 5.02–21.51%, 4.25–13.06% at the age of 3 days, and elasticity modulus of concrete increase by 6.07–27.45%. It was also found that GO can also enhance the shrinkage strain of concrete mix.

Mani and Nandini Devi (2017): This paper discusses the behaviour of concrete containing Nano Silica, CNT and Nano Titanium Dioxide of size smaller than 500nm. The tests conducted on cubes, cylinders and prism shows increase in compressive, split tensile and flexural strength. They carried out test for various %of silica and reported that 3% in optimum for Nano silica. Results also show that resistance to permeability and corrosion is higher for concrete containing Nano-Silica than ordinary concrete. There is reduction in workability of concrete by increase in percentage of silica fume. From results it is concluded that durability and corrosion resistance of concrete improved by mixing of Nano-silica.

H. O. Shin et al. (2016): In this paper author studies the changes in properties of slabs by using various fibres as reinforcement. The fibres used for reinforcement are steel fibres and blast furnace slag. Results of tests conducted indicate 56% replacement of slag as optimum percentage as at 56% replacement mix shows optimum results than other mixes. The mix of concrete with replacement of slag as 56% also shows lesser emission of carbon dioxide than the other mix. Results also indicates that when steel and GGBFS is mixed combine the properties resulted will be better than that of mix containing GGBFS only.

4. NANO-CONCRETE

Nano-concrete is a concrete produced by filling pores in conventional concrete by particles of size less than 500nm. When concrete is reduced to Nano level there properties are greatly influenced.

Why Nano-concrete for slab?

1. To increase load carrying capacity of so that to transport higher loads.

2. To obtain thinner sections of concrete slab.

3. Reduce the cost,.

4. To increase corrosion resistance.

5. Nano-concrete increases effective length of Prestress.

In this research we are going to use Graphene and Nano silica as Nano additives. Previous studies show that addition of Addition of Graphene and Nano silica improves the compressive strength as well as tensile strength of concrete. It also increases the young's modulus of concrete. Nano concrete reduces the transmission length in Prestress concrete. Effective Prestress value is more for conventional concrete.

Nano Silica

Laboratory experiments show that Nano silica particles can be obtained by sol-gel process from the hydrolysis of tetra ethoxysilane in ethanol with use of ammonia as catalyst. Particle size of Nano silica can be governed by use of alcohol as solvent and changing reaction temperature.

Table1: Characteristics of Nano-silica

Characteristics	Value
1. Density	2.7
2. PH	3.7-4.7
3. SiO2 Content	>99.8% by wt.

Graphene

Graphene has had very thin layer of carbon, has a higher SSA, high Young's modulus of elasticity, higher thermal conductivity and greater electrical conductivity. These properties make graphene important nanomaterial in applications of reinforced concrete.

Graphene can be defined as single film of carbon atoms organized in a hexagonal lattice. Graphene is fundamental building block for graphite materials of all dimensions.

Graphene Nano particles are the extraction of carbon, which improves the strength of concrete, but graphene material does not mix properly with concrete directly, before adding it to concrete have to dissolve with water with the help of SDL.

Graphene with SDL (10%of graphene) by weight add in water and mix it properly one day before testing, to dissolve.

Table-2: Characteristics of Graphene

Characteristics	Value
1.Specific Gravity	1.9
2. Test	Test less
3. Odor	Odor less
4. Color	Black

5. FINITE ELEMENT MODEL OF PT NANO-CONCRETE SLAB:

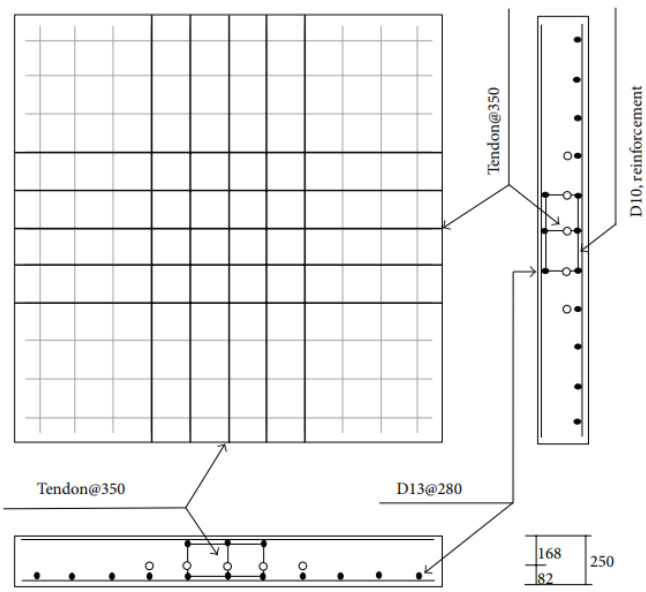

Fig 1: Details of PT Slab

5.1 Material Properties:

a) Concrete:

