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Experimental Investigation on Retrofitting of SCC Concrete Beams using CFRP

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ABSTRACT: As we have seen the many structures are designed only for limit state of collapse not for the Limit state of serviceability. Results of it so many structures are subjected to the long-term effects by observing the cracks and damage in the structure. The process of improving the strength of the section by adding the element is called Retrofitting of structure. There are many materials are available in the market as retrofitting materials like Fiber reinforced polymer (FRP), Aluminum foam sandwich and carbon fiber reinforced polymer (CFRP).Carbon fiber reinforced polymer(CFRP)are the most promising materials, which works by externally bonding the strengthening material with the surface of the concrete.RC structural members have to be retrofitted to comply with the revised codal provisions and changes in functionality of structures. This study aims to investigate the behavior of prototype RC beams having high shear span ratio externally bonded with CFRP laminates. two- point bending tests were conducted up to failure of the specimens. The applied load, deflection, strainin concrete, steel reinforcements and CFRP laminate were measured during the testing. The retrofitted specimens showed an increase in ultimate load carrying capacity and stiffness up to30% . This study concludes that CFRP laminates are to be anchored on RC beams along with bonding using adhesives.

KEYWORDS: Aluminum foam sandwich, Fiber reinforced polymer (FRP),Carbon fiber reinforced polymer(CFRP) network lifetime

I. INTRODUCTION

In recent years the RC structures are necessity of strengthening technique because of various reasons such are damage of element, effect due to corrosion , loads are increment ,stress reduction ,ageing of structure, crack width and deviation in the architecture plan on extension of existing plan for construction. The above are causing of for the retrofitting of structures. Retrofitting is the strengthening technique where it can be doing for the structure as well as member also. The main of doing the retrofitting is to enhance the structural capacity of structure or member. Retrofitting is classified as Global Retrofitting and Local Retrofitting. Global Retrofitting is mainly for the structure which is subjected to seismic effects. Generally, in the earthquake prone area the additional of shear wall is common practice to resist the seismic effects. Local Retrofitting is mainly to define about the enhance of individual element by either jacketing method, Fibre reinforced polymer and by increasing the cross-sectional area etc. CFRP is the abbreviation for carbon fibre-reinforced plastic. CFRP is a material consisting ofseveral constitutes: a base or carrier substance, also called matrix, and a second reinforcing component, the carbon fibre, which is embedded in the matrix. Usually a synthetic resin is chosen as matrix material. The cured composite has different mechanical properties depending on the type of carbon fibres used, the matrix and the manufacturing process.

Carbon fibres is the product of a high-tech manufacturing process. It starts with a starting product such as polyacrylonitrile (PAN). Polyacrylonitrile is a solid in the form of a white powder. It is hard and stiff as well as resistant to chemicals and solvents. In a first process step, thin threads are produced from it, which are then wound0onto a spool – the so-called PAN "precursor" has been created.

The next step involves, threads are placed in oven , it will be oxidized to 200 to 300 degree Celsius.Celsius and then carbonized at 1200 to 1800 degrees Celsius. What remains are threads with a very high carbon content and high strength. After surface0treatment and application of a sizing, the carbon fibre is wound up and is ready for use.which offer different advantages in terms of production costs and/or range of properties, depending on the application. At the beginning of the CFRP manufacturing process, however, is always the carbon fibre. It is woven or laid into a carbon fibre textile or even braided or wound using processes known from the textile industry.

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II. RELATED WORK

A number of studies have been carried out to understand the structural behavior of RC beams with different types of retrofitting material as a additional material. The CFRP are used or utilized as per the need or even if the by-products obtained from the industrial, agricultural or any other process thathas an economic impact on the concrete and necessary to be disposed of properly.

Shriram H. Mahure (2018) has studied on properties of self-compacting concrete in terms of fresh and Hardened concrete. The cement is partially replaced by Fly ash with varying the percentage interval of 10% by weight of cement. The fresh properties of self-compacting concrete are determined using Slump flow, U Box, L –Box and J ring. The hardened properties are determined using compressive, split tensile and Flexural strength. The optimum replacement of Fly ash is 30% to the cement has shown the best effect on fresh and hardened properties compared to conventional mix.

M.Iyappan (2017) has worked on self-compacting concrete in which Portland cement is partially replaced by nano silica. It is observed that replacement of Nano silica with 5 % gives maximum strength compared to conventional mix. The mix is subjected to durability test also. The durability tests are like acid resistance. The acid resistance is determined under immersion of sample in HCL acid for 56 days. It is concluded that replacement of nano silica up to 4% by weight of cement helps to increase the strength.

B.H.V.Pai (2019) the experiment is carried out on the self-compacting concrete where cement is replaced by Ground granulated blast furnace slag and silica fume is partially replaced with cement. The fresh properties are flowing ability and passing ability of the concrete were satisified with EFNARC guidelines. It is observed that replacement of cement by GGBS helps to improve the mechanical properties of concrete than the replacement of Silica fume. The results concluded that GGBS can replace up to80% by weight of cement and silica fume utilization restricted up to 5% by weight of cement.

AkinropoMusiliu OLAJUMOKE (2104), Flexure or bending and shear are the major reasons of failure of reinforced concrete beams. If beam elements are not properly designed and constructed, problems of excessive deflection and materials degradation (for example, spalling of concrete and corrosion of steel) may occur. These may then lead to flexural and shear failure. Steel plates were retrofitted to existing beams to serve the purpose of strengthening. Steel plates were introduced either by External Bonding of Reinforcement (EBR) technique or by Near Surface Mounting (NSM)technique.

