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Flexural Performance Near Surface Mounted Technique On RC Beam

Application Of Near Surface Mounted Technique To Improve Flexural Performance)

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Abstract : This After certain period of time, concrete structure elements require Re-construction or Rehabilitation, due to different reasons as mechanical damage, environmental effects, increased service loads, and errors in design and construction. Since past few decades, Near-Surface Mounted (NSM) technique using Glass Fiber-Reinforced Polymer (GFRP) bars has become an effective to increase flexural strengthening of existing Reinforced Concrete (RC) beam. This technique involves grooves cut such that the depth of groove must be less than the concrete cover. The grooves are partially filled with epoxy, into which FRP bar are placed, later these grooves are fully filled with epoxy. In total five RC beams were casted and tested under two-point load system. The main aim of this is to study the structural capacity by varying the amount of flexural reinforcement and spacing of stirrups. The experimental results shows that strengthening with NSM FRP bars significantly increase the flexural and shear strength compare to the control specimen. This technique will eliminate or reduces the crack width and growth rate, delay initial cracking and extend the life of RC beams.

***Key Words* – Near Surface Mounted Technique, Flexural Performance, NSM, NSM Technique, GFRP Bar**

I. Introduction

Reinforced concrete (RC) structures have a limited service life. Damage of reinforced structures may be the result of insufficient reinforcement, large deflections, poor concrete quality, and corrosion of steel reinforcement or insufficient capacity. The bonding of steel plates for the strengthening and rehabilitation of reinforced concrete structures was a popular strengthening method in the past. Strengthening is the process of enhancing capacity of damaged components of structural concrete to its original design capacity, or an improving over the original strength of structural concrete. Reinforced concrete structures damages are affecting the integrity of structures or buildings such as beam, column joint. In this Poor concrete quality, reinforced structures may be result of insufficient reinforcement, Shear failure is a common problem in concrete structures. Natural disasters, such as hurricanes and earthquakes, may also cause shear Failure of structures before full flexural capacity is achieved. Reinforced concrete (RC) and Restressed concrete (PC) structures, such as buildings and bridges that were designed several decades ago, also exhibit shear cracks because of regular and unintended or unforeseen loads, uncounted loads in the earlier designs, inferior material behaviour, and loss of concrete strength due to aging. Efficient and cost-effective method of strengthening concrete members in sheer is of reinforcement, Increased Service Loads, large deflections, Errors in design and Construction. Electrochemical corrosion utmost importance to encounter shear-deficiency problem in RC and PC structures. In this Corrosion of steel of steel is a major cause of the deterioration of civil engineering infrastructure. It is becoming a principal challenge for the construction industry world-wide. The climatic conditions where large amounts of salts are used for ice removal during winter months may contribute to accelerating the corrosion process. These conditions normally need costly repaired as they may lead to catastrophic failure. Due to, above mention problem, all over the world require rehabilitation of the reinforced concrete structures. “Rehabilitation” of a building means returning a building or a structure to a useful state by means of repair, modification or alteration.” Structural rehabilitation involves the upgrading or changing of a building’s foundation in support of changes in the building’s owners, its use, design goals or regulatory requirements. In every case it is determined that it is cheaper to rehabilitate the structure and make the building improvements instead of demolishing and constructing a new building in the allotted space. The objective of any repair should be to produce rehabilitation- which means a repair carried out relatively low cost, with a limited and predictable degree of change with time and without premature deterioration and/or distress throughout its intended life and purpose The cost of rehabilitation and repair in most cases is far less than the cost of replacement. Furthermore, repair and rehabilitation usually take less time than replacement and thus reducing service interruption time. However, corrosion of steel under certain environments can lead to deterioration of structural elements, deriving to large repair and rehabilitation costs. In order to prevent these high expenses, construction industry has but they normally appear to be either expensive or ineffective. The tried several approaches to inhibit the corrosion of steel. Superior mechanical and physical properties of fiber reinforced plastics (FRP) make them excellent candidates for repairing and retrofitting structures. FRPs are made of high-strength filaments such as glass, carbon, and aramid placed in a resin matrix. Glass-based composites have been readily available and fairly inexpensive. They have been used in applications involving concrete and masonry structures. The low-tensile modulus of these composites made them ineffective for retrofitting steel structures.

