Scientific Journal of Impact Factor (SJIF): 5.71

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 04, April -2018

ANALYTICAL STUDY ON STRENGTHENING OF REINFORCED CEMENT CONCRETE TWO WAY SLAB WITH TEXTILE REINFORCED MORTAR

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Abstract- *This paper examines analytically the application of textile reinforced mortar (TRM) as a means of improving the flexural capacity of reinforced cement concrete two way slabs. The parameters considered in the study include number of TRM layers, strengthening configuration and the material of the textile fiber (basalt, carbon).The slabs are analysed using ANSYS software and the ultimate load and corresponding deformation is noted.It is concluded from the study that the TRM is effective in increasing the ultimate load carrying capacity and decreasing the deformation value, thus increasing the flexural capacity of the slabs.*

Keywords- *Basalt fiber, carbon fiber, strengthening, Textile Reinforced Mortar, Analytical study*

I. INTRODUCTION

Strengthening of existing concrete structures is gaining importance due to their deterioration as a result of ageing, chemical attack, presence of pollutants in the atmosphere, environmentally induced degradation, lack of proper maintenance or to meet the current design requirements. Since strengthening provides a sustainable and cost effective method, a shift from new construction to renovation and retrofitting has taken place. The most commonly used strengthening method for concrete members is the use of Fiber Reinforced Polymer (FRP) composites. But in spite of many favorable properties, FRP has some drawbacks like poor temperature performance, inability to apply on wet surfaces, high cost etc.

TRM is a cement based composite material which incorporates high strength fibers in the form of a mesh and eliminates most of the disadvantages of FRP. Many researchers have studied the use of TRM in several cases of structural retrofitting like strengthening of RC beams, confinement of columns, strengthening of masonry elements, retrofitting of masonry infill walls and many more. However the number of studies regarding flexural strengthening of two- way RC slabs are limited. The main aim of this study is to examine analytically the contribution of Textile Reinforced Mortar in the flexural performance of RCC two- way slabs.

II. ANALYTICAL STUDY

2.1 Methodology

The study consists of analyzing six slabs of size 3000 mm x 2000 mm x100 mm. The slabs are reinforced with 8 mm diameter bars at 250 mm spacing on both sides, with a cover of 20 mm. One slab served as a control specimen, three slabs were strengthened with one, two and three layers of basalt fabric textile. One slab was given basalt fiber in a cross configuration, covering the critical regions. One slab received carbon fiber as the strengthening material. The reinforcement details are shown in Figure 1. The TRM layers were applied on the tensile (bottom) face of the slabs.

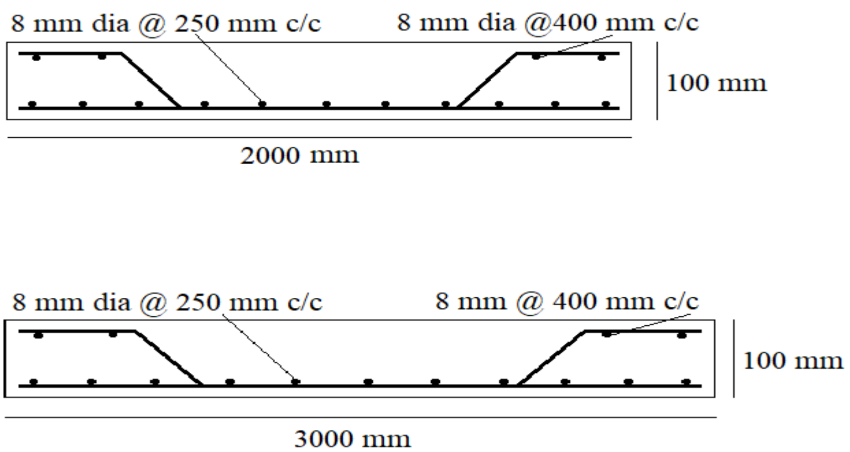

Figure 1. Reinforcement Details of the slab

2.2 Material Properties

Concrete with a compressive strength of 20 MPa is used for the slabs. Steel used for reinforcement bars were Fe415. The basalt textile layer used had a grid spacing of 25 mm x 25 mm and ultimate tensile strength of 1160 MPa. The dry weight of the basalt textile was 233 g/m^2. One slab was strengthened with a layer of carbon textile, which had a weight of 348 g/m^2 and a grid spacing of 25 mm x 25 mm. The tensile strength of the fiber was 3800 MPa.

