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Study on Flexural Behaviour of RCC Beams Retrofitted with Biplanar Geonet

Sherine Stanly, D. B. Tisny

Abstract—Major problem in the construction industry is deterioration of concrete structural elements. Replacement of deficient structural elements is uneconomical and inconvenience due to interruption of function of the structure. It is often better to upgrade the structure by retrofitting. External strengthening has become an acceptable way of improving the load carrying capacity of the existing structure. The present study intended to develop a technique of retrofitting of RCC beams, using geonet. In this study biplanar geonet was used as an externally bonded material. Prior to retrofitting, the specimens were subjected to different levels of distressing, 67%, 80% and 90% of the flexural capacity of control specimen. The flexural behaviour of control specimen and retrofitted specimen were studied. From the result obtained, a significant improvement in load carrying capacity was observed, which depends upon the distressing level.

Index Terms: Biplanar Geonet, Flexural Behaviour, Retrofitting.

I. INTRODUCTION

Reinforced concrete structures are one of the most important structure system. After a period of rapid economic growth, structural modification of existing infrastructures that have been aging rapidly. Reason for the demand for structural modification is the upgrading of load carrying capacity and resistance to withstand underestimated loads, to ameliorate the increased perceived risk from earthquakes.[1] In such circumstance replacement or retrofitting is adopted. Replacement is uneconomical and inconvenience due to interruption of function of the structure. It is often better to upgrade the structure by retrofitting. Retrofitting is the upgrading of existing structure for improving its structural performance even before or after the damage. Retrofitting is a more feasible economic alternative than demolition and reconstruction.[2] Studies were conducted on reinforced concrete members strengthened with ferrocement and steel plate bonding.[3,4] Ferrocement jacketing and steel plate bonding has become an acceptable way of improving the load carrying capacity of the existing structure. Major drawback with these retrofitting system is the corrosion of externally bonded steel plate and wire mesh. To overcome these drawback, many alternative materials were introduced for retrofitting, which includes Textile-reinforced mortar (TRM) and Fibre reinforced polymer (FRP).[5-7] The present study intent to develop a new retrofittingsystem using biplanar geonet. Studies were conducted using geosynthetics as shear reinforcement. The use of geosynthetics was found to be effective in increasing the strength and ductility characteristics.[8] Biplanar geonet is a geosynthetic material consisting of two sets of intersecting ribs overlaying at different angles and spacings. Owing to the non-rusting properties of the geonet mesh, the wire mesh in the ferrocement jacketing can be replaced by the geonet. The main aim of the paper is to introduce a new retrofitting material. In this study, the flexural behavior of pre-damaged reinforced concrete beams retrofitted with biplanar geonet was studied.

II. EXPERIMENTAL DETAILS

A. Material Properties

Concrete with an average compressive strength of 28 N/mm^2 was used for casting the tested specimens. High tensile steel of diameter 10mm was used for bottom reinforcement and 8mm diameter was used for top reinforcement. Mild steel of diameter 6mm was used as shear reinforcement. The geonet used in the study had a thickness of 3.2mm withtensile strength of 30kN/mm^2.

B. Specimen Descriptions

Nine reinforced concrete beams were cast. All beams had a cross section of 100 mm x 150 mm, and a total length of 1m. . For flexure reinforcement, two reinforcing bars of 10mm high tensile steel were used as tension reinforcement and two reinforcing bars 8mm high tensile steel were used as compression reinforcement. The shear reinforcement consist of 2 legged, 6mm diameter stirrups at 90mm spacing throughout the span. Fig. 1 shows the reinforcement details of tested specimen.

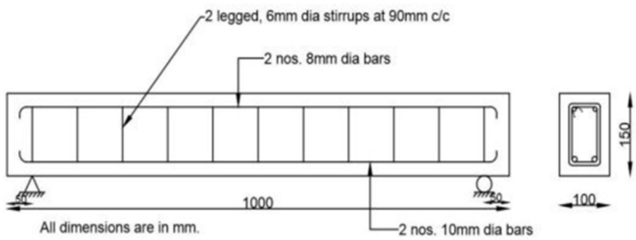

Fig. 1 Reinforcement details of tested specimens.

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TABLE I: DESIGNATION OF SPECIMENS

Beam No.	Designation	Description
B1	CS0	Control specimen
B2	DN67	Beams distressed with 67% of ultimate load, then retrofitted using geonet

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B3	DN80	Beams distressed with 80% of ultimate load, then retrofitted using geonet
B4	DN90	Beams distressed with 90% of ultimate load , then retrofitted using geonet

Table I presents the summary details of the beams used in the experimental study. The beams designation stands for two letters and number, CS stands for control specimen, D stands for distressing the beam and N stands for retrofitting with geonet. The number refers to the percentage of distressing with respect to the ultimate carrying capacity of control specimen. The retrofitting of beam was done in constant moment region of length 300mm after distressing the beam specimens. The beam surface was roughened using a grinding machine to improve the bond with concrete substrate. The concrete surface was cleaned and bonding agent was placed over the surface. Geonet was wrapped around the surface using U-wrapping technique. Finally a layer of mortar of 1:3 ratio was applied over the geonet.

C. *Test Setup*

All beams were tested under two point loading condition. The effective span of the beams was 900mm. A dial gauge was used to measure the deflection at the mid-span. These values were used to plot load-deflection relation. Strain gauges were placed on tension reinforcement and compression reinforcement to measure the strain. Loading was applied using a 1000 kN universal testing machine at 2.5 kN load increment. All readings from the dial gauge and strains were manually recorded.

