Reduction in Stress & Deformation in Rectangular Slab by using NBD Fibre Strips Instead of CFRP

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Abstract— Slabs, A shallow i.e. having depth very less to other dimensions reinforced-concrete structural member that is very wide compared to depth spanning between beams, girders & columns. Concrete slabs are widely used for floors, roofs & bridge decks. When a slab is supported on four sides with reinforcing bars is called a two-way slab. Those slabs are generally designed by empirical methods. This is a fine & cost effective structural system. The slab will deflect in both directions, and the loads on the slab are transferred to all supports. There are different types of two-way slabs. The two way slabs are further divided to 3 different systems: flat plates, flat slabs, & two-way beam-supported slabs. The simplest type of two-way slab is known as a flat plate. This type of slabs is supported directly by the columns. Column spacing typically ranges from 15 to 25 ft with minimum slab thicknesses of 0.5 to 0.83 ft for live loads of about 2.5 kPa. Drop panels are added at the columns for longer spans. These types are known as a flat slab and have an economical span range of 25 to 30 ft with minimum slab thicknesses of 0.70 to 0.83 ft. In this report a Rectangular slab is modeled using a 3D modeling software called SOLIDWORKS. Computer based analysis software called ANSYS is used to perform the deformation tests of various Rectangular slabs with or without openings. The 3D model of the Rectangular slabs is imported to ANSYS software to carry out the Finite Element modeling. Meshing is done using ANSYS software. Also change the CFRP strips material with NBD material to reduce the cost of the product. Because of the cost of NBD material is very less as compared to the CFRP material. And also drop in stress and deformation in the RC slab.

Key words: Rectangular Slab, Solid Works, Static Structure, ANSYS, FEA

I. INTRODUCTION

Slabs, A shallow i.e. having depth very less to other dimensions reinforced-concrete structural member that is very wide compared to depth spanning between beams, girders & columns. Concrete slabs are widely used for floors, roofs & bridge decks. When a slab is supported on four sides with reinforcing bars is called a two-way slab. Those slabs are generally designed by empirical methods. This is a fine & cost effective structural system. The slab will deflect in both directions, and the loads on the slab are transferred to all supports. There are different types of two-way slabs. The two way slabs are further divided to 3 different systems: flat plates, flat slabs, & two-way beam-supported slabs. The simplest type of two-way slab is known as a flat plate. This type of slabs is supported directly by the columns. Column spacing typically ranges from 15 to 25 ft with minimum slab thicknesses of 0.5 to 0.83 ft for live loads of about 2.5 kPa. Drop panels are added at the columns for longer spans. These types are known as a flat slab and have an economical span range of 25 to 30 ft with minimum slab thicknesses of 0.70 to 0.83 ft.

II. LITERATURE REVIEW

Nura Jasim et al. (2012) introduced to strengthen the RC slab where there is need of providing the cuts in existing structures. Since there are several approaches but it is good to select the approach that is cost effective. The paper deals with the CFRP sheets & the steel fibres used as a strengthening material. In this study eight slabs were studied out of which 3 slabs were controlled. The 3 controlled slabs were without opening, with square opening & with rectangular opening respectively. Next the 3 slabs were modeled using steel fibres without opening, with square opening & with rectangular opening respectively. Then the two slabs were modeled using CFRP laminates with square & rectangular opening respectively. The slabs were loaded uniformly with simply supported edges. The results showed that the CFRP increased the load carrying capacity by 30% instead the glass fibres increased the load carrying capacity by 20%.

Duarte et al. (2007) presented the nonlinear behavior of slab column connection without punching shear reinforcement. The analysis was taken using ATENA 3D to predict the punching failure behavior. The study was based on real behavior of concrete under tension & compression. The modeling was done based on smeared crack concept & the fixed crack model. The curve drawn at the end showed the comparison between the experimental & numerical nonlinear analysis subjected to punching load.