The textile fibers were sandwiched in a layer of mortar, it served as a binding material between the concrete slab and the textile layer. The binding material is a polymer modified mortar with cement polymer ratio 8:1. The average compressive strength of the mortar was taken as 33 MPa.

2.3 Modelling and Solution

ANSYS Multi-physics module under static structural system was used for the analysis. The slab and reinforcements were modeled using various tools available and the properties were assigned. Concrete property was assigned to slab and structural steel property was assigned to reinforcements. Figure 2 shows the model of the control slab in ANSYS.

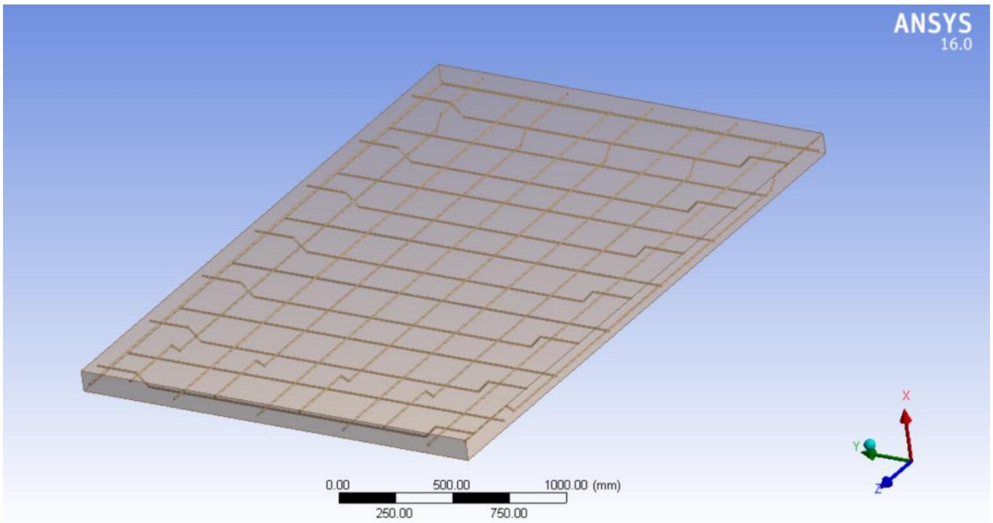

Figure 2. Model of the slab with reinforcement

Figure 3 shows the meshed control slab.

