



Article Title: **Strengthening of RC Beam Using Different Techniques**

Strengthening of RC Beam Using Different Techniques

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ABSTRACT

Structural strengthening is the process of upgrading structures to improve performance under existing loads or to increase the strength of structural members to carry additional loads. The need for structural strengthening is commonly driven by building codes, deterioration, change in use, or deficiencies caused by design or construction. Strengthening of concrete structures must be considered when the existing structure deteriorates or any alteration to the structure has to be made due to which the structure may fail to serve its purpose. Concerns must be taken to existing materials, often in deteriorated condition, loads during strengthening and to existing geometry. In some cases it can also be difficult to reach the areas that need to be strengthened. When concrete structural strengthening is to be undertaken all failure modes must be evaluated. Strengthening a structure for flexure may lead to shear failure instead of giving the desired increased load bearing capacity. It should also be noted that not only the failure mode of the strengthened member is important. If a critical member in a structure is strengthened, another member can become the critical one. Because of changed stiffness in an undetermined structural system the whole structure must be investigated. The strengthening should also designed with consideration to minimize the maintenance and repair needs.

1 Introduction

Many of the existing concrete structures throughout the world are in urgent need of rehabilitation, repair and re-construction because of deterioration due to various factors like corrosion, failure of bonding between beam column joints, increase in service loads, etc., leading to cracking, spalling, loss of strength, deflection, Need for efficient rehabilitation and strengthening techniques of existing concrete structures has resulted in research and development of strengthening of structure. Although a majority of concrete structures have performed satisfactorily over the past years but many problems have raised due to improper quality of materials, incorrect specification, faulty design and mistakes in construction process or extreme environmental conditions Significance depends on the type of structure as well as the nature of the cracking. To strength the cracks on the reinforced concrete beams has different methods. This project work focuses to strength the reinforced concrete beams using different techniques and also to improve the strength of the beams. In the present scenario, deterioration of concrete structure is a worldwide problem. There a sons behind this are many, like-occurrence of natural hazards like earthquakes, lack of awareness of several important co dal provisions in construction, poor quality of supervision etc...These factors lead to strength 2 deficient structures. Sometimes, overloading of structures leads to excessive deformations and corrosion which need considerable attention today.



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To overcome all these effects on reinforced concrete structures: repair, retrofitting or strengthening are regularly required activities in construction field today. The damages caused by all of these possible ways will require variety of possible repair techniques, from which most effective one will be chosen in each particular case. In some cases even newly built structures require, repair and strengthening so as to eliminate defects due to mistakes in design or construction. The repair of concrete structure or its element has always been very difficult, and adequate solutions have often entailed extensive works. Specialized techniques of strengthening, stiffing and repair are needed to deal with damaged structural elements due to unusual event such as fire, earthquake, foundation movement, impact and overload. Many existing bridges, industrial structures, urban transport structures, marine structures and earth retaining structures are in need of repair or upgrade. During the service life due to many reasons the reinforced concrete structures have to face some modifications and improvements. In such case there are two possible solutions: replacing or strength. Replacing of whole structures causes disadvantages like high costs for labour and material. So without replacing the whole structure, it is desirable to repair it or upgrade it by strength.

2 Literature Review

Susanne Heyden (2014): This paper presents the result so far an experimental study to investigate the behaviour of structurally damaged full-scale reinforced concrete beams retrofitted with laminates in shear or in flexure. It was found that the efficiency of the strengthening technique by carbon fibre reinforced polymer in flexure varied depending on the length. The main failure mode in the experimental work was plate delamination in retrofitted beams. Farid and S. Ahmad (2011): This paper presents the result of an experimental investigation on the strengthening of existing cracked RC members. The beams were then repaired with the application of polymer modified mortar technique an improvement in the load carrying was observed in the beams after the retrofitting Alberto Balsamo and Francesc Saceroni (2012): An experimental investigation has been carried out on prestressed-concrete beams strengthened in flexure with traditional and different innovative composite externally bonded systems in order to compare their structural performance between them and with respect to unstrengthened specimens.

Nesreen M. Kaseem (2012): This paper presents an experimental study for the structural performance of reinforced concrete (RC) exterior beam-column joints rehabilitated using carbon-fiber-reinforced polymer. The structural performance of the control specimen while strengthening the joints using externally bonded carbon fibre reinforced polymer strip and sheets failed to restore the strength of the joints capacity.

McAdams et al., (1998): have studied the Epoxy resins were first commercialized in 1946 and are widely used in industry as protective coatings and for structural applications, such as laminates and composites, tooling, molding, casting, bonding and adhesives, and others. The ability of the epoxying to react with a variety of substrates gives the epoxy resins versatility. Treatment with curing agents gives insoluble and intractable thermoset polymers.



