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# An Experimental Study on Rehabilitation of RC Beam by Stitching Method

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***Abstract:*** ***The current work presents an experimental study on rehabilitation of RC beam by stitching method. For the study, a total of Twenty-Four RC beams were casted and cured for 28 days. Among the beams casted, three is control beam. Under two point loading, the control beam was tested for ultimate failure load and remaining twenty one beams were loaded for 75% of the ultimate failure load. The damaged beams were then rehabilitated by Stitching method using two different patterns. The rehabilitated beams were tested for ultimate failure load and the results are compared with control beam and the effectiveness of the rehabilitation is determined. From the result it is observed that as the diameter is gone increasing the flexural strength of the beam is gone increasing. As the depth of insertion of the bar inside the beam is gone increasing the flexural strength of the beam is gone increasing. It is concluded from this study that stitching methods is effective to restore the flexure capacity of damaged beams.***

***Keywords: Rehabilitation, Reinforced Concrete Beam, Stitching Method***

## I. INTRODUCTION

The Civil Engineering is a vast field and has different structures like residential, commercial and industrial buildings. Concrete is the most versatile construction material, which is used in all types of Civil Engineering structures. Because of the concretes flexibility in giving desired shape, economy and other features, has made it one of the most suitable building materials. Now a days usage of Concrete structure is on the rise. Beam is an important part which has significant role in construction of Concrete structure. Repair is the technical aspect of rehabilitation. It refers to change of a structure partly or completely which is damaged in usefulness or in appearance. Rehabilitation is the process of restoring the structure to service level. Now a days usage of Concrete structure is on the rise. Rehabilitation of the damaged structures which are already existing, have emerged as the most important construction activities globally. The replacement of deficient structural elements requires an enormous amount of money and time, so rehabilitation has become an important aspect in improving the load bearing capacity and increasing service life of structure. Rehabilitation by Stitching method in that the beams are rehabilitated with the help of additional reinforcement. Holes are drilled on soffit of damaged beams. Reinforcement in the form of U shape is provided.

## II. METHODOLOGY

The following methodology are adopted in this current study

*A.* For the study, a total of twenty-four RC beams were casted and cured for 28 days. Among the beams casted, three is control beam
*B.* Under two points loading the control beam was tested for ultimate failure load and remaining beams were loaded for 75% of the ultimate failure load.
*C.* The damaged beams were rehabilitated by Stitching method.
*D.* The rehabilitated beams were tested for flexural strength and the results are compared with control beam and the effectiveness of the Rehabilitation is determined.

## III. MATERIAL PROPERTIES

Properties of materials used in this study were obtained by testing of the corresponding material. OPC and Artificial sand are used in this project. The coarse aggregate used is 20mm in size. The properties of cement, fine aggregate, coarse aggregate, used are given in Table 3.1,3.2,3.3, respectively.

As the water actively participates in the chemical reaction with cement water is considered as an important ingredient of concrete. It helps to form cement gel which imparts strength to the concrete. The quantity and quality of water should be very carefully inspected and it should be free from any foreign materials. Potable drinking water having pH value ranging between 6 and 8 can be used for construction. Therefore, water used for this project was portable water free from impurities.

Table -3.1: Properties of Cement

| | |
|---|---|
| Specific Gravity | 3.13 |
| Fineness | 5% |
| Soundness | 3 mm |
| Initial Setting Time | 90 Minutes |
| Final Setting Time | 250 Minutes |

Table -3.2: Properties of Fine Aggregate

| | |
|---|---|
| Specific Gravity | 2.64 |
| Water Absorption | 0.8% |
| Fineness Modulus | 3.12 |

Table -3.3: Properties of Coarse Aggregate

| | |
|---|---|
| Specific Gravity | 2.67 |
| Fineness Modulus | 7.31 |
| Water Absorption | 1.74% |
| Flakiness Index | 15.04 % |
| Elongation Index | 9.64% |
| Impact Value | 11.42% |

## IV. MIX DESIGN

Casting of concrete specimens was done as per Indian Standards. M25 mix was chosen and done mix design. Mix ratio obtained was 1 : 1.65 : 3.17 and water cement ratio is 0.5

## V. EXPERIMENTAL WORK

The experimental work which was carried out is discussed briefly and it includes casting of beams, test setup and testing procedure. Total Twenty-four reinforced concrete beams of dimensions 700 mm × 150 mm × 150 mm were casted. For casting of beams steel molds satisfying the beam dimensions were prepared. The inner surface of the mold was spread with machine oil. The measured quantity of cement, fine aggregate and coarse aggregate were mixed thoroughly to obtain a uniform color in the laboratory concrete mixer. The measured quantity of water was added to the dry mix and mixing. The steel reinforcement was placed inside the mold with proper cover. The concrete was poured into the mold in layers. Each layer of concrete was compacted well. The top surface of the concrete was finished well. The beam specimen was removed from the mold after 24 hours of cast. After that beams are placed in water tank for curing for 28 days.

Fig No-5.1 Casting of Beam

Fig No-5.2 Curing of Beam

## VI. TESTING OF BEAMS BEFORE REHABILITATION

To study the behavior of beams under pure flexure, two - point loading system are used on the beams after 28 days of curing. Control beams are tested up to failure and the. Beams to be retrofitted are loaded 75% of ultimate load as shown in table no 6.1.
Among the beams casted, three is control beam Under two-point loading, the control beam was tested for ultimate flexural load as shown in Table 4 and remaining twenty-one beams were loaded for 75% of the ultimate failure load. The damaged beams were then rehabilitated by Stitching method using two different patterns. The rehabilitated beams were tested for ultimate failure load and the results are compared with control beam and the effectiveness of the rehabilitation is determined.

Table-6.1 Ultimate flexural load

| Sr . No. | Specimen | Load at failure ( KN) | Average load at failure (KN) |
|---|---|---|---|
| 1 | Control beam 1 | 65.95 KN | |
| 2 | Control beam 2 | 84.25 KN | 70.62 KN |
| 3 | Control beam 3 | 75.30 KN | |

Table No 6.1 - Average load calculation of tested beams and 75% of the ultimate failure load is 52.96 KN and this load is given to remaining 21 beams

## VII. STITCHING METHOD

Method consists of rehabilitating the damaged beams by providing U-type bars and stitching them in to the bottom of beam. The bar is bent at $90^0$angle at both the ends. This U-type bar is provided as an extra tension reinforcement.
Stitching method was done by using 2 different patterns as follows :

*1)* 9 Beam of Double bar pattern ( 3 sets of each 3 specimen with 8,10, 12 mm Diameter)
*2)* 9 Beam of Different depth pattern ( 3 sets of each 3 specimen at 25, 50, 75 mm Depth)

Fig No 7.1 - U shape Bars

*A. Pattern I :- Diameter Variation in Beams .*

*1)* After testing of damaged beam First, the dust is removed completely and cleaned.
*2)* Holes are drilled on tension side of beam and two U shaped bars of 8 mm, 10 mm, 12 mm are placed.
*3)* The dust from the holes is removed and kept clean.
*4)* The holes are filled with grouting material.
*5)* After that concrete cover of 25 mm is maintained throughout the beam.
*6)* And then beams was kept for curing.

*B. Pattern II :-Depth Variation in Beam.*

*1)* After testing of damaged beam First, the dust is removed completely and cleaned.
*2)* Holes of 14 mm diameter are drilled on the tension side of the beams and two U-type bars of 10 mm are placed up to 25 mm , 50 mm , 75 mm depth in to the beam.
*3)* The dust from the holes is removed and kept clean.
*4)* The holes are filled with grouting material.
*5)* After that concrete cover of 25" is maintained throughout the beam .
*6)* And then beams was kept for curing

Fig No 7.2- Insertion of U shape bars in beams

Rehabilitated beams were tested for ultimate flexural strength and the results are compared with control beam and the effectiveness of the rehabilitation is determined.

## VIII. RESULT

The following table shows result of the RC beams after applying stitching method. Two ways are applied for rehabilitation of beams.