III. PROPOSED ALGORITHM

The aim of the present investigation is to study the flexural behaviour of Self compacted concrete RC Beams with CFRP a retrofitting material and comparing it with that of Normal or Conventional RC Beams, so as to study the usage of CFRP, To overcome the problem of long term effects especially the deficiency in the flexural strength , cracks propagation and to avoid the various deterioration of structural member.

Scope of the Proposed Work

It is proposed to conduct a detailed study on the characterization of constituent material required for Self-compacting concrete. It was proposed to study the Flexural Behaviour of RC Beams of Standard size (2m*0.15m*0.25m) for three different Conditions of Beams i.e. Under Reinforced Beam, Balanced Beam,and also Beam with Minimum reinforcement.

Steps Involved in the Experimental Work

The steps involved in the experimental investigations carried out are

- Characterization of Materials used for the Experimental work.
- Mix Design for the grades of concrete considered for the study.
- Design of RC Beam for flexure and shear as per IS 456:2000.
- Studying the fresh properties, casting of cubes, beams and curing it.
- Testing of cubes for its compressive strength for curing periods of 3 day, 7 day and 28 days.
- Testing of RCC Beams for flexural behaviour, simply supported beam under 2 point loading condition.

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- Recording deflection at a constant increment of loading, crack development and failure loads, tabulation of results and discussions.

IV. SIMULATION RESULTS

Tests for Compressive Strength of Concrete Specimen

The compressive strength of concrete is determined as per IS codal provision IS: 516 – 1959, Reaff 1999.The size of the specimen are 150x150x150 mm is used as specimen for the compressive strength test. The compressive strength is determined using the formula F=P/A
F- Compressive strength in MPa , P is the Compressive load (kN)or N , A is the cross sectional area (mm2)

Testing machine – The testing machine may be of any reliable type of sufficient capacity for the tests and capable of applying the load at the rate specified.

Flexural strength of RCC Beam

Beam size and number of beams – The Size of the RC beam were cast at a dimension 2000mmx220mmx150mm were casted by using the two grade of concrete. The grade of concrete are considered as M20 and M30. The total 24 beams were casted for the study. The variation in the beams were under reinforced, balanced and over –reinforced.

Casting of Beam Specimens for Flexural Strength Test

The beam formwork are made using MS steel only the formwork are coated with oil on their inner surface and placed horizontal to the ground. The design reinforcement are placed in the form work and by ensuring the cover to the reinforcement is 25mm. The reinforcement cage was placed in the formwork. The amount of materials

required for producing number of cubes and concrete beam specimens were weighed. The materials were first mixed in the dry condition and then mixed throughly in the concrete mixer. Concrete is poured into the moulds in three layers, each layer was fully compacted by using taming rods.

Loading Frame

A loading frame of 60-tonne capacity was used for testing of the beam specimens. The supports of beams were made of mild steel. These supports were placed on the channel section of the loading frame, which could be adjusted for the required span. The loading frame that was stiffened on its flange and web by MS plates as an angle section was respectively used to apply the load at the center as two point loads on the test beams. Solid MS rollers of 40 mm dia and 250 mm long were used for transfer of loads. The test set up of the beam is as shown in the below Figure1.

Fig. 1 Loading frame apparatus set up

Figure 2 :Loading Jack Apparatus

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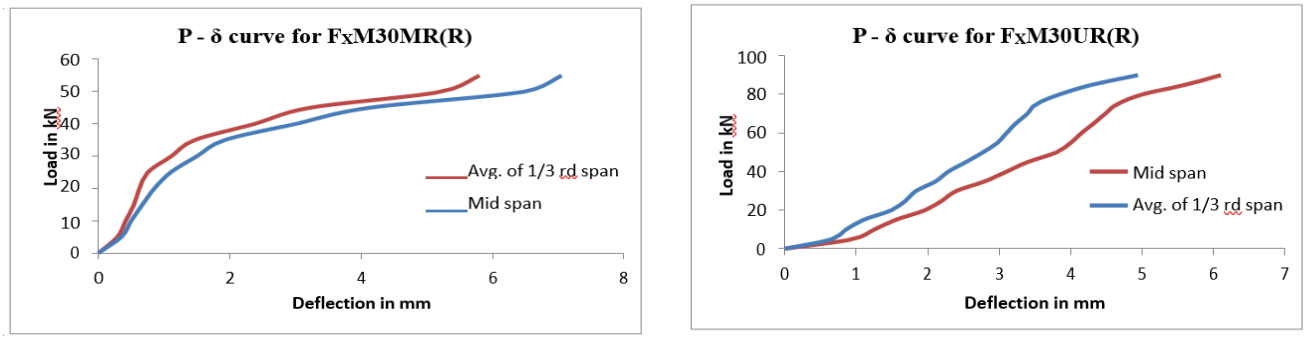

(a) (b)

Figure 2: Load v/s Deflection for Fx M30MR(R)

V. CONCLUSION AND FUTURE WORK

From the detailed discussion of the test results of M30 grade concrete in RCC beams, the following conclusions were made.Self compacting concrete can be effectively used in RCC Beam Concrete.SCC concrete shows high workability when compared that of Normal concrete.The Compressive Strength of SCC concrete was found to be higher than that of Normal Concrete at curing periods of 3, 7 and 28 days, for both the grades of concrete.From the flexural behaviour results of load at first crack, second crack and failure load, it may be observed SCC concrete is higher than conventional concrete.Addition of CFRP The load carrying capacity 30% higher than the unretrofitted beams.

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