II. Objectives Of The Study

Since the available studies on NSM strengthening technique are still limited, the need of further experimental researches are essential to deeply understand the bond behavior between the NSM reinforcement and concrete. Moreover, the effectiveness of the NSM strengthening system on the flexural and shear behavior of RC beams also still needs to be supported on rigorous studies able to provide reliable data to be used to propose design and prediction methods. The main objective of the present to investigate the effectiveness of strengthening RC beams with NSM FRP rods and strips. In order to achieve this aim, the following tasks were undertaken

1. Experimentally investigate the flexural behaviour of RC beams strengthened with GFRP bars. The experimental programmer was carried out to study the effect of FRP materials (glass), number and area of bars, bond length, epoxy properties, and strengthening arrangement on the flexural response of RC beams strengthened with limited bond length of NSM FRP reinforcement.
2. Experimentally investigate the study load deflection relationship between steel and FRP materials.
3. To study crack pattern failure modes of RC beams with GFRP and CFRP bars. In order to measure the crack pattern create of the tested RC beams. And to study load capacity of the beam.
4. The experimental programmer was carried out to study the effect of FRP materials (glass), and load caring capacity on the RC beam.

III. Overview Of Near Surface Mounted technique

In order to reinforce RC components and masonry to increase member's flexural and shear strength, the NSM FRP has emerged as an appealing technique. This method involves cutting grooves into the concrete cover and bonding the FRP reinforcement into those grooves. When it comes to reinforcing masonry walls and concrete buildings, the NSM FRP technology has a number of benefits over the EB FRP technique. The most noteworthy advantages are that the application of NSM reinforcement does not require any surface preparation work except grooving; once the NSM reinforcement is protected by the concrete cover, it is then suitable to strengthen the negative moment regions of beams and slabs; a significant decrease of harm resulting from fiber, mechanical damages and other effects, NSM reinforcement is less prone to de-bonding from the concrete substrate, and furthermore, the aesthetics of a strengthened structure with NSM reinforcement are virtually unchanged. Although the bond performance is greatly improved as compared with the EB system, it is still the key factor in the design of NSM FRP strengthened elements. There are two interfaces in this technique, the bar-epoxy and the concrete-epoxy, in which the bond is affected by factors which include FRP properties, FRP surface treatment, bar size, groove surface, groove geometry, adhesive, test setup and concrete properties. ACI Committee 440 is presently a revision of the document titled: "Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures" to include such technology. Based on previous studies the committee recommends the use of de-bonding strain of the NSM FRP reinforcement "Ɛfd = 0.7Ɛfu, "Ɛfu is the ultimate tensile strain in the FRP.

IV. Experimental Program's Results

Five beams are being prepared and tested as part of the project. M20 and Fe 500 Grade are used to cast the beams. After a few trial mixes, the concrete grade is decided. The remaining beam specimens were reinforced with steel bars, while the first beam served as the control beam. The beam was 150mm wide, 200mm deep, and 1000mm long. All of the beams underwent 28 days of curing after casting. Now installation of the strengthening FRP bars began with the cutting of groove. The grooves were made with a special concrete saw with a diamond blade. A hammer and a hand chisel were used to remove any remaining concrete lugs and to roughen the lower surface of the groove. The grooves were cleaned with a wire brush and a high pressure air jet. after the grooves were partially filled with epoxy the frp bar rod was inserted and gently forced within it was compelled to flow around the inserted bar as a result the surface was smoothed and the groove filled with more epoxy the beam was kept for a week to verify that the epoxy had fully developed its strength. After all this we have to compare the both of the strengthening readings which will give the exact idea about the how much strength we can get after the surface mounted technique.

4.1 GFRP(Glass Fibre Reinforced Polymer) Reinforcement

The RC beam specimens that were flexurally reinforced using NSM procedures were made with the ribbed GFRP bars. The market pricing and the density, tensile and shear strength, and modulus of elasticity of the GFRP bars are shown below based on information provided by the manufacturer (MRG Composite).

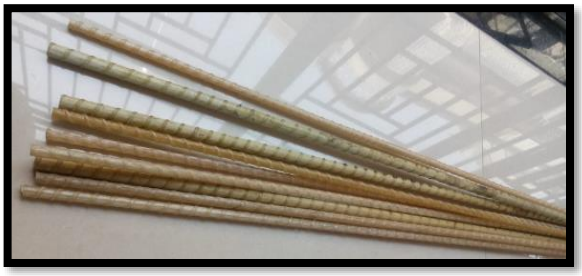

Fig.1 GFRP Bars

Fig. 2 Cross-Section Area Of GFRP Bars

Table 4.1 : Properties Of GFRP Bars

Diameter(mm)	Density(g/cm3)	Ultimate tensile strength (Mpa)	Ultimate shear strength (Mpa)	E-Modulus(GPa)
8	2.2	1080	150	40
19	2.2	980	150	40

4.2 Epoxy Adhesive

The specimens' concrete base and reinforcing reinforcements were joined together using Sikadur® 30 epoxy paste adhesive. Components A and B make up the epoxy adhesive; A is white in colour and is made up of epoxy resin, while B is black in colour and is made up of a hardener. A uniform grey hue was produced by combining the two ingredients in a 3:1 ratio.

4.3 Specimen Preparation

Figure displays the specimen's size and reinforcing information. The beams were made to fail in flexure by being under-reinforced beams. The beams had cross-sectional measurements of 150 mm by 200 mm and a length of 1000 mm.The three different types of steel bars, with diameters of 12 mm, 10 mm, and 8 mm, were used to build the beam specimens. For shear reinforcement, bars with a diameter of 10 mm were utilised instead of 8 mm for tension reinforcement. While 8 mm diameter bar was utilised to strengthen anchorages. Each beam had a constant 130 mm spacing when it was cast.

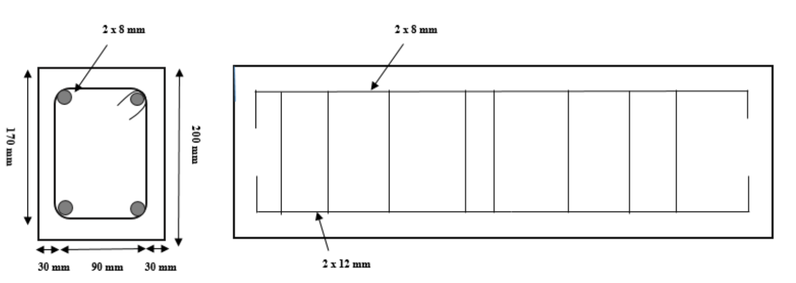

Fig. 3 Control Beam

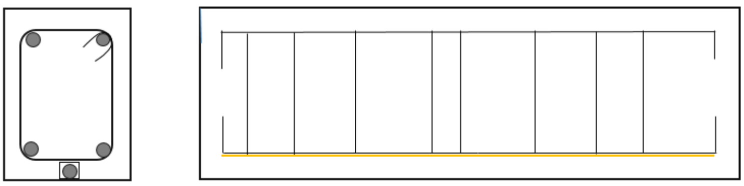

Fig. 4 Flexural Strengthening Beam

Strengthening GFRP bars were inserted into the grooves with a light force, as indicated in Figure, and the grooves were then halfway filled with epoxy glue. The strengthening GFRP bar was moved about by the adhesive as a result of this force. To fill up the groove and level the surface, more glue was applied. The enhanced specimens were kept in storage for a week of hardening so the epoxy glue could cure and reach its maximum strength.


