Strengthening of partially damaged RC beam by Internal Implanting

Rainu Simon[1], Manjusha Mathew[2]

[1]Student, Dept. of Civil Engineering, MGM College of Engineering and Technology, Pampakuda, Kerala, India
[2]Professor, Dept. of Civil Engineering, MGM College of Engineering and Technology, Pampakuda, Kerala, India

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Abstract – *Corrosion of embedded reinforcing steel and therefore the complication of concrete structures may be a worldwide problem. Damages thanks to corrosion reduce the service lifetime of structures and may create a significant problem. Traditional techniques for determining the presence and rate of corrosion are costly and difficult to seek out out. Therefore, it is vital to provide protection and offer appropriate repair methods of buildings vulnerable to the degrading effects of corrosion. The present study is focused on the rehabilitation of a partially damaged RCC beam by implanting technique using cold formed steel. Cold formed steel are light weight , sustainable, higher speed of construction, high Young's modulus hence higher bending resistance and cost wise also it is reasonable than other retrofitting elements.*

Here, the CFS strip will be implanted internally in the tension zone. The analysis will be carried out using ANSYS software were the retrofitted beams will be tested for shear, flexure and the parametric studies will also be carried out to identify the best model. We are using High Strength M40 grade concrete.

***Key Words*: Corrosion, Implant, Cold Formed Steel.**

1. INTRODUCTION

Reinforced Concrete (RC) is the foremost engineering materials thanks to the flexibility of its applications, popularity of occurrence, and straightforward production technology. With the growing demand for concrete, new challenges are posed to concrete technologists. The repair and rehabilitation of structural members are perhaps one among the foremost crucial problems in engineering applications. The load carrying capacities of structural members in reinforced concrete structures may decrease due to manufacturing and construction defects, earthquake and climate conditions. on the top, improper applications applied to the structural members after the building construction can reduce the capacity. In recent years the rehabilitation of damaged concrete (RC) structures has become a crucial task in engineering . One among the challenges within the strengthening of the concrete structure is that the selection of a strengthening method which will enhance strength and serviceability of the structure while addressing limitations like constructability, building operations, and budget structure . The use of fiber reinforced concrete (FRC) composites for the rehabilitation of concrete structures has become a popular choice due to its advantageous properties. However, an extreme load event can exceed the serviceable limit leading to excessive cracking and enormous plastic deformation in the structure, thus investigations are needed for the increased load perspective. The theoretical analysis of these severely damaged beams retrofitted using Cold formed steel (CFS) can also be different compared to the retrofitted beams under service load due to the fact that the latter scheme experienced tensile cracking of concrete only, whereas the previous one was subjected to high degree of permanent deformation. As a result, incorporation of permanent deformation is required to think about during a theoretical model for predicting the strength of the repaired beams..

2. MODELING AND ANALYSIS OF BEAMS

The main objective of this investigation is to rehabilitate the partially damaged beam by implanting also to test the performance of CFS as a retrofitting element.

2.1. General

In this study ten beam models are considered. Simply supported beams with 150 x 200mm cross-section and 1800mm span are taken. In this study, finite element modeling of RC beams is carried out using ANSYS software, to simulate the behavior of the conventional, deficient beams and the strengthened beams, from linear through non-linear response and up to failure. FE analysis is an effective and economical tool to research the response of structures under various load conditions and examine virtually endless number of variables that might be otherwise very difficult to find experimentally, due time, cost, and laboratory restraints.

Here, a robust three-dimensional FE model was developed and calibrated for RC beams strengthened with cold formed steel and subject to impact load, comparing against several tests. Proper modeling techniques were used for simulating the linear and non-linear material properties, and CFS-concrete interfacial relations. The calibrated model was then used in a detailed parametric study, focusing on the effects of location relative to mid-span, CFS configuration, among other parameters.

2.2. Specimen Configuration

All the ten beams had a cross-section of 150 × 200 mm and were 1800mm in length. The conventional beams were reinforced with two bars of 8 mm diameter at the compression face and three bars of 12 mm diameter at the tension face with nominal cover of 20mm. Shear reinforcement consists of 8 mm diameter stirrups at 160 mm spacing. Reinforcement details provided are taken from Nawal Kishor Banjara et.al(5).Material properties of the elements are shown in Table 1.

Table – 1: Material Properties

Material	Properties	Values
Concrete	Density (kg/m^3)	2400
	Poisson's ratio	0.12
	Young's Modulus (MPa)	31500
	Compressive Strength(MPa)	40
Steel	Density(kg/m^3)	7850
	Poisson's ratio	0.3
	Young's Modulus (MPa)	2.0x10^5
	Yield strength (MPa)	500
FRC	Density(kg/m^3)	2400
	Poisson's ratio	0.12
	Young's Modulus (MPa)	37749
	Compressive Strength(MPa)	57
CFS	Density(kg/m^3)	7850
	Poisson's ratio	0.3
	Young's Modulus (MPa)	2.0x10^5
	Yield strength (MPa)	574

To validate the accuracy of developed FE models, two sets of experimental works were used, totaling ten samples. The first set contains a series of beams includes a conventional beam, a partially damaged beam and beams strengthened with FRC while the second set includes five beams, which were strengthened in shear and flexure with various CFS configurations.

2.3. Internal Implant

Implanting is a new method in which partially damaged RC structures can be rehabilitated in a more effective and economical way. In this study, internal implanting is carrying out in which CFS strips of size 3 x 25mm is being implanted inside the damaged beam and that too in different configurations of CFS in order to found out the best way in which it can be oriented.. Modeling is done by varying CFS orientation. Such as;

1. Implanting CFS in four layers at 25mm spacing
2. Implanting CFS in three layers at 35mm spacing
3. Implanting CFS in two layers at 50mm spacing
4. Implanting two parts of CFS intermittently
5. Implanting three parts of CFS intermittently
6. Implanting four parts of CFS intermittently