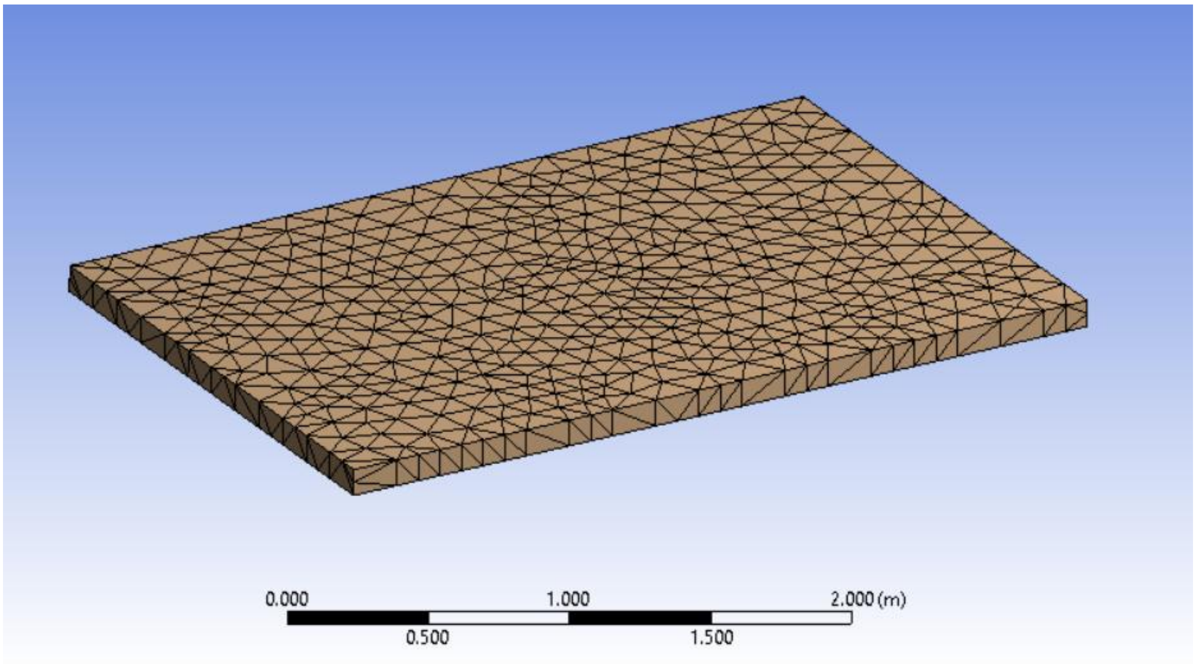

Figure 3. Meshed control slab

In order to get the two way action of slab, all sides of the slab are supported, the figure is shown in Figure 4. The load is applied as pressure on the top face of the slab as represented in Figure 5.

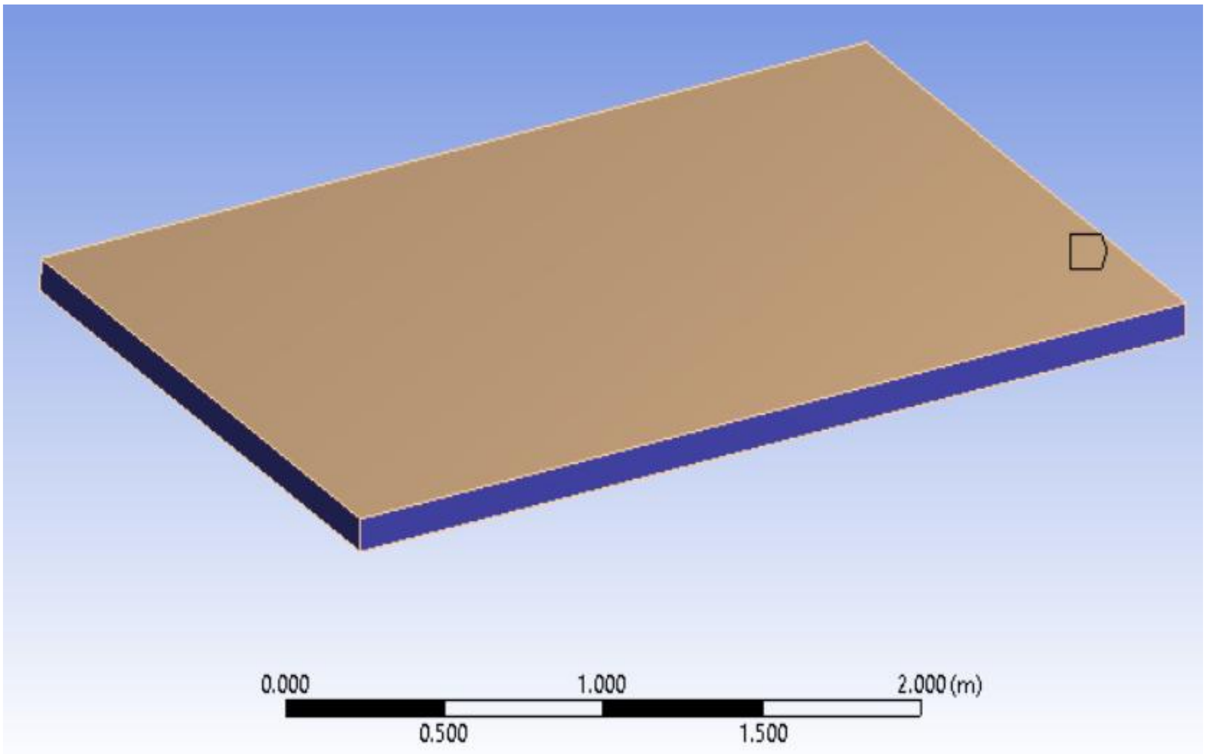

Figure 4. Supports in ANSYS

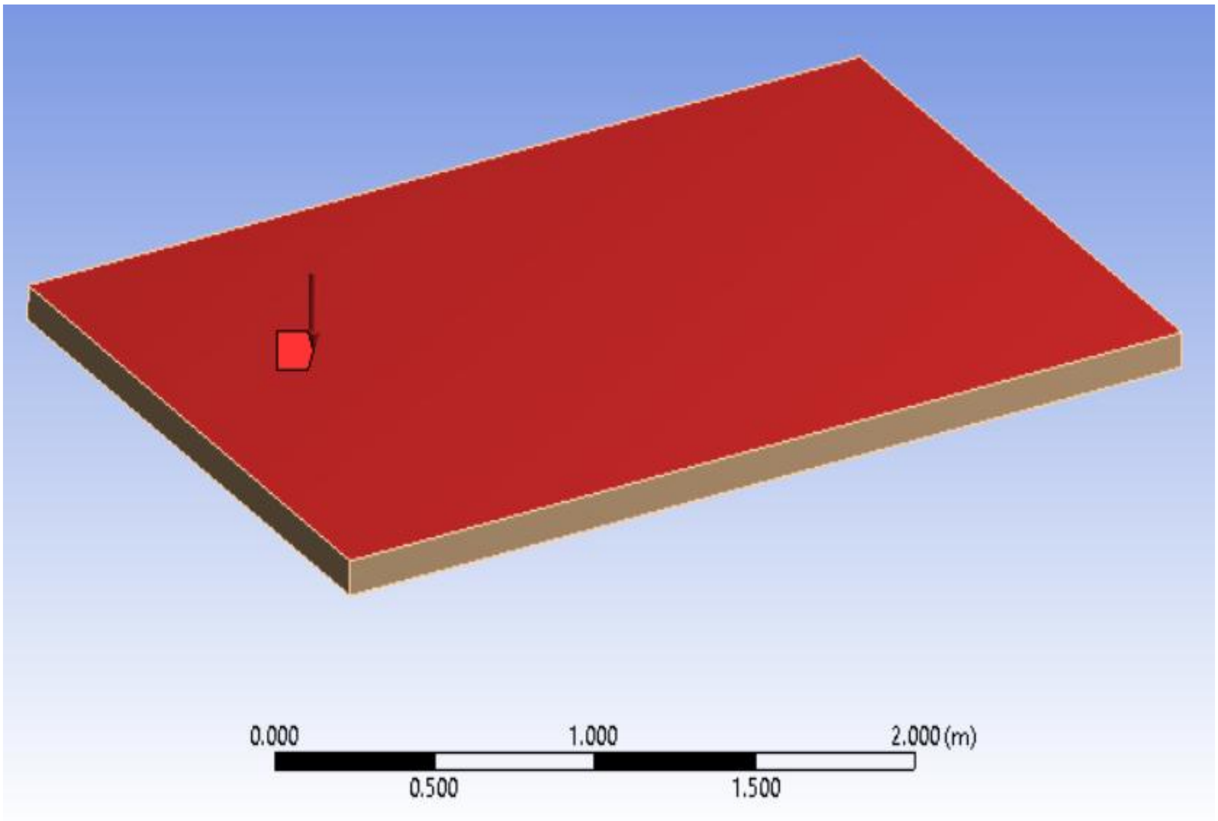

Figure 5. Loading in ANSYS

The deformation of the slabs at ultimate load is taken as result to conclude about the flexural capacity of slabs. Figure 6 shows the deformation contours obtained for the control slab.

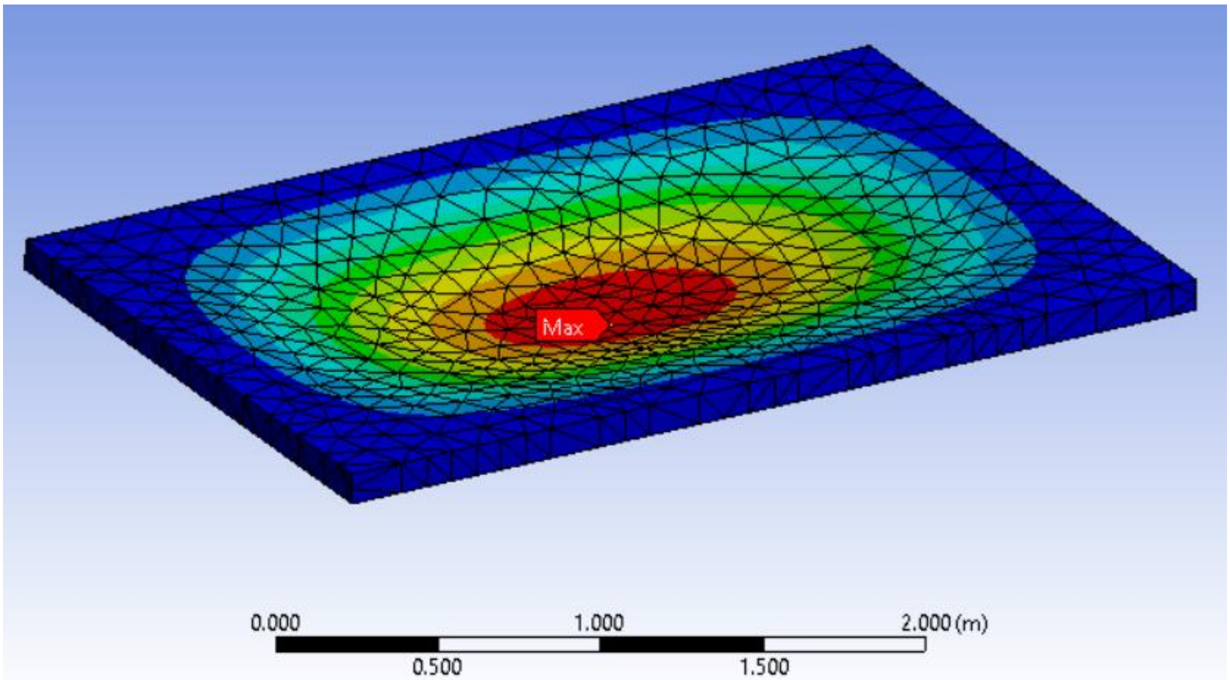

Figure 6 Deformation contours obtained in ANSYS

III. RESULTS AND DISCUSSIONS

3.1 Number of TRM layers

A comparison of the results of control slab and slabs with one, two and three layers of basalt fiber shows that the effectiveness of TRM in strengthening is nearly proportional to the number of layers. The number of layers cannot be increased without control as ACI 440-2R(2008) and ACI 549-4R(2013) states that the flexural strength provided by strengthening should not exceed 50% of the existing strength. This limit is set to guard protect against a collapse of the structure due to bond or other failure of the composites that may occur in case of fire, vandalism, damages or other causes.

Figure 7 shows the load v/s deformation curves for control specimen and slabs with one, two and three layers of basalt fiber.

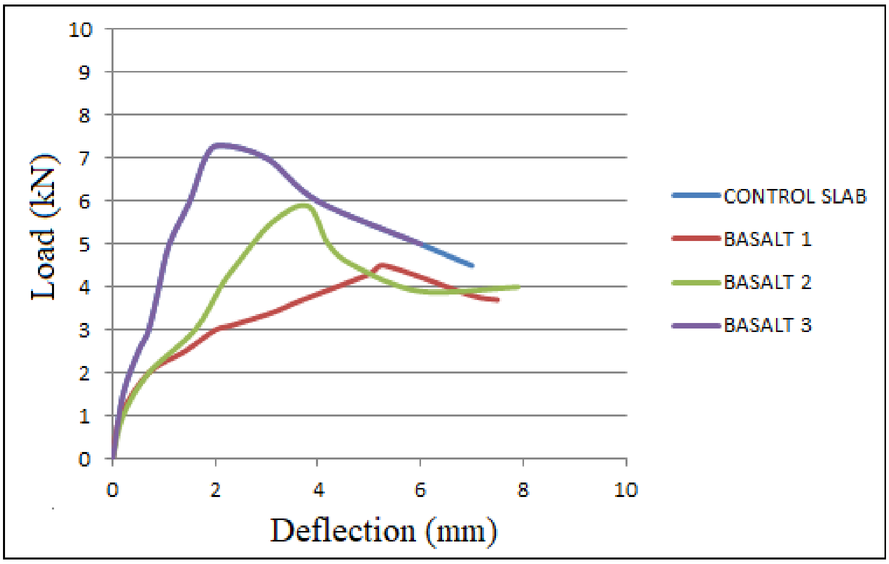

Figure 7. Load v/s Deflection curves for number of fiber layers

From the above figure it is clear that with increase in number of textile layers, the ultimate load is increasing and the corresponding central deformation is decreasing which implies that the flexural capacity of the slabs increased with number of layers.

3.2 Strengthening Configuration

The specimen received two strips of basalt fiber in a cross configuration in the bottom center portion of the slab as shown in Figure 8.

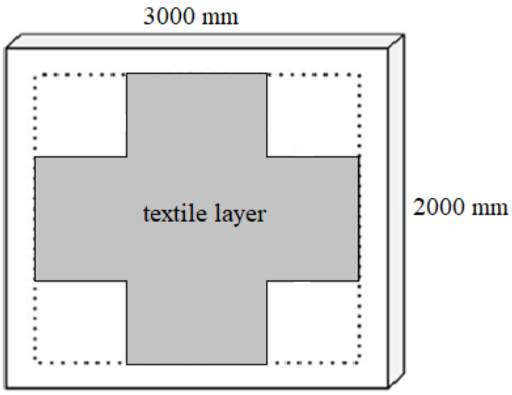

Figure 8. Cross configuration of basalt fiber

From the results obtained covering the slab in the full face is better than cross configuration. The cross configuration doesn't have much effect on ultimate load compared to the slab with fiber covered in the full face. Also from the previous studies it should be noted that the chances of debonding of the fiber material is more in this cross configuration. The comparison of the two configurations is done in Table 1.

Table 1. Comparison of two configurations

Specimen	Ultimate load (kN)	Central Deformation (mm)
Slab with one basalt layer	4.5	5.3
Slab with cross configuration	4.1	4.94

3.3 Material of the fiber

Two materials, carbon and basalt fibers were analyzed, each with one layer of fiber. Carbon fiber was found to be superior to basalt fiber in case of ultimate load carrying capacity. The load v/s deformation curves for the two fibers are shown in Figure 9.

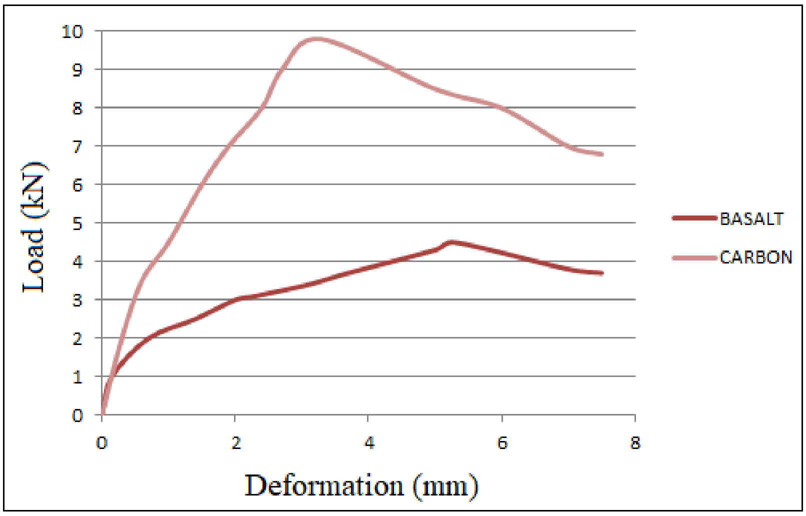

Figure 9. Load v/s Deflection curves for material of the fiber

IV. CONCLUSION

On the basis of the analytical study, the following conclusions can be drawn.

1. The performance of two way slabs can be improved by strengthening them with Textile Reinforced Mortar (TRM). The effectiveness of strengthening depends on the number of layers of the fabric and the configuration.
2. The material of the fiber result in a load capacity increase which is directly affected by the axial capacity of the layer.
3. Covering the full tensile face with fiber is much more effective than selected area coverage.

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