Elsayed et al. (2007) studied the simulation of width of FRP laminates. The finite element study was carried out to study the behavior of RC slab with or without FRP sheets. The load deflection curve was drawn using different widths of FRP laminates. It was found that as the width of FRP laminate was increased, stress concentration on slab decreases.

A. Kheyroddin et al. (2008) had investigated the finite element modeling for slab column connection under eccentric loading. In this study, non-linear models of flat slabs had been created to simulate the behavior of punching shear reinforcement. The effect of punching shear reinforcement along with moment transfer had also been investigated. The load-deflection response, the ultimate failure load & the crack pattern were drawn.

Kim et al. (2008) presented that how the pre stressed CFRP sheet effect on the ductility of RC slabs. Models were prepared using finite element method. First the control RC slab was taken then the RC slab with non-prestressed CFRP laminate & then the RC slab with prestressed laminate was taken.

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III. OBJECTIVE OF THE STUDY

1) ANSYS of the rectangular slab find out the maximum stress and deformation area in the slab.
2) To reduce cost of the slab by using NBD material instead of CFRP material.
3) To compare performance of CFRP and NBD material for strengthening of openings in Rectangular slabs.

IV. METHODOLOGY

As we know before the use of any structural element, it is necessary to test it first whether it can sustain the value of load required or not. Since the experimental analysis of the structural elements hold cost of materials thus presently it is wise to check the structural elements with numerical methods. Also, the experimental analysis is time consuming. So it is preferable to use numerical methods. In the present study, firstly the non-linear rxesponse of controlled RC slab (without openings) using FE modeling under the incremental loading had been carried out. Then the nonlinear response of RC slab with different types of openings & then the use of FRP near opening is carried out. These include load displacement graph & the crack patterns. The seven slab models are analyzed using ANSYS software. The analysis is done up to the failure of slab and the load deformation curves and the cracking behavior is taken. The results obtained from the analysis of this FE models have been plotted in the shape of load v/s deflection graph. Comparisons between numerical & experimental results are made. Deflection and cracking behavior of the RC slab beam models are also studied.

V. GEOMETRIC MODELING & FINITE ELEMENT ANALYSIS

A. *Sketcher*

Sketcher is utilized to make two-dimensional portrayals of related inside the part. We can a pitiless arrangement of bends, and from that point indicate conditions called targets to depict the shapes all the more completely and catch our format part. Each bend is proposed as a portray challenge. To impact another to portray, picked begin to mechanical structure and sketcher by then select the reference plane or delineate plane in which is to be made.

B. *Modeling*

SOLIDWORKS writing computer programs is used to influence Slab to illustrate. SOLIDWORKS is a natural PC upheld lying out and amassing structure. The knave limits robotize the run of the mill building, blueprint and drafting capacities found in the present collecting associations. Arrangement of a 3-D show in SOLIDWORKS can be performed using three workbenches i.e.: sketcher, showing and get together.