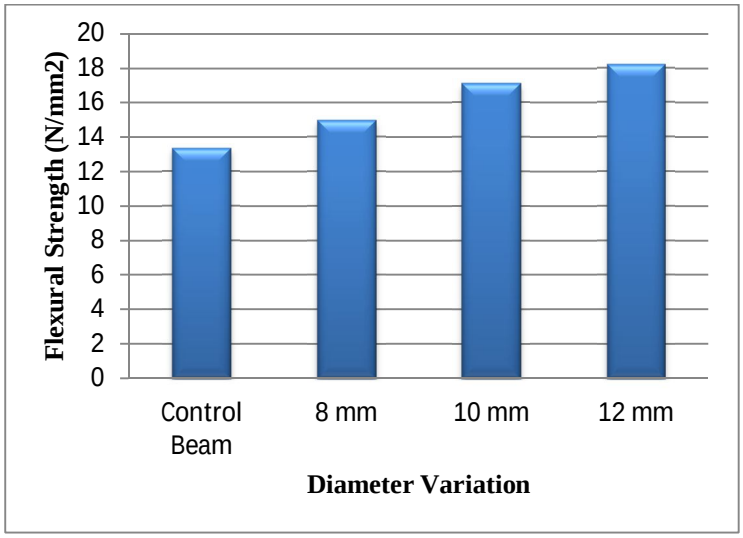
*1)* Variation of diameter of bar used for rehabilitation of beams. In experimentation diameter of bars 8mm, 10mm,12mm were used.
*2)* Variation of insertion of depth of bar. In experimentation depth insertion of 25mm, 50mm, 75mm were used.

*A. Test Results of beams after Rehabilitation*

*1) For Diameter Variation*

Table No 8.1 Overall results of flexural strength For Diameter Variation

| Sr No | Identification | Flexural strength in (MPa) | % Increase in strength |
|---|---|---|---|
| 1 | Control beam | 13.35 | --- |
| 2 | 8 mm Diameter bar | 14.96 | 12.06 |
| 3 | 10 mm Diameter bar | 17.12 | 28.24 |
| 4 | 12 mm Diameter bar | 18.19 | 36.25 |

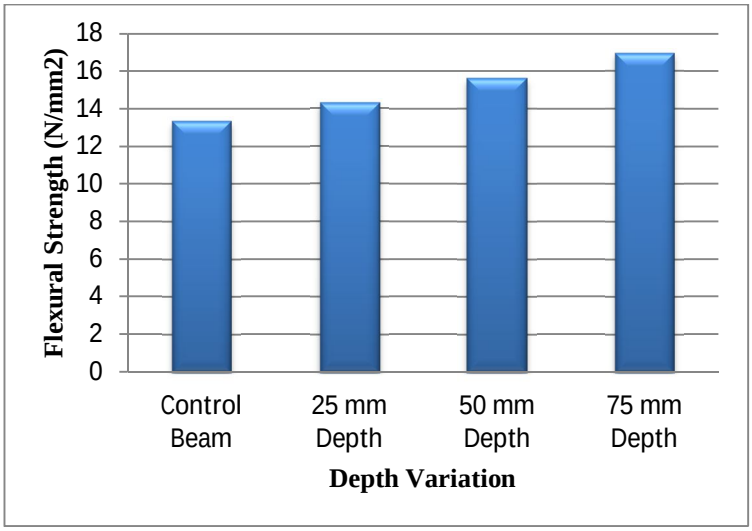



Graph No 1- Variation in Flexural Strength For Diameter Variation.

*2) For Depth Variation*

Table No 8.2 -Overall results of flexural strength for Depth Variation

| Sr No | Identification | Flexural strength in (MPa) | % Increase in strength |
|---|---|---|---|
| 1 | Control beam | 13.35 | --- |
| 2 | 25 mm depth | 14.29 | 7.04 |
| 3 | 50 mm Depth | 15.63 | 17.07 |
| 4 | 75 mm Depth | 16.97 | 27.12 |




Graph No 2- Variation in Flexural Strength For Depth Variation.

## IX. CONCLUSION

Based on results of experimentation conducted the following conclusion can be drawn

*A.* The flexural strength of rehabilitated beam by stitching method for 8mm diameter bars is 12.06 % more than control beam without any rehabilitation.
*B.* The flexural strength of rehabilitated beam by stitching method for 10mm diameter bars is 28.24 % more than control beam without any rehabilitation.
*C.* The flexural strength of rehabilitated beam by stitching method for 12mm diameter bars is 36.28 % more than control beam without any rehabilitation.
*D.* As the diameter of bar used for rehabilitation of beam is go on increasing the flexural strength of the beam is also go on increasing.
*E.* The flexural strength of rehabilitated beam by stitching method for 25mm insertion of 10mm diameter bars 7.04 % more than control beam without any rehabilitation.
*F.* The flexural strength of rehabilitated beam by stitching method for 50mm insertion of 10mm diameter bars 17.08 % more than control beam without any rehabilitation.
*G.* The flexural strength of rehabilitated beam by stitching method for 75mm insertion of 10mm diameter bars 27.12 % more than control beam without any rehabilitation.
*H.* As the depth of insertion of bars used for rehabilitation is go on increasing the flexural strength of beam is also go on increasing.

