Investigation on Behaviour of Near Surface Mounted Beams strengthened by Fibre Reinforced Polymers using ANSYS Software

Comparison of Beams Strengthened by GFRP, CFRP and AFRP

Krishnapriya.S
Department of Civil Engineering
Sree Buddha College of Engineering
Pathanamthitta-Kerala, India

Linda Ann Mathew
Assistant Professor
Department of Civil Engineering
Sree Buddha College of Engineering
Pathanamthitta-Kerala, India

Abstract: Deterioration of concrete structures is one of the major problems faced by construction industry. Complete replacement of deficient structure requires a huge amount of public money and time. Strengthening has become an acceptable way of improving the load carrying capacity. In this work, comparative studies on behaviour of beams strengthened by Near Surface Mounting (NSM) method were done. Effectiveness of various fibre reinforced polymers like Carbon fibre reinforced polymer, Glass fiber reinforced polymers and Aramid fibre reinforced polymers were also studied. A two point loading system is adopted for the analysis. Beams were analyzed using ANSYS workbench software and the results are plotted graphically.

Keywords-Glass Fibre Reinforced Polymer, Carbon fibre reinforced polymer, Aramid fibre reinforced polymers, Near Surface Mounted Beams

I.INTRODUCTION
Concrete structures require strengthening and repairing when they become deficient during service life. This need may arise as a result of design or construction errors or even due to environmental factors. Since replacement of deficient structures need huge investments, strengthening has become the suitable way for improving their load carrying capacity and method of increasing their service life. Strengthening/repair is often the most economical way to solve this major problem.

Nowadays, fiber reinforced polymer systems are used in several applications to strengthen existing RC structures instead of the traditional systems using steel. To provide additional flexural strength FRPs may be attached on a beam or a slab tension surface, to provide additional shear strength FRPs can be attached on the sides of a beam, or wrapped around columns to provide confinement and additional ductility.

Near surface mounting (NSM) is the method of insertion of FRP reinforcements into grooves cut in the structural members is generally called. This can also be done by inserting steel reinforcement bars in grooves made in the concrete surface and filling it with cement mortar. Factors affecting the bond performance of strengthened with NSM CFRP rods are the type of FRP material, the shape of FRP surface, groove-filling material, groove shape and size, bonded length, and concrete strength.

Literature review shows that a large number of experimental as well as analytical works have been done based on NSM method of strengthening beams. At present no study is made on the effectiveness of shape of the groove and use of fibre reinforced polymer in NSM method. In this work the best shape of groove among circular and rectangular groove is determined. Effect of using different fibres in NSM method is also evaluated.

II.SCOPE AND OBJECTIVE
The main aim of the research is
1. To obtain load deflection behavior from analysis results.
2. To obtain stress strain relationship of various FRPs and comparing the results.
3. To determine the effect of fibres in NSM method considering variation in ultimate load when compared to the reference beam.
4. To study the importance of Near Surface Mounting method in beam strengthening.

The objectives of the project are listed below.
1. To study the structural behavior of GFRP in NSM method by cutting circular and rectangular grooves on beams.
2. Comparing the structural behavior of GFRP with circular and rectangular grooves and obtains the most effective groove shape.
3. Replacing GFRP with CFRP and AFRP for the most effective groove shape to determine the better FRP material.

III. METHODOLOGY

The strategy followed in this research was first started with geometry selection. Modeling was then done using ANSYS workbench software. Then the models were analyzed for similar loads and boundary conditions and the results obtained were compared.

IV. ANALYTICAL PROGRAMME

1. General:

An analytical programme was carried out to study the effectiveness of various types of fibres as shear reinforcements in reinforced concrete beams. Analyses were carried out on the beams to find the influence the type of FRP reinforcement on the structural behavior. The work includes modeling of beams of size 175mm × 250mm × 1400mm which were shear deficient. Out of the prepared beams, one beam was the control beam and other beams were strengthened for shear, using GFRP, CFRP and AFRP. GFRP was provided in the form of rectangular strips and circular rods for shear strengthening. All the specimens were simply supported and analyzed under two point loading.

2. Modeling of Beam Specimen:

The size of the beam selected for the study was 175mm × 250mm × 1400mm. All the beams were designed as shear deficient beams. Steel bars of 6mm, 8mm and 16mm diameter were used as the steel reinforcement in the beams. For tension reinforcement 3 numbers of 16mm diameter bars were used, 3 numbers of 8mm diameter bars were provided as top reinforcement and 6mm bars were used for lateral ties. At both ends of the beam two legged 6mm diameter bars were provided as holding stirrups. Clear cover of 25mm was provided for the reinforcement. Required groove size was cut on the lateral faces of the beams.