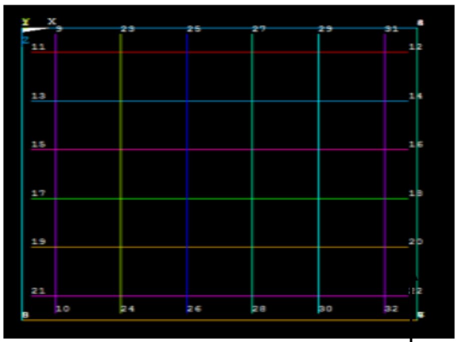

Fig. 1: Top View of Slab

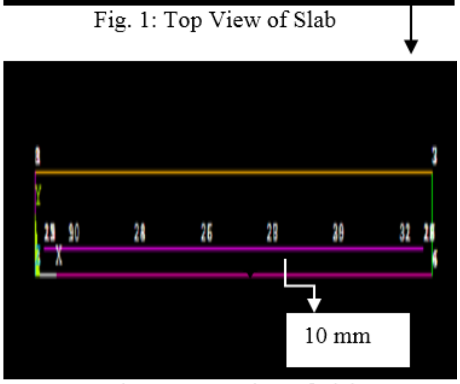

Fig. 2: Front View of Slab

C. *Finite Element Analysis*

Finite Element Method (FEM) is a technique in which not only structural element even electronic instruments & mechanical instruments are being tested. This method comes under numerical methods. FEM uses different methods for analyzing process. The basic concept on which FEM works is that it divides system into number of components which are known as finite elements. The process is known as meshing. Without meshing it is not possible to analyze in FEM. Also this is the reason that FEM differs from other methods. There are several software's that can be used for FEM. But the present work deals with ANSYS. It is also FEM software. There are many versions available for ANSYS. But not so much difference in the different versions. A new version comes with new type of element types.

D. *Mesh Generation*

Work age is the exhibition of conveying a polygonal or polyhedral work that approximates a geometric zone. The verbalization "cross area age" is routinely utilized then again. Run of the mill usages are for rendering to a PC screen or for physical reenactment, for example, obliged part examination or computational liquid segments.

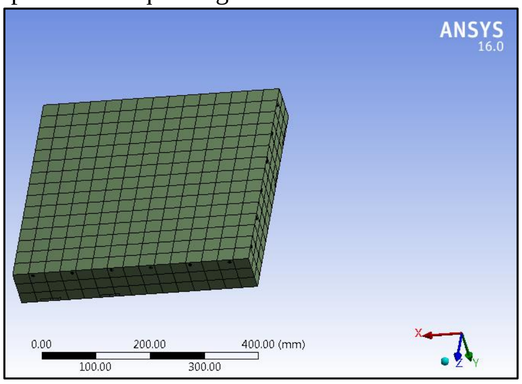

Fig. 3: Meshing of Slab

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1) *Material 1: for M30 Concrete*
- Density of Concrete=2300 kg m^-3
- Young modulus = 3E+10 Pa
- Poisson's ratio =0.18
- Bulk modulus= 23333 Pa
2) *Material 2: for steel*
- Density of Concrete=7050 kg m^-3
- Young modulus = 28000MPa
3) *Material 3: for CFRP*
- Modulus of elasticity, $E_{cf} = 2.3e+5$ N/mm^2
- Poisson's ratio, ν = 0.20
4) *Material 4: for NBD*
- Modulus of elasticity, E_{gf} = 0.8e+5N/mm^2
- Poisson's ratio = 0.30
- Density=2450 kg m^-3

VI. RESULTS

ANSYS of the Slab with CFRP strips and CFRP & NBD strips.