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Some of the characteristic so fepoxyresins are high chemical and corrosion resistance, good mechanical and thermal properties, outstanding adhesion to various substrates, low shrinkage upon cure, good electrical insulating properties, and the ability to be processed under a variety of conditions. Depending on the specific needs for certain physical and mechanical properties, combinations of choices of epoxy resin and curing agents can usually be formulated to meet the market demands. However, in terms of structural applications, epoxy resins are usually brittle and notch sensitive. As a result, tremendous fort has been focused on toughness improvement during past three decades.

Benjamin et al, (1958): This latter method allows to organize the sequence of operations so as to control the moving front of the infiltrated resin and discharge the air in the fracture. 14 Moreover, in the final stage the feeding pressure can be maintained at all the ports throughout the polymerization process, counter acting the possible drainage through the concrete pores. In the experimental programmer of this study a pro- prietary kit has been adopted (Chereco System® by Cosipi Ltd, Italy), based on customized polyethylene syringe actuated by an adjustable number of rubber bands. They are usually loaded with about 40 ml resin and arranged at a 0.2Å·0.4 m interval depending on the crack width and depth. This is the most favorable solution to perform a complete saturation while preventing the reduced pot-life which affects a larger mass of polymer. Nonetheless, the immediate replacement of the empty or catalyzing syringes is also possible, thanks to the threaded coupling with the entry ports. The cylinders are also fitted with as toppe r which allows to pause the injection in case of excessive leakage or to prevent a reverse flow from the surrounding feed-points. A series of case histories regarding the application of this system to real structures has been collected.

Wen-ChengLiao, (2010): The main objective of this study was to develop and validate a seismic design methodology for RC SMF which is able to produce structures with predictable and intended seismic performance. Based on performance limit states of target drift and desired yield mechanism, this design methodology accounts for inelastic structural behaviour directly, and practically eliminates the need for assessment or iteration by nonlinear static or time-history analysis after initial design.

Ohki. Kenji, and bcssho, santoshi sept. (1980): Five one storey, on bay. one 1/2 of scale bolstered concrete frame sad here examined to be able to attain the designing information for a seismic strengthening of the prevailing morioka station constructing of the Japanese countrywide 15 railway. In of them, the prevailing frames in which enhance with metallic plate encasing. It became showed that those enhance frames all have pattern earthquake resistance properties. Compared with the prevailing frames and monolithically solid shear walls. According to the plan for the development of latest Morioka station constructing for the Tohoku Shinkansen (bullet train) strains of JNR beneath structures part of new station constructing properly be located at the antique station constructing no win use. Has necessitated these is mic strengthening in a few manner or the alternative of the antique one storey give a boost to concrete station constructing with one storey basement in guidance



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towards growing earthquake hundreds from the first rate shape to be constructed upon it.

Alberto Balsamo and Francesa Ceroni (2012): An experimental investigation has been carried out on prestressed-concrete beams strengthened in flexure with traditional and different innovative composite externally bonded systems in order to compare their structural performance between them and with respect to unstrengthened specimens.

Hany Abdalla [5] described the development of simple approaches in estimating the deflection and crack width of seven simply supported FRP reinforced concrete beams and eight concrete slabs reinforced with conventional steel and FRP were used to evaluate serviceability of members in bending. The prediction of these approaches are compared with the experimental results. Good agreement was shown between the theoretical and the experimental results. Deflection and strains of concrete member reinforced with FRP rods are generally larger than those reinforced with steel rods.

Nordin [4]: studied strengthening concrete structures with prestressed CFRP rods bonded in slots in the concrete cover. Strengthening concrete structures with prestressed CFRP have proven to be an effective alternative to prestressed CFRP. The use of prestressed NSMR rods has shown to in a better way be able to transfer the stresses from the rod to the concrete. Although there are losses in the strain at the ends when releasing the prestressing force there have been no peeling failure during bending.

Barros and Fortes [3] studied the effect of (NSM) near surface mounted strengthening technique using (CFRP) carbon fiber reinforced polymer laminates bonded into slits on flexural strengthening of concrete beam. The test result shows that strengthening by (NSM) technique using (CFRP), doubling the ultimate load of the corresponding reference, increasing of yielding load (P_{sy}) varying from 32% to 47%, increasing of service load (P_{ser}) was 45%, between the cracking load and the yielding load the strengthened beams showed higher stiffness than reference beam.

Cruz and Barros [9] calibrated the parameters that define a local bond stress – slip relationship (Z-S) able to reproduce the pre – and the post – peak bond stress phases carbon fiber reinforced polymer (CFRP) in a near surface mounted (NSM) strengthening technique. The research involved data obtained in experimental tests and a numerical strategy developed to solve the second-order differential equation that governs the slip phenomenon. The analytical method developed is also useful to evaluate the anchorage length of CFRP at service and ultimate limit state analysis. The performance of the numerical simulation of the pull out bending test revealed that the analytical and the numerical strategy developed were adjusted. The (Z-S) relationship was used as the tangential component of the material constitutive law for a line interface finite element, used to simulate the concrete – CFRP bond behavior.

3 Experimental methodology and investigation

Primarily testing of materials as such as FA CA cement etc are done for the casting of beam. Followed by casting of four beams there are several techniques for the strengthening of beam.



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But in this investigation following these methods are chosen.

3.1 Fiber-reinforced polymer

Fiber-reinforced polymer composites are widely used in concrete technology due to their high mechanical and durability properties. FRP has become a mainstream material not only to strengthen damaged elements but also to sustain more service loads and solve long-term ever-growing issue so new infrastructures. Therefore, this review aims to establish a database of research works that focus on the assessment of flexural, shear, and torsional strengthening of reinforced concrete (RC) beams using various types and application methods of FRP composites. The efficiencies of these

Strengthening techniques were compared in terms of structural behaviors of RC beams, types of FRPs, wrapping configurations, etc. This state-of-the-art review reveals that FRP composites can be used successfully to recover the strength of damaged beam and improve the structural behaviors of new elements. It was found that FRP composites were more beneficial for torsional strengthening compared to flexural and shear retrofitting in terms of load capacity and ductility.

3.2 Ferro cement Techniques

Increase in the number of layers increases strengthening, however, the number of layers can also be increased due to a certain limit depending on the reinforcement already provided in the beam to be strengthened. Undoubtedly, all strengthening techniques do possess varying merits, however, the versatility of Ferro cement technique is its low cost, readily available materials, simplicity in construction, reasonable quality control along with good strength and cracking resistance, which makes Ferro cement especially suitable for rural areas of the developing world. Concrete is used frequently in rural areas and sand and the cement and sand is easily accessible. Even the wire-meshes are also readily available due to its use in many other household works. Ferro cement is also known to be a forgiving material and can, therefore, sustain varying atmospheric conditions satisfactorily. Ferro cement can also be used sustainably due to lesser skill of rural workers in comparison to other construction techniques.

3.3 Glass fiber reinforced polymer

Glass fiber reinforced polymer sheets (GFRP) is a composite material or fiber-reinforced plastic made of a plastic reinforced by fine glass fibers like graphite-reinforced plastic, the composite material is commonly referred to as fiberglass, glass can be in the form of a chopped strand mat (CSM) or a woven fabric. Many researches proposed an enhanced retrofitting technique using anchors to avoid the slipping between glass and RC beam and also show the effect of increasing the number of layers of GFRP. The advantage of glass fiber reinforced polymer sheets (GFRP) easily to mold into any shape has mechanical strength that is so strong and stiff for its weight that it can out-perform most of the other materials, low



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maintenance, and anti-magnetic, fire resistant, good electrical insulator and weatherproof. Many experimental works concluded three layers of GFRP equivalent to one layer of CFRP and the minimum layers of GFRP to use in strengthening R.C. beams in flexure not less than two or three layers.

3.4 Carbon Fiber Reinforced Polymer

The most common method used to strengthening, rehabilitation or repairing of reinforced concrete (RC) members is to use external carbon fiber reinforced polymer (CFRP) sheets. CFRP can greatly improve the flexural and shear capacity of deteriorated members and therefore extends their useful life. CFRP materials can be used in different configurations for the strengthening of deteriorated concrete elements as well as the main reinforcement for concrete in new constructions. Among the main advantages of using CFRP material in structural engineering applications are that CFRP can be bonded to structural elements in various configurations due to its light weight and flexibility. This material can offer desirable structural properties such as resistance to corrosion, high stiffness to weight ratio, high tensile strength and high fatigue resistance (Nguyen, Chan et al. (2001)). During the past few years, many different methods have been developed for repairing and strengthening of RC elements. Among these methods, the application of CFRP sheets has been proved as one of the most effective methods. CFRP material can be a perfect alternative to conventional materials for rehabilitating, strengthening and repairing of existing RC structures as well as in new constructions as an alternative to steel reinforcement. Due to the widespread employment of CFRP in strengthening applications, many theoretical and experimental studies have focused on studying the behaviour of externally strengthened RC beams. Most of these studies have reported that the well bonded CFRP has improved the flexural strength of the structural elements and enhanced their stiffness and durability.

4 Result And Discussion

Four beams were tested in this experimental investigation. One control beam was tested and three beams were strengthened with CFRP, GFRP sheet and Ferro cement. The detailed description of the above mentioned beams is presented in table 4.1

Beam ID	F _c (Mpa)	Strength system
CB	25.93	Control beam(no sheet)
SB1	26.77	One layer bonded top and side of beam(fully wrapped)
SB2	26.90	One layer bonded top and side
SB3	27.12	Wrapped with wire mesh



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5 Conclusion

There are different techniques that can be used for strengthening flexural behavior of R.C. beams, and there are one or more factors affecting the choices of the suitable technique this factors include cost of strengthening, increase of dimensions, availability of materials used and percentage of enhancement of load capacity. The paper investigates four techniques used to strengthening R.C. Beams and concludes the best technique which enhancement the load capacity, deflection, ductility, toughness and which have a suitable cost according to the percentage of strengthening. Methodology adapted for the experimental investigation are carbon reinforced polymer, glass fiber reinforced polymer and Ferro cement techniques.

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