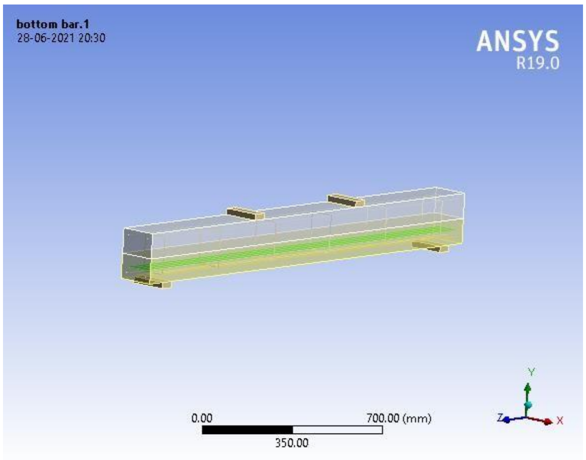

Fig – 1: Model with CFS implanted in four layers

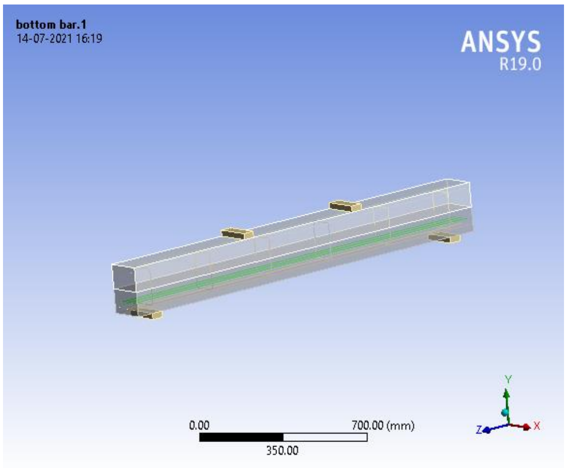

Fig – 2: Model with CFS implanted in three layers

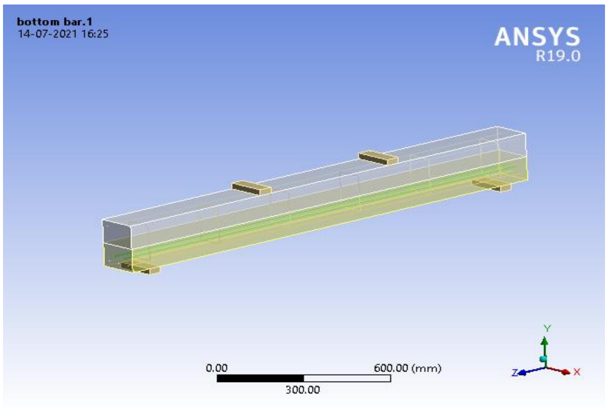

Fig – 3: Model implanted with CFS in two layers

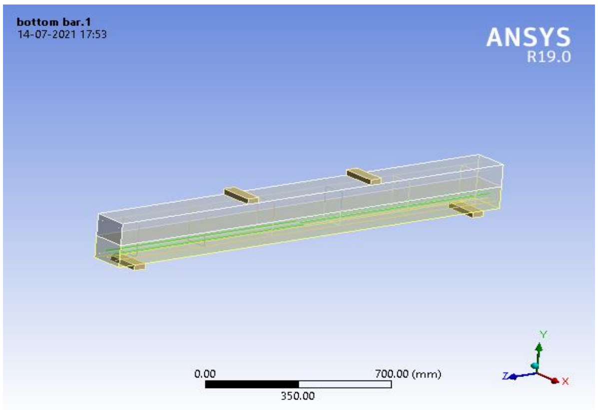

Fig – 4: Model implanted with two parts of CFS intermittently

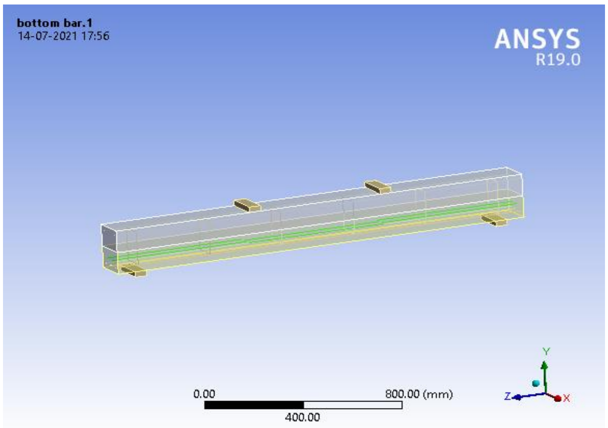

Fig – 5: Model implanted with three parts of CFS intermittently

The isometric view of each model implanted with CFS with varying orientation is shown figures 1-6.Material properties assigned are as shown in table-1.

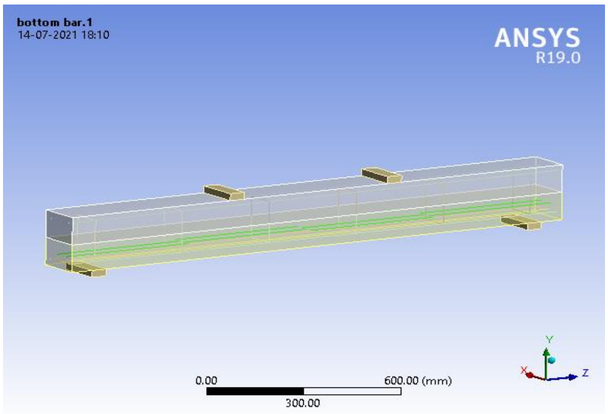

Fig – 6: Model implanted with four parts of CFS intermittently

From the structural analysis conducted the model with maximum deflection and load capacity obtained are shown in the figure-7. Maximum total deflections are shown in the figure at which the the model fails and therefore the corresponding load carrying capacity is obtained as it is the maximum strength up to which the beam can withstand.

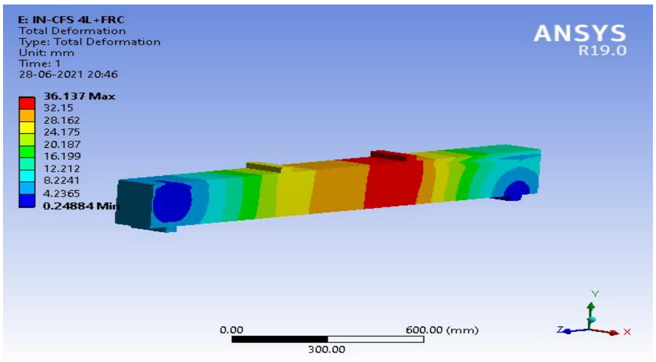

Fig – 6: Total deflection of model implanted with four layer of CFS

The chart-1 shows that the beam model implanted with cold formed steel internally in four layers parallel to the reinforcement in the tension zone is having the higher load carrying capacity than the other models implanted internally with CFS.