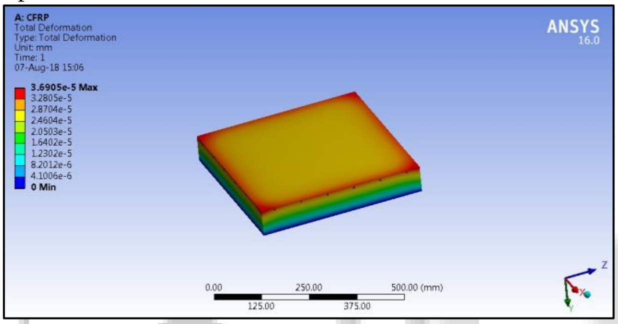

Fig. 4: Maximum Deformation in simple slab with CFRP

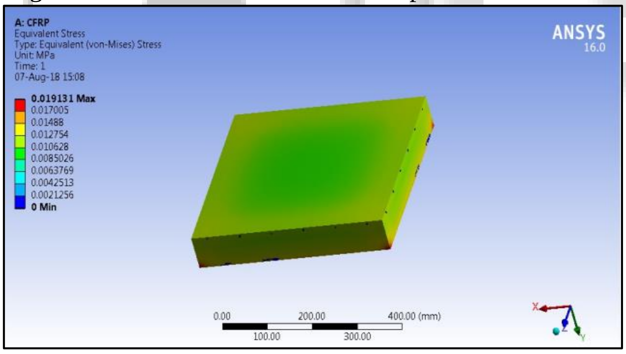

Fig. 5: Maximum Stress in simple slab with CFRP

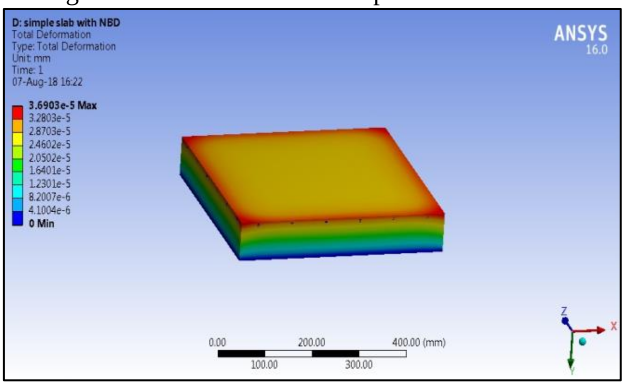

Fig. 6: Maximum Deformation in simple slab with NBD Fibre

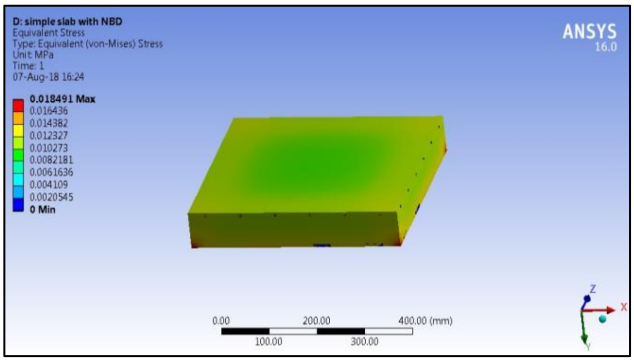

Fig. 7: Maximum Stress in simple slab with NBD Fibre

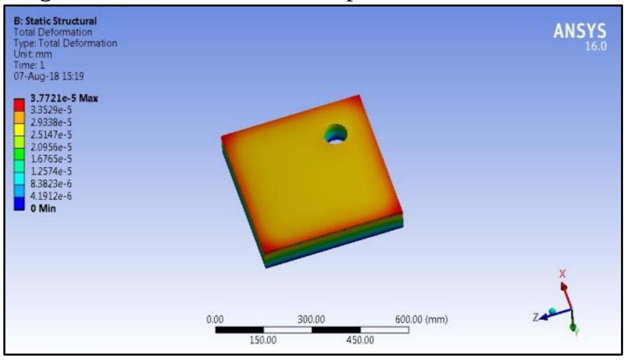

Fig. 8: Maximum Deformation in circular cut slab with CFR

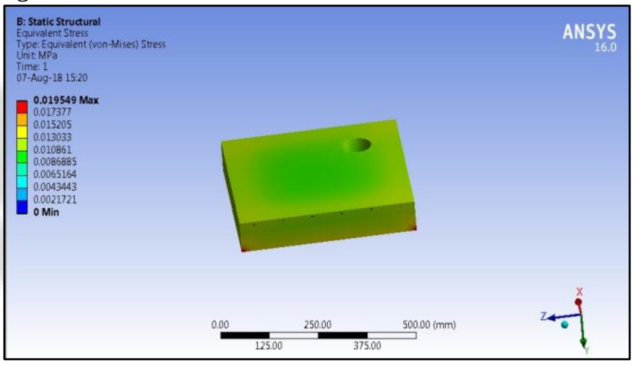

Fig. 9: Maximum Stress in circular cut slab with CFRP

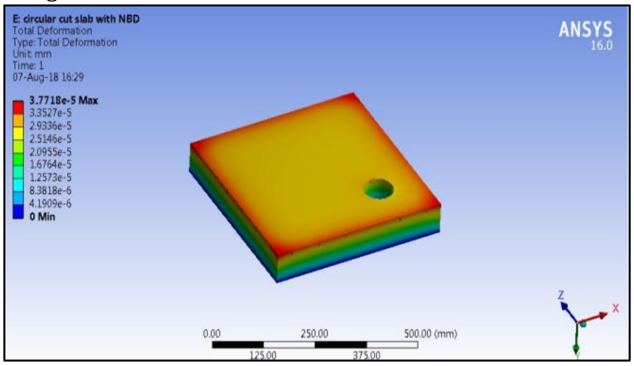

Fig. 10: Maximum Deformation in circular cut slab with NBD FIbre

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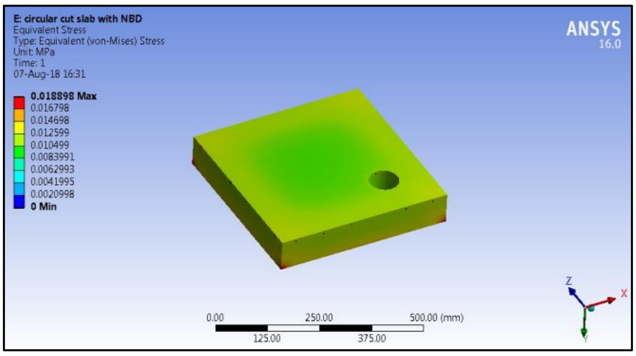


