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NUMERICAL STUDY OF WIRE MESH ORIENTATION ON RETROFITTED RC BEAMS USING FERROCEMENT JACKETING

E. Sowmya[1], Dr.R.Venkatasubramani[2]

[1] *PG student, Department of Civil Engineering, Dr. Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu, India*
[2] *Professor & Head, Department of Civil Engineering, Dr. Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu, India*

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Abstract - *Reinforced concrete structures are damaged due to various causes such as improper design, faulty construction, blasting etc. This kind of loading collapses the structure prematurely or causes extensive damage to them. When the damage is minor, it is possible to retrofit the structure in order to expand their life span. Among the various retrofitting methods, ferrocement jacketing is one such method to improve the performance of RC structures. In this paper, finite element analysis have been carried out to investigate the behavior of reinforced concrete beams retrofitted with different wire mesh orientation using ferrocement jackets, to increase the strength of beams in flexure. ANSYS 16.1 workbench was used for the analysis. Results showed that the beam with 45° wire mesh orientation has more load carrying capacity and lesser deflection compared to control beam and beam with 0°, 60° wire mesh orientation. Also a considerable increase in ductility ratio is observed for all the orientation.*

Key Words: *ANSYS, Ferrocement jacketing, Ductility ratio, Retrofitting, Wire mesh orientation*

1. INTRODUCTION

Reinforced concrete structures that are being constructed nowadays are very wide. For example, buildings, high rise structures, bridges, dams, shopping malls, airport terminals etc., are some of the structures built for different purposes and to carry out different activities. These structures are built with materials like masonry, concrete, steel, aluminum as per the design requirements and economical considerations. These structures are subjected to different kind of loads i.e., DL, LL, wind load, EQ load, vibration etc. But a structure may not have enough strength to resist the load or the structure becomes too old to carry the loads. Number of causes occurs in structures are due to change of usage of the building, change in codal provisions, overloading, earthquakes, corrosion, wear and tear, flood, fire etc. Since, replacement of such deteriorated elements of structures incur a huge amount of public money and time, strengthening has become the acceptable way of improving RC structures.

In the last few decades several attempts have been made in India and abroad to study the problems and to increase the life of structures by suitable retrofitting and strengthening techniques. The strengthening of structures has been practiced and accepted as a viable means of improving the serviceability, performance and upgrading the load carrying capacity of structures. Strengthening may be needed to allow the structure to resist loads that are not anticipated in their original design. Additional strength may be needed due to deficiency in the structures ability to carry the original design loads. Number of techniques are available to strengthen different types of structures. The selection of strengthening technique depends on one or more of the following criteria accessibility, availability of materials, equipment, qualified contractors, construction, maintenance and life cycle costs, magnitude of strength etc.,

The methodology should be simple in execution, offer better performance even when handled by less experienced workers, must involve materials, which are readily available, durable, strong and economical. Ferrocement jacketing is one such material which could afford to answer to such a situation and hence ferrocement jacketing is utilized for improving the performance in construction. This paper presents the numerical study to stimulate the behavior of control RC beams and Ferrocement jacketing beams with different wire mesh orientation using ANSYS. The results of strength, deflection and ductility ratio are compared for all the beams.

2. FINITE ELEMENT ANALYSIS

Finite element analysis provides an accurate prediction of the structural elements subjected to various loads. It is one of the method to study the behavior of concrete faster than the experimental method and is cost effective. In this paper, four beams were modeled and analyzed using ANSYS software. In four beams, one beam is a control beam without retrofitting and other beams are retrofitted with 0°, 45°, 60° wire mesh orientation using ferrocement jacketing. In this numerical study, simply supported reinforced concrete beam is subjected to two point loading was modeled using ANSYS. Initially creating the model of the control beam and it is applied for ultimate load. After that remaining beams are damaged by applying 50% of safe load and they are strengthened by wrapping the ferrocement jackets with different types of wire mesh orientation in soffit side of the beam (single layer) and then retrofitted with 15mm thickness of ferrocement jackets.

2.1 Geometry of the beam

Dimensions of the RC beam consider for this study is 1000mm x 100 mm x 200 mm. The beam is simply supported with hinge at one end and roller at other end. Two point loads are applied at one- third of the span. The details of the beam are shown in fig 1

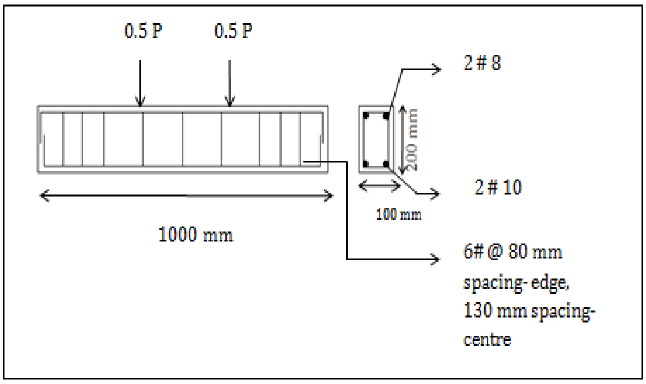


Fig 1 Beam details

2.2 Material properties and Element types

2.2.1 Reinforced concrete

Solid 65 element was used to model the concrete. This element has eight nodes with three degrees of freedom at each node- translations in the x, y and z directions. This element is capable of plastic deformation, cracking in three orthogonal directions and crushing. The properties of reinforced concrete are shown in table 1

Table 1 Material Properties for Reinforced concrete

S.NO	PROPERTIES	VALUE
1	Young's Modulus	27.38 x10^3 N/mm^2
2	Poisson Ratio	0.15
3	Density	2500 Kg/m^3

2.2.2 Steel Reinforcement and Steel wire mesh

Beam 188 is used to model the steel reinforcement and steel wire mesh. Two nodes are required for this element. This element is capable of representing the plastic deformation. The thickness of steel wire mesh used in the study is 1 mm and spacing of 15 mm was used. The properties of steel reinforcement and steel wire mesh are shown in table 2

Table 2 Material Properties for Steel reinforcement & Steel wire mesh

S.NO	PROPERTIES	VALUE
1	Young's Modulus	2 x 10^5 N/mm^2
2	Poisson Ratio	0.3
3	Density	7850 Kg/m^3
4	Yield stress for steel reinforcement	415
5	Yield stress for steel wire mesh	250

2.3 Numerical Analysis of Control Beam

The beam has been modeled as per the dimension and analyzed using ANSYS. The solution of control beam are shown below

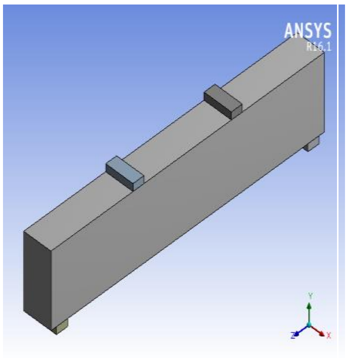


Fig 2 3D Model of Control beam

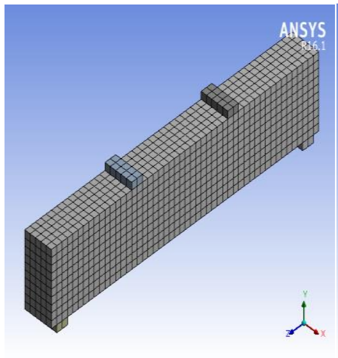


Fig 3 Meshed Model of Control beam

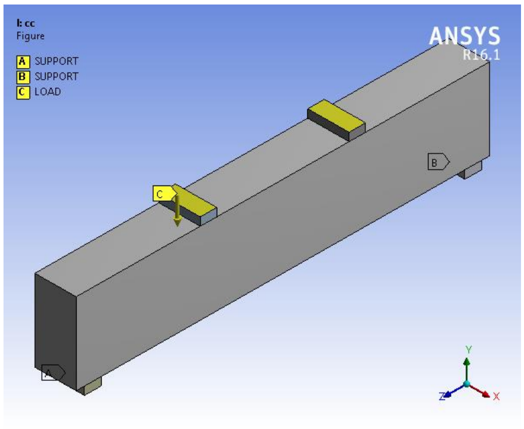


Fig 4 Loading

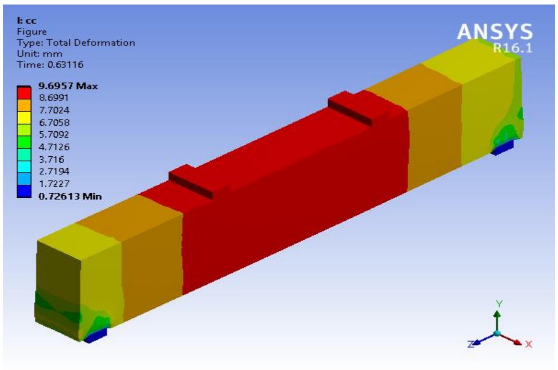


Fig 5 Total Deformation

2.4 Numerical Analysis of Retrofitted beam with 0°, 45°, 60° wire mesh orientation using ferrocement jacketing

In control beam, the load corresponding to an allowable central deflection of 4 mm (Span/ 250) was obtained from the load deflection curve as 52.41 KN. The numerical analysis of retrofitted beams are stressed upto 50% of safe load i.e., 26 KN initially and they are strengthened by wrapping ferrocement jacketing. After that the retrofitted beams are analyzed. The solution obtained for retrofitted beam with 0°, 45°, 60° wire mesh orientation are shown below

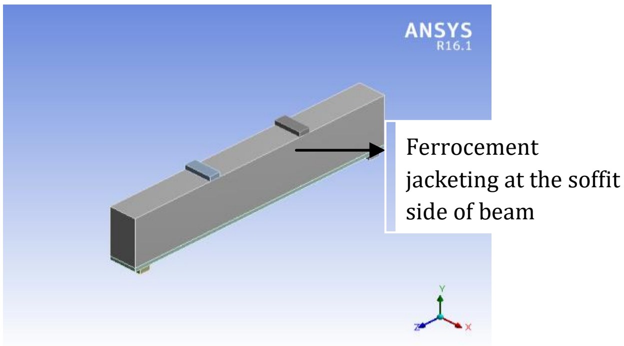
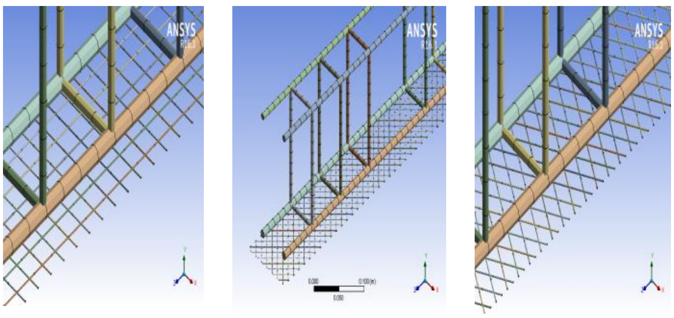


Fig 6 Geometric model of retrofitted beams



0° wire mesh **45° wire mesh** **60° wire mesh**

Fig 7 Wire mesh orientation

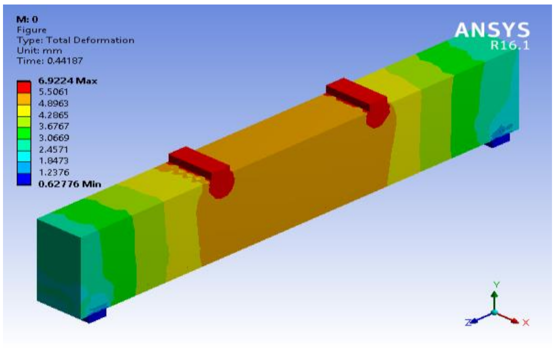


Fig 8 Total deformation for 0° wire mesh

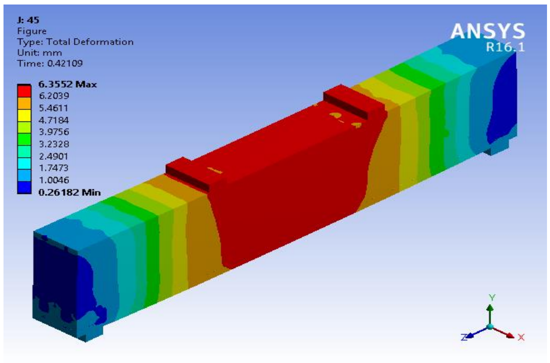


Fig 9 Total deformation for 45° wire mesh

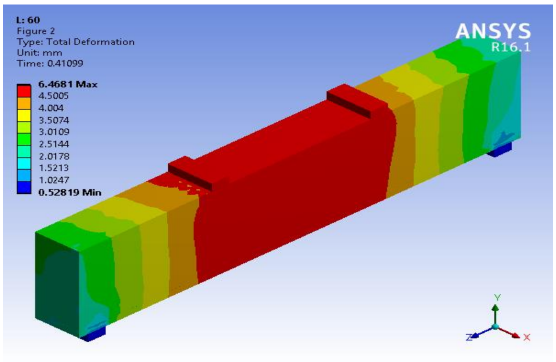


Fig 10 Total deformation for 60° wire mesh

3.RESULTS AND DISCUSSION

The results obtained from the numerical investigation are tabulated in table 3. Various results are discussed as follows

Table 3 Numerical analysis results

Beam Designation	Load (KN)	Deflection (mm)	Ductility ratio
Control beam	54	9.69	6.29
0° wire mesh	62.9	6.92	6.46
45° wire mesh	66.13	6.35	6.35
60° wire mesh	61.3	6.46	6.39

3.1 Ultimate load

From the Table 3, it is clear that ultimate load was found to be maximum for wire mesh at 45° orientation. In case of control beam, the ultimate load was found to be increased by 17% for 0° wire mesh, 23% for 45° wire mesh, 14% for 60° wire mesh. The ultimate load for various beams is shown below,

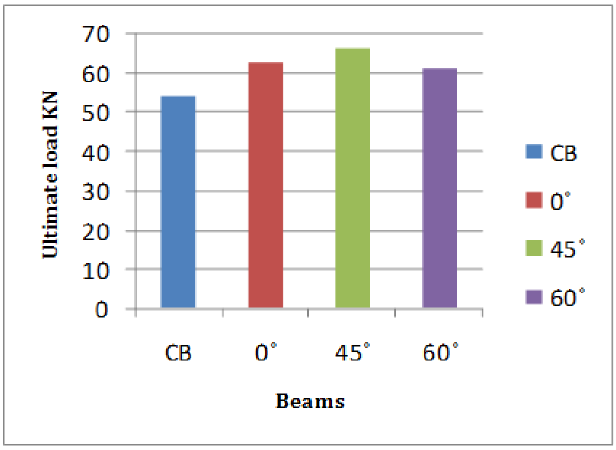


Fig 11 Ultimate loads for all the beams

3.2 Ductility factor

Ductility is the ratio between deflections at ultimate load to deflection at first yield. The ductility factor was found to be increased by 2.63%, 0.95%, 1.58% for 0º, 45º and 60º respectively as that of control beam. The values are presented in Table 3

3.3 Load versus deflection comparison

From the load versus deflection curves, shown graphically in fig 3. It is observed that, when the load increases, there is a considerable reduction in deflection for all the beams. From an overall assessment the best results were obtained when the beam is retrofitted with 45° wire mesh using ferrocement jacketing.

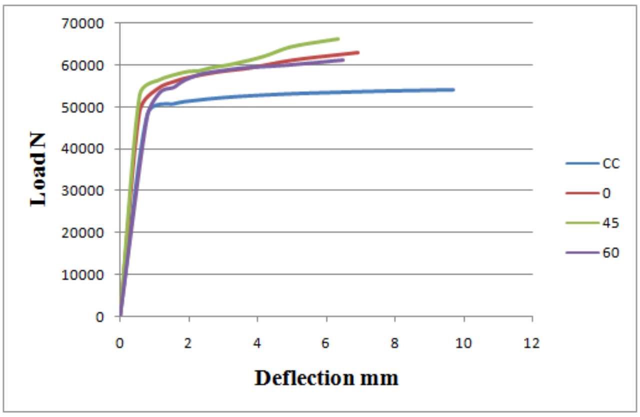


Fig 12 Load versus deflection curve

4. CONCLUSION

Based upon the numerical analysis, the following conclusions are drawn.,

- The ultimate load carrying capacity of retrofitted beams are increased by about 17%, 23%, 14% for 0°,45° and 60° wire mesh orientation using ferrocement jacketing when compared to control beam.
- The beam strengthened with ferrocement jacketing of different wire mesh orientation have reduced deflection compared to control beam.
- The wire mesh orientation 45 degree is considered one of the best orientation in ferrocement jacketing, has the highest load carrying capacity as compared to control beam as well as the other beams retrofitted with 0° and 60°.
- The increase in ductility ratio of beams retrofitted using ferrocement jacket at 0° and 60° orientation of wire mesh is suitable for dynamic load application.
- Retrofitting is the best method for rectifying a damaged structure instead of its whole replacement.

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