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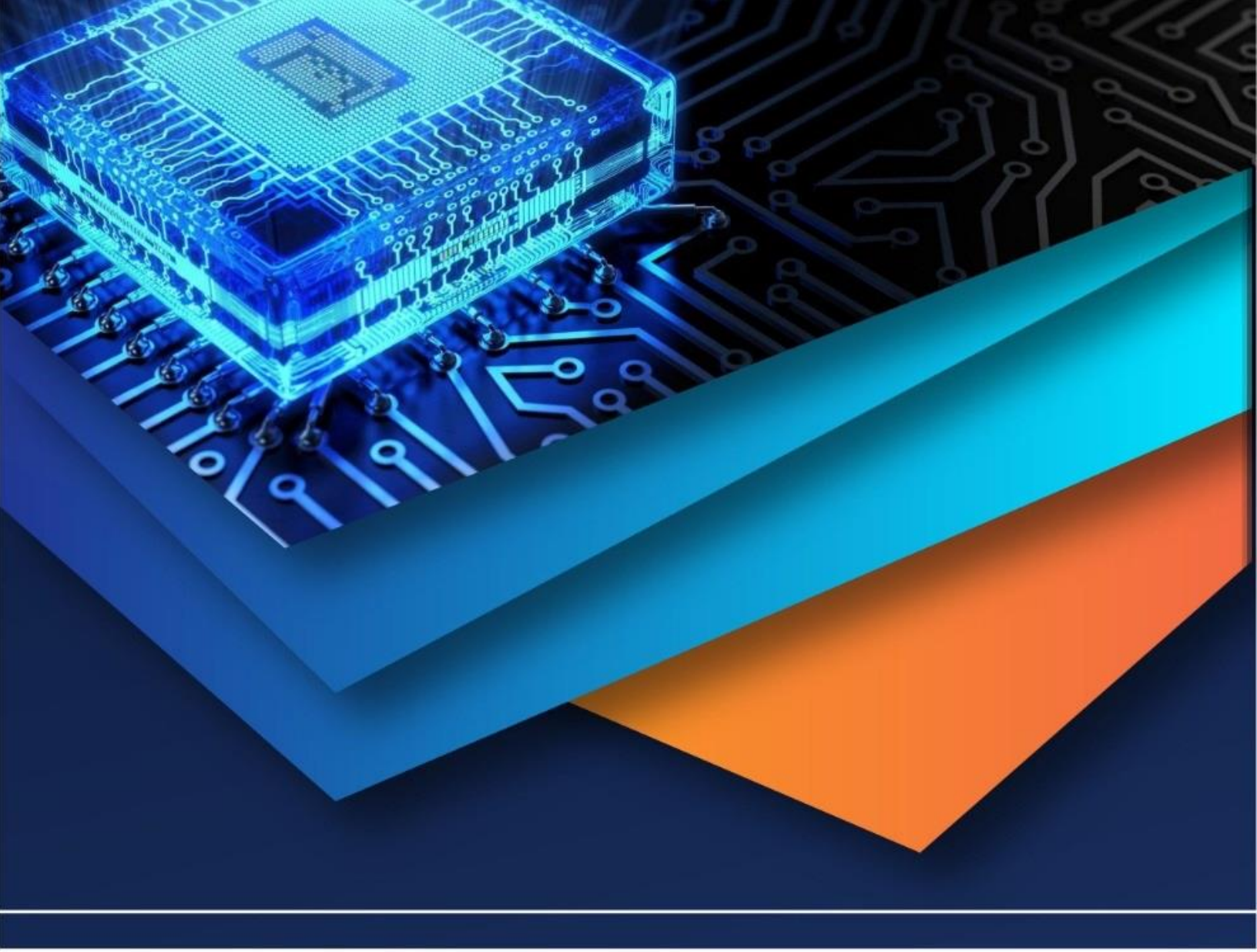

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