Fig. 11: Maximum Stress in circular cut slab with NBD Fibre

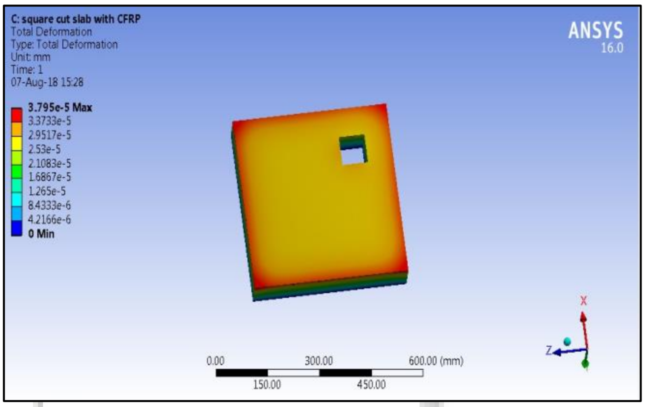


Fig. 12: Maximum Deformation in square cut slab with CFRP

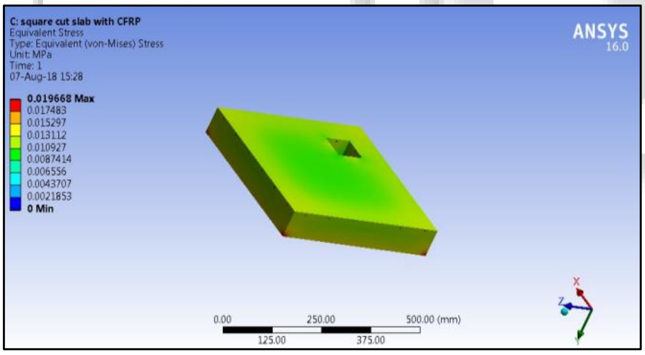


Fig. 13: Maximum Stress in square cut slab with CFRP

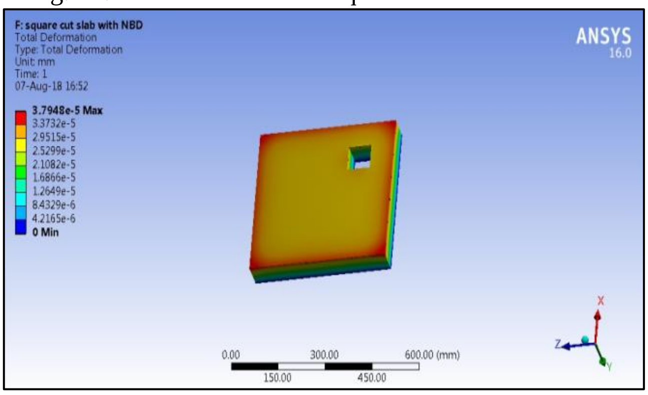


Fig. 14: Maximum Deformation in square cut slab with NBD Fibre

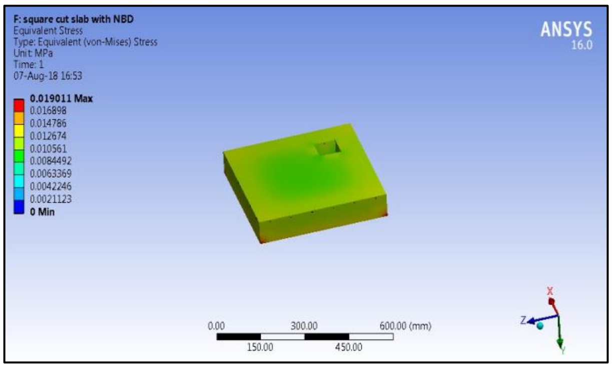
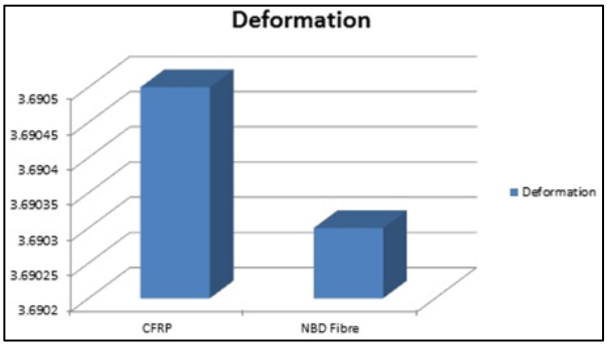
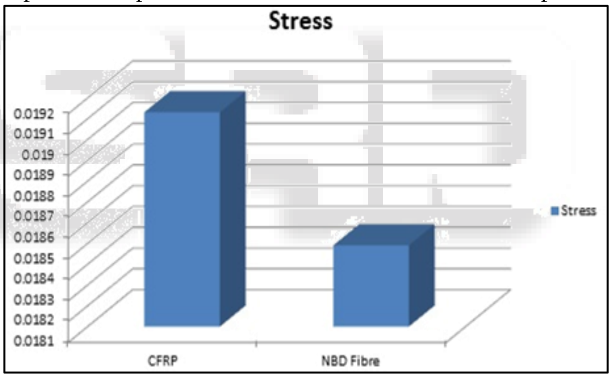