III. TEST RESULTS AND DISCUSSION

A. *Cracking Behaviour and Failure Mode*

The failure mode of each tested specimen was determined by referring to the initiation and propagation of the cracks. For the distressed beams, at specified distressing level, the maximum crack widths at constant moment region varies between 0.18 and 0.36. After the loading is removed, the cracks were partially closed and the maximum crackwidth varies between 0.04 and 0.1. The crack patterns of the beams after distressing indicates that the number and depth of the cracks increases with increase in distressing level. For all beams, crack was initiated in the span between two concentrated loads. In this region the flexural stress is highest and shear stress is zero. The cracks formed were vertical and was perpendicular to the direction of the maximum principal tensile stress induced by pure bending. The crack pattern of retrofitted beams is shown as in fig. 2.

Fig. 2. Crack patterns of the retrofitted beam specimens.

For the control specimen the first crack occurred at 18 kN and first cracks for DN67, DN80 and DN90 specimens were 22.5 kN, 20 kN and 15 kN respectively. The control specimen failed by forming large flexural cracks at the constant moment region. Intermediate flexural crack followed by tributary cracks were formed on DN67 specimen. Flexural shear cracks were formed on DN80 specimen. For DN90 specimen, the width of the flexural crack was more pronounced as compared to other specimens. The cracking loads, yield load, ultimate loads and crack pattern of specimens were given in table II.

TABLE II. SUMMARY OF TEST RESULTS.

Designation	First Crack Load (kN)	Yield Load (kN)	Ultimate Load (kN)	Crack Pattern
CS0	18	48	59	Flexural crack
DN67	22.5	59	67.5	Flexural crack followed by tributary cracks
DN80	20	51	63	Flexural shear crack
DN90	15	43	55	Flexural crack followed by tributary cracks

B. *Load – Deflection Behaviour*

All the curves were characterized by three distant stages: Un-cracked beam, development of cracking up to yielding of steel reinforcement and post yielding response up to failure. Any difference between the curves of the retrofitted beams and the control specimen is attributed to the contribution of retrofitting material to the flexural performance of the beams. The effect of retrofitting was more pronounced during stage – II, where the development of flexural cracks was progress. During this stage, for specimen DN67, both the steel reinforcement and geonet were activated in tension and contributed to the increase of the beam's flexural resistance. The load – mid span deflection curves of the tested beams are as shown in fig. 3.

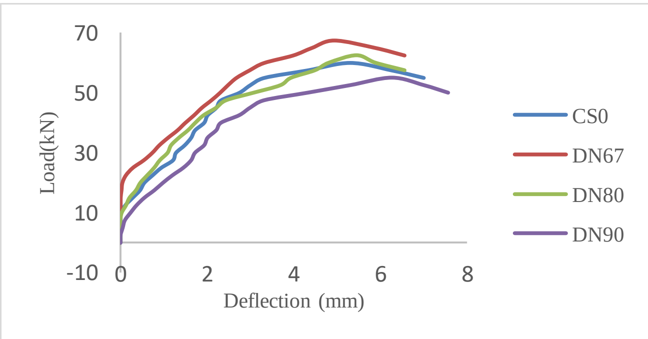

Fig. 3. Load – mid span deflection of test specimens

C. *Energy Absorption*

Energy absorption capacity of reinforced concrete specimen is one of the crucial structural properties that define the specimen's seismic resistance.

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The use of geonet for the retrofitting of reinforced concrete beams is predominantly motivated by the energy absorption capacity. Energy absorption is obtained by the area under the load deflection curve. Due to limitation in experimental setup, the energy absorption iscalculated by successive integration method. The energy absorption of control specimen and retrofitted specimens are shown in fig. 4.

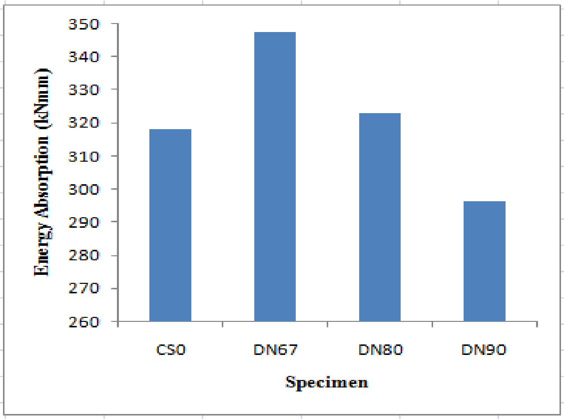

Fig. 4. Energy absorption of test specimens

IV. CONCLUSIONS

This study investigated experimentally the flexural behaviour of reinforced concrete beams retrofitted using geonet. The obtained results revealed the following conclusions:

- Two types of crack patterns were observed in the geonet retrofitted beams. These crack patterns were found to be sensitive to the level of distressig.
- For the specimens DN67 and DN80, the load carrying capacity was substantially increased compared to the control specimen (up to 14% and 7%).Thus, damaged beams retrofitted with geonet appear to be structurally efficient and reliable.
- Specimens distressed with 67% of ultimate load of control beamshowed significance improvement in energy absorption due to the formation of finer cracks

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Ms. Sherine Stanly,

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