Fig. 5 Grooving In Beam

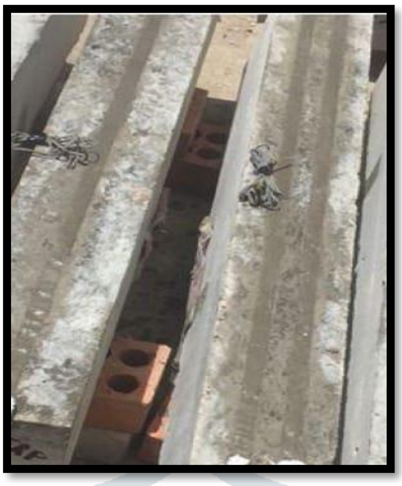
Fig. 6 Apply The GFRP Bars


Fig. 7 Filled Using Epoxy Adhesive

4.4 Test Setup

The universal testing machine (UTM) was used to test the RC beam specimens, and a dial gauge was used to measure the mid-span deflection of the beam. The two point flexure test is the experimental setup used to examine RC beam specimens, as illustrated in figure. The RC beam specimens are positioned horizontally over the lower support, and a force is then applied to the top of the beam until the specimen breaks. The beam measures 1000 mm in length. Every beam is built with under-reinforced beams to cause flexure failure. Some of the beams collapsed owing to the combined effects of shear and flexure, whereas others failed due to flexure alone. The failure of the RC beam under shear when its flexural strength is sufficient is evidence that the strengthening strategy used in flexure is successful. It was found that all of the reinforced beams failed under flexure with fewer and finer cracks than the control beam CB, indicating that the stiffness of the enhanced beams had increased.


Fig. 8 Testing Of Beam

4.5 Mode Of Failure

` The top fibre of the RC beam was crushed by concrete in the first failure mode, and the tension steel reinforcement gave way in the second. All of the beams had a similar pattern of cracking. A little flexural crack near the beam's midspan first appeared. Additional fractures formed near the neutral axis or beyond the neutral axis as the external load rose, significantly increasing the beam's deflection. In contrast to the control beam, all enhanced beam specimens had smaller and more minute fractures. This is as a result of the reinforced beam specimens' increased stiffness.


Fig. 9 Failure Of Beam

V. RESULTS AND DISCUSSION

In the first stage, the behaviour of all the beams is linear and elastic. Before the first crack, the bond between the steel bar, adhesive and concrete is perfect. At the beginning of this stage, the cracks do not pass through the integrant materials because of their higher tensile strength and low elastic modulus. As the loading increases, the cracks become more widespread and new flexural cracks arise. The use of NSM steel bars increased the yield load of the strengthened beams by 4.87% , 7.31%, 2.44% and 9.75% for NSM1 FB1 (Flexure beam), NSM2 FB2, NSM3 SB1 (Shear beam) and NSM4 SB2 respectively over the control beam.

Table 5.1 : Test Result

Beam specimen	Ultimate load (KN)	Percentage increase in load carrying capacity (%)
CB	82	-
NSM1 FB1	86	4.87
NSM2 FB2	88	7.31
NSM3 SB1	84	2.44
NSM4 SB2	90	9.75

CONCLUSION :

- Flexural strengthening of RC beams with the NSM technique using GFRP bars is effective, as NSM bars significantly improved the flexural performance via the reduction of the deflection, the delay in the formation of first crack, the decrease in crack width and the increase in the number of cracks and ultimate loads of the specimens compared with the control specimen.
- The load carrying capacity of beams strengthened with NSM steel reinforcement showed an increase of maximum by 7.31 % when compared to control beam specimen.
- Energy absorption capacity, ductility and stiffness under the service load were all significantly enhanced by the NSM technique via the use of GFRP bars.
- Increasing the strengthening reinforcement improved the flexural performance of the specimens compared with the control specimen.
- This shows that this method can enhance the flexural performance of RC beams. Strengthened beams showed lesser number of cracks with fine cracks implying increase in stiffness of the strengthened beams.
- The predicted and experimental results for flexural and shear strengthening of the beam specimens are in good agreement

VI. ACKNOWLEDGMENT

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