Properties	Conventional PT Slab	Nano-concrete PT Slab
Young's Modulus	33541 MPa	36895 MPa
Poisson's Ratio	0.18	0.17
Coefficient of Thermal Expansion	$1.2 x 10^{-5}$	$1.2 x 10^{-5}$
Ultimate Compressive Strength	45MPa	59.4MPa
Ultimate Tensile Strength	4.69	6.76 MPa
Density	$24 kN/m^3$	24 kN/m

b) Prestressing Tendons:

Young's Modulus	195000 MPa
Poisson's Ratio	0.3
Tensile Yield Strength	1640 MPa
Ultimate Tensile Strength	1865 MPa
Density	78.5 kN/m^3

5.2 3-D Model of PT Nano-Concrete Slab:

For modeling of PT Nano-concrete slab first solid model of PT slab is required to build and then meshing and loading conditions is required to be applied. Firstly 3D solid model is drawn in AutoCAD and then it is imported in ANSYS. In this type we can build full slab volumetric model in ANSYS 19.2. The PT slab volumetric model built is shown in Fig.

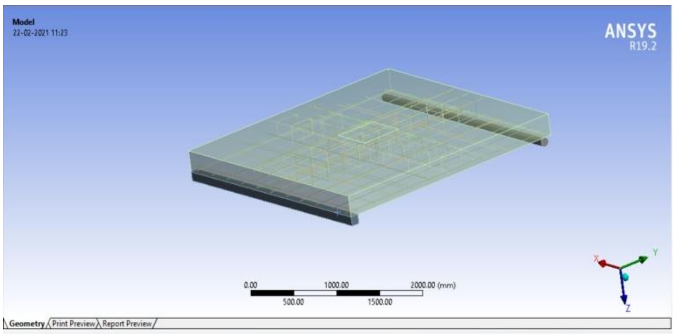

Fig 2: 3-D Model of PT Nano-Concrete Slab

5.3 Meshing:

The volumetric model of the slab built in ANSYS is then discretized with sweep method of meshing. A total of 19257 elements and 87547 nodes have been used The FE model has been utilized for studies of influential parameters and thereby a better knowledge concerning the structural behavior is gained. The obtained FE meshed model of the slab is shown in Fig.5.

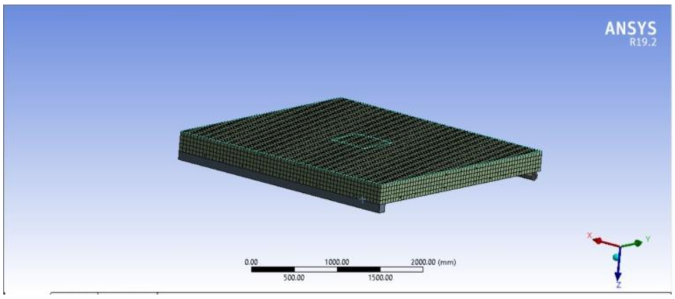

Fig 3: Mesh Model PT Nano-Concrete Slab

5.4 Loading Conditions:

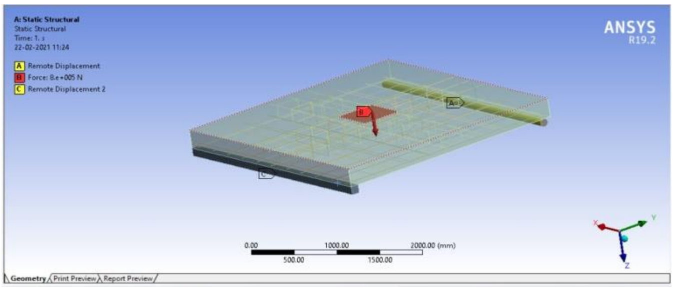

Fig 4: Loads and Support Conditions

5.5 Static Stress Analysis results:

For carrying out the static analysis, deflection is obtained for the s model. From FEM analysis we can see that the vertical deformation is larger at center of slab. Fig.5 and Fig.6 shows results of total deformation in conventional PT slab and Nano-concrete PT slab respectively.

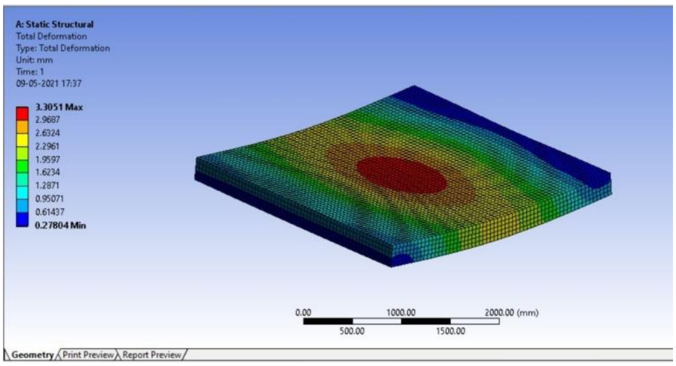

Fig 5: Total Deformation in Conventional PT slab

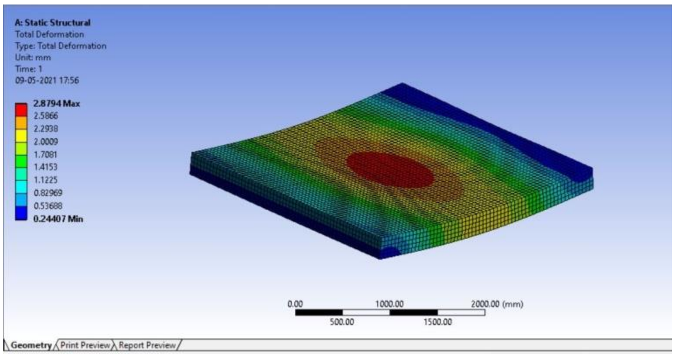

Fig 6: Total Deformation in Nano-concrete PT slab

In fig. 5 we can see that max deformation come out to be 3.30 mm for conventional PT slab at centre.
In fig. 6 we can see that max deformation come out to be 2.87 mm for Nano-concrete PT slab at center.

From fig 5, and 6 we can conclude that total deformation in Nano-concrete PT slab is less than total deformation in conventional PT slab.

5.6 Load v/s Total Deformation:

Following figure and Table shows load v/s total deformation graph for conventional PT slab and Nano-concrete PT slab.

LOAD(kN)	DISPLACEMENT	
	CONVENTIONAL PT SLAB	NANOCONCRETE PT SLAB
0	0	0
80	0.27	0.24
160	0.61	0.53
240	0.95	0.82
320	1.28	1.12
400	1.62	1.41
480	1.95	1.7
560	2.29	2
640	2.63	2.29
720	2.96	2.58
800	3.3	2.87

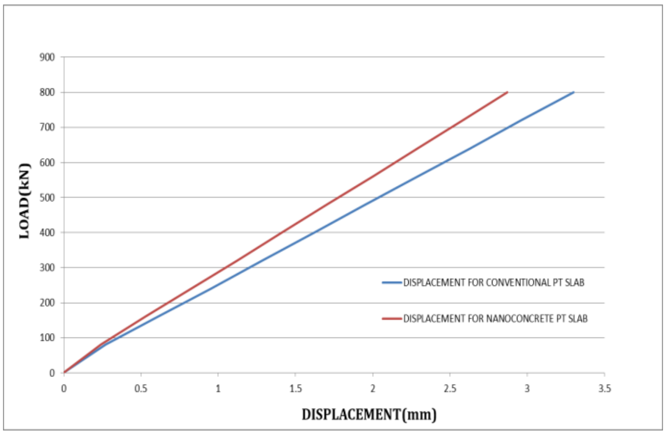

Fig 7: Load v/s Total Deformation

From load deflection curve we can see that, total deflection in conventional PT slab is 12-13% less than that of PT slab with concrete containing Nano-silica and graphene.

When Nano-silica added in concrete the pores in concrete gets filled, thus reduces shrinkage hence increases strength, corrosion resistance and durability.

When graphene is added into concrete, it results into higher C-S-H gel forming which increases strength, durability characteristics of concrete.

Hence, the slab with Nano-concrete has higher load carrying capacity and lesser yield deflection than that of conventional concrete slab.

CONCLUSIONS

1. By using Nano-concrete in slab, load carrying capacity of slab increased by 26.19%.
2. Prestressed Nano-concrete slab can results in lesser deflection for same load than conventional slab.
3. Prestressed Nano-concrete slab has higher Yield deflection than conventional slab.
4. By using Nano-concrete Yield deflection of slab increased by 12-13%.
5. By using Nano-concrete we can reduce the section of slab for same load. Also we can use same section for higher load and high speed than present load and speed.

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