Fig. 15: Maximum Stress in square cut slab with NBD Fiber

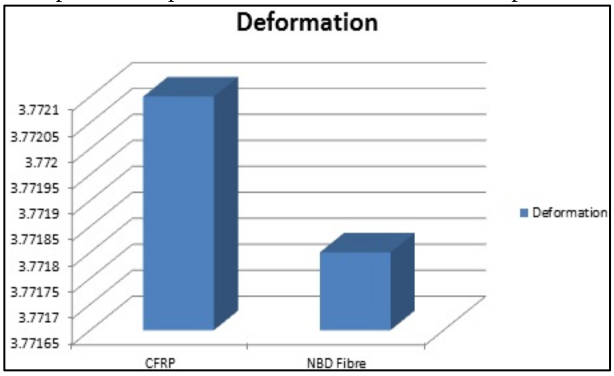
A. *Graph comparison*



Graph 1: Comparison between Deformations in Simple Slab



Graph 2: Comparison between Stresses in Simple Slab



Graph 3: Comparison between Deformations in Circular Cut Slab

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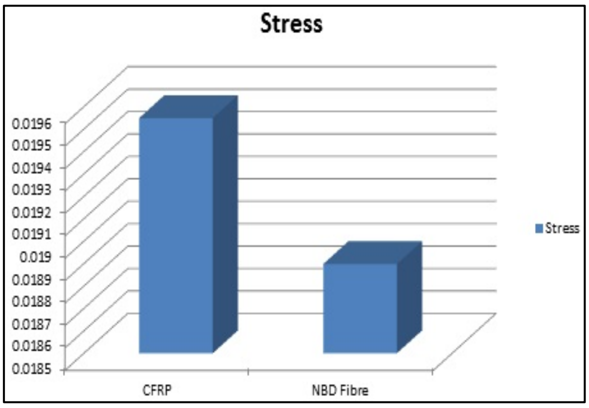
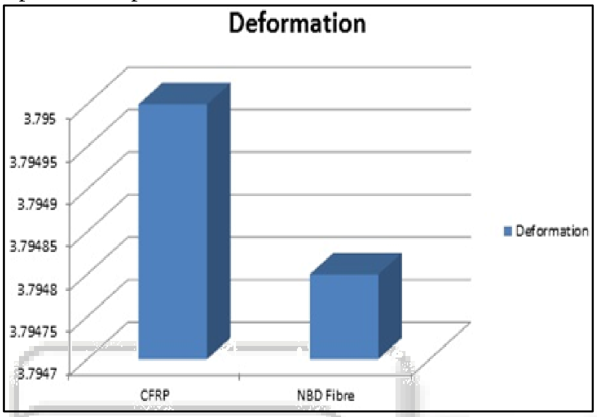
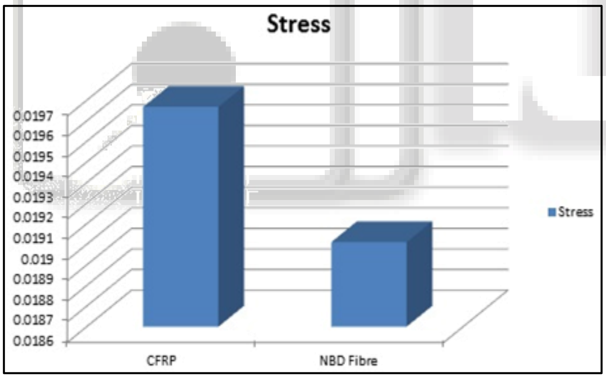


Graph 4: Comparison between Stresses in Circular Cut Slab



Graph 5: Comparison between Deformations in Square Cut Slab



Graph 6: Comparison between Stress in Square Cut Slab

VII. CONCLUSION

1) The maximum deformation in circular cut slab with CFRP strips is 3.7721 mm and 3.7718 mm with NBD Fibre strips.
2) The maximum stress in circular cut slab with CFRP strips is 0.019549 N/mm^2 and 0.018898 N/mm^2 with NBD Fibre strips.
3) The maximum deformation in simple slab with CFRP strips is 3.6905 mm and 3.6903 mm with NBD Fibre strips.
4) The maximum stress in simple slab with CFRP strips is 0.019131 N/mm^2 and 0.018491 N/mm^2 with NBD Fibre strips.
5) The maximum deformation in square cut slab with CFRP strips is 3.795 mm and 3.7948 mm with NBD Fibre strips.
6) The maximum stress in square cut slab with CFRP strips is 0.019668 N/mm^2 and 0.019011 N/mm^2 with NBD Fibre strips.
7) It is observed that load carrying capacity of solid slab is more than slab with openings.
8) It is observed that load carrying capacity of slab strengthened with NBD is more than the capacity when strengthened with CFRP.

From the above graphs we can see that the results of slab after changing the strips material are coming best as compared to the old material. therefore we can say NBD Fibre is best as Compared to the CFRP material the stress and ,deformation are less produced in NBD Fibre .Therefore we will prefer NBD material for the strips of slab.

A. Future Scope

From the literature review and the present work done in this thesis has provided useful for future application of a finite element method for analysis. FEM model helps in comparing the results with experimental results data. Modeling the RC slab model in FEM based ANSYS software gives good results which can be included in future research. Further the numerical analysis can be done on to check the deflection control under different ways & more types of using FRP.In the future scope we can take another material like Natural fibre, Carbon fibre and Glass fibre instead of NBD fibre. And can be also reduction in the stress and deformation

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