3. Strengthening of Beam Specimens:

To strengthen the shear deficient beams using NSM method, GFRP strips and GFRP rods were provided. The GFRP strip of tensile strength 750 N/mm² is used. Glass Fibre rods used is of tensile strength 900 N/mm². The groove filler used is Conbextra EP10 which is the medium for the transfer of stresses between the GFRP and the concrete.

Figure 3: Cross Section of FRP Strip in Rectangular Groove
4. Loading Conditions.

All the beams were tested for a maximum load of 300kN under two point loading condition. The beam specimens were simply supported with a span of 1200mm. Load is provided as step load 40 steps where provided with 20kN applied per step.

V. RESULTS AND DISCUSSION

The results obtained based on the analytical investigations carried out on the beam specimens and the discussion of analysis results is presented here.

1. Determination of Best Groove Shape

In analytical method cracking load taken corresponding to the time steps based on the stress strain graph of beam specimens. Ultimate load is taken corresponding to maximum deflection value calculated as span/250 for simply supported beams.

Table 1: Analytical Results

<table>
<thead>
<tr>
<th>Beam Designation</th>
<th>Cracking Load(kN)</th>
<th>Ultimate Load(kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Beam</td>
<td>100</td>
<td>166</td>
</tr>
<tr>
<td>6mm diameter GFRP Rods</td>
<td>131.5</td>
<td>240</td>
</tr>
<tr>
<td>3mm x 10mm GFRP Strips</td>
<td>155</td>
<td>270</td>
</tr>
</tbody>
</table>

The first crack load was more for all strengthened beams when compared with the control beam specimens. The results obtained from analytical study almost matches with the experimental result. From the study the beams strengthened by GFRP strip gives more cracking load as compared to the beam strengthened by GFRP rod. From this result we can conclude that the strength of beam will be 14% more in the case of rectangular groove than circular grooves.
2. Selection of Best FRP material

The first crack load and ultimate load obtained for the various beam specimens during testing are tabulated in Table 2.

<table>
<thead>
<tr>
<th>Beam Designation</th>
<th>Cracking Load (kN)</th>
<th>Ratio of increase</th>
<th>Ultimate Load (kN)</th>
<th>Ratio of increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Beam</td>
<td>100</td>
<td>-</td>
<td>166</td>
<td>-</td>
</tr>
<tr>
<td>GFRP strip</td>
<td>155</td>
<td>1.55</td>
<td>270</td>
<td>1.62</td>
</tr>
<tr>
<td>CFRP strip</td>
<td>160</td>
<td>1.60</td>
<td>276</td>
<td>1.66</td>
</tr>
<tr>
<td>AFRP strip</td>
<td>180</td>
<td>1.80</td>
<td>290</td>
<td>1.75</td>
</tr>
</tbody>
</table>

The load-deflection plots for all the tested beam specimens are as shown in Figure 5.

The first crack load was more for all strengthened beams when compared with the control beam specimen. The beam specimen strengthened by AFRP showed an increase in ultimate load of 1.75 times when compared to the control beam specimens. Whereas those strengthened with GFRP and CFRP showed an increase varying between 1.62 to 1.66 times ultimate load when compared with the control beam specimens. From load deflection behaviour, GFRP shows less improvement in ultimate load than control beam.
All the strengthened beam specimens showed better load deflection characteristics than the control beam specimen. For any particular load, the deflection of all the strengthened beam specimens was lesser than that of the control beam specimen. It is clear from figure that load deflection variation of all the strengthened beams shifted upwards as compared to the control beam. This is due to lesser deflection and greater load carrying capacity.

VI CONCLUSION

From the analytical study, the following conclusions can be drawn.

1. The beams strengthened by NSM method showed better result than control beam. This method can be adopted for increasing the service life of reinforced concrete beams.
2. The groove shape also plays a vital role in NSM method of strengthening. Beams strengthened by cutting rectangular grooves showed better performance than beams strengthened by circular grooves. Beam with rectangular groove showed 62% more ultimate load than control beam.
3. The FRP chosen for strengthening also affects the ultimate strength of the beams. For the same loading condition AFRP showed better performance than CFRP and GFRP. The properties of fibre used for strengthening improves the load carrying capacity of beams. Ultimate load in case of AFRP increased by 75% when compared to control beam.

REFERENCES: