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Strengthening of the Existing Structural Beam Member by using Pre-Stressed Fibre Reinforced Polymer

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ABSTRACT

Reinforced concrete beam members are load-carrying members in structures. The beams performance is largely depending on the condition of the tensile reinforcement in members and quantity in the beam. Focus is put on flexural strengthening, which currently is the most common application field for composite materials in structural engineering. Generally, pre-stressed FRP will be demonstrated to follow the principle of conventional pre-stressed concrete by resulting in higher cracking, yielding, and bearing loads. Especially under service loads, the structural behavior is improved. Civil structures in several situations require strengthening of the structural members due to lack of stiffness, strength, serviceability, durability. Some situations where the members are in need of rehabilitation in their lifespan. There are many situations where the requirement of strengthening is must for structures such as Retrofit for seismic effected building.

Introduction

Motivation and history for the development of FRP in the field of retrofitting. Earlier days in Europe, FRP's were started develop as an alternative to the bonding of steel plate. Steel plates bonding to the tension zone of reinforced concrete members with adhesive resins used as new technique for dramatic increase in the flexural strengths of the RC members. This technique has been further used in strengthening of many bridges & buildings around the world. Reinforced concrete structures are being used since form a long time. The reinforced concrete structures face many improvement and modifications and need of repair in their service lifespan of concrete structures. Reinforced concrete structural members are designed for long lifespan in day-to-day life, and there is rapid growth of structures, so the structures may be subjected to heavy loads than what was supposed to be in the design. As the FRP can be applied to any structural elements to strengthen such as columns, beams, walls, slab. But this work is based on study of the behaviour of concrete beams strengthened with carbon FRP (CFRP).

Objective of the Work

The main objective of this work is to strengthen the beam member of the existing structure due to deterioration due to aging and change in the live load. To check the behavior of the reinforced beam strengthened with the pre-stressed FRP.

The work is followed up with the study of RC beams, with external bonded FRP subjected to pre-stress.

- To take advantage of pre-stressed FRP for the rehabilitation of the structural members, which is being emerging in field of the retrofitting of structures in economical way.
- To know how the pre-stressed FRP enhances the serviceability limit state (SLS) of the reinforced beam.

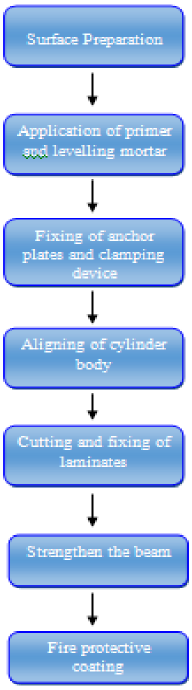
- Importance of anchors system in the pre-stress of laminates at the termination of the laminates in the shear region.

- By bonding the pre-stressed FRP laminates, the tensile stresses of internal steel reinforcement are relieved, because greater tensile stresses are being transferred from steel to the fiber reinforced polymers.

- The pre-stress process relieves the tensile stresses and makes that as compression zone in the beam member and increases the load carrying capacity.

- In strengthening of the existing structures, the anchorages plates for the Carbon FRP laminates were to be used in-order to resist against the delamination at the end of Carbon FRP.

Methodology



Reinforced concrete beam members are load-carrying members in structures. The beams performance is largely depending on the condition of the tensile reinforcement in members and quantity in the beam. So additional tensile reinforcement or strength is often required to rehabilitate corroded concrete members and damaged steel reinforcement to restore strength and stiffness to the member. The site that proposed to strengthen the beam member because of additional increment or changing of live load in second floor level and also due to aging. The site located in Navalur, Chennai. Hence to increase the load carrying capacity of the structural member of beam as per deficiency in moment and shear that occurs. The details and drawings were given by the clients of the building and based on these data have to design for the existing member of beam and check for the shear and moment and design for the respective and enhance the load carrying capacity. After designing of the beam member, select the FRP composite layer and the respective thickness and design for strengthening the beam and satisfying the load carrying capacity as per the ACI 440.2R-08. After strengthening of the beam with the pre-stressed laminates load test has to be carried out by placing the gunny bags over the slab and connect the linear potentiometer at the soffit of the beam and have to note down the value for the incremental loading of gunny bags because as the load transfer from slab to beam. The linear potentiometer readings should be noted and the loadings should be carried out in the three steps that are of $1/3^{rd}$, $2/3^{rd}$, and full load and respective deflection of the strengthened beam readings has to be noted.

Methodology for Load Testing

Step 1: Slab panel for load test

It is proposed to conduct a load test on therein forced concrete slab where strengthening has done.

Step 2: Sensor location

At below the slab the Sensors (linear potentiometer) for measuring deflection in the slab are placed. Out of three sensors, one was placed at centre of the slab, second was placed at corner of slab and third was placed at beam centre.

Procedure for slab load test

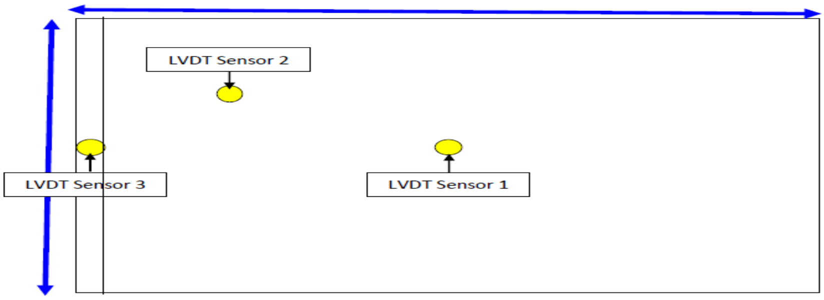


Fig.1. On-site picture of sensors location

Before the loading of the slab, linear potentiometer shall be fixed at the locations as shown in Fig.1. The platform over which sensors to be placed should be completely rigid. The initial readings shall be noted and loading of the slab with the help of water can be started. The linear potentiometer readings shall be noted and the load to be applied in three equal steps of 1/3rd of Load, 2/3rd of Load and full load of the test load.

The corresponding linear potentiometer readings are to be recorded. The full load shall be maintained for 24 hrs on the slab. After 24 hours, the final readings shall be noted. After 24 hrs, loading is to be removed. Unloading to be carried out in three equal steps. On removal of each decrement, the linear potentiometer reading to be noted and the deflection recovery to be calculated if necessary according to IS code.

Fig.2. Gunny Bags for load testing

Result and Discussion

The result of the dissertation work on the topic of rehabilitation of existing structure with the externally bonded pre-stressed FRP is briefly explained in this chapter. The result of the beam retrofit and slab retrofit is summarized along with this as per the readings that are acquired from the DIQ9178 software. The linear potentiometer that are connected to the software are being in contact with the soffit surface of the beams and slabs, the experiment is conducted for a slab and beams by placing the gunny bags above the top surface of the floor and the load is distributed to the connected beams and the loading is done in the pattern of $1/3^{rd}$,$2/3^{rd}$and full loading, further after deflection readings and check out for the increase in load carrying capacity of same buildings. The result of deflection of the members is discussed below. The linear potentiometer sensors positions are placed and get in contact with the soffit surface of the member as shown in the below Fig.3.

Fig.3. On-site picture of sensors location

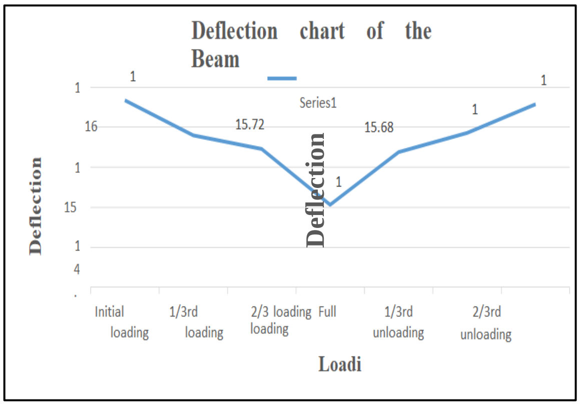


Fig.4. Deflection readings of the slab

At the early load that is initially it was of 17.53 mm and at time of full loading it was 15.03 and later after unloading it starts to regain that is from15.03 mm to 17.49 mm. The above result of the slab deflection exhibits that difference observed is of 2.5 mm where the potentiometer is placed at the center of slab. The rebound percentage observed after the unloading is nearer to the 100% that is of 99.78%. The deflection of slab should not exceed the $40l^2/D$ and it is satisfied the condition.

Declarations

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Consent for publication

Authors declare that they consented for the publication of this research work.

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