The maximum load at which the beam fails and the comparisons made are shown in table-2.Among the six beam models the load carrying capacity of model-1; beam internally implanted with CFS in four layers is 100.84kN and is greater than that of other models being implanted internally with other configurations.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 07 | July 2021 www.irjet.net p-ISSN: 2395-0072

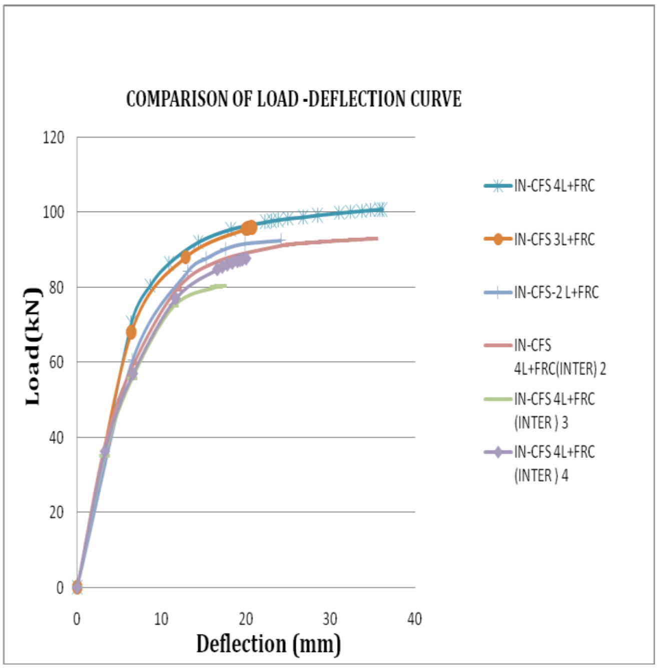

Chart – 1: Load-deflection curve

Model	Deflection (mm)	Load (kN)	Yield Displacement (mm)	Ductility
M1	36.137	100.84	6.5818	5.49
M2	36.684	99.475	6.4172	5.72
M3	36.435	92.939	6.5277	5.58
M4	34.983	92.937	6.7117	5.21
M5	21.782	81.62	6.5276	3.34
M6	33.944	91.162	6.6252	5.12

Table – 2: Comparison of models

3. RESULTS AND DISCUSSIONS

Results shows that beam model-1 being the best model with largest load carrying capacity, it must be noted that the other two models strengthened with CFS in three and two layers have shown nearly similar performance in total deformation as well as in case of load carrying capacity. So, these beams which are strengthened using CFS internally in four, three and in two layers have regained the strength equal to that of a conventional beam, as shown in chart-2.

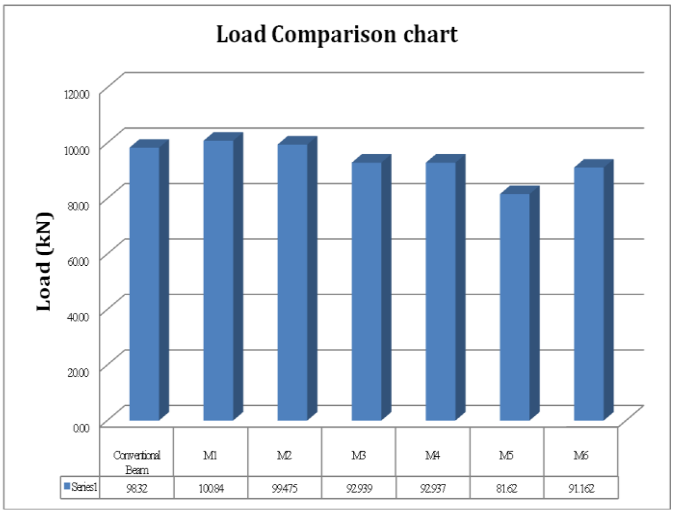

Chart – 2: Load comparison chart

Intermittent implanting of CFS strips internally also shown improvement in performance but not as like of the previous models but the ductility performance of all the internally implanted beams have improved than that of a conventional beam.The improvement in load carrying capacity for beams strengthened by implanting CFS internally in four layers, three layers and two layers continuously is 40.74%, 50.64% and 52.71% respectively. While that for beams that are strengthened by CFS intermittently by two parts, three parts and four parts are18.24%, 23.60%, and 38.05% respectively. Thus internal implanting is one effecting method in rehabilitating a partially damaged RC beam.

4. CONCLUSIONS

In this study, a new concept called implanting is developed to rehabilitate partially damaged RC beam where cold formed steel is implanted internally. Based on the obtained results the following conclusions can be drawn,

1. This method of implanting using Cold formed steel are economical as well as effective

2. Use of CFS as a retrofitting element is a sustainable method

3. In internal implanting, beam implanted with four layer of CFS has shown increase in load capacity by 52.71% and ductility by 43.41%

4. While in intermittent arrangement, higher performance is achieved for beam implanted with two parts of CFS intermittently i.e.; improvement in load by 40.73% and ductility by 36.14%.

5. In internal implanting, arrangement of CFS is effective than the intermittent one

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