

Experimental Study on Structural Health Monitoring of Carbon Fibre Reinforced Concrete Beam

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Abstract- The main objective of this project is to monitor the structural health of carbon fibre reinforced concrete beam by using sensor embedded in it. The problem that has been identified is there is no standard method of structural health monitoring for carbon fibre reinforced structures. Carbon fibre reinforced concrete is those structures in which the steel reinforcement is replaced by carbon fibre mesh. The grade of concrete that is used is M25 with OPC53 cement. 6mm size of coarse aggregate and manufacturing sand. Casting of prism and beam specimens is done by placing the carbon fibre mesh in box type. The carbon fibre reinforced concrete is the structure which the steel reinforced is replaced by carbon fibre mesh. In this study, the casting the prism and beam specimen is done by placing the carbon fibre mesh. The concept of design is not only to monitor strain but also act as a structural strengthening mechanism in target. The sensor that is used thermocouple, which is used for measuring the internal concrete temperature. The temperature of carbon fibre reinforced concrete beam during loading is measured. To arrive, the relation between internal concrete temperature and load applied. To monitor the structural behaviour of carbon fibre reinforced concrete beam during structural health monitoring system. The temperature range can be fixed in the sensor for continuous monitoring of structure. While the system can be programmed to ring an alarm. When temperature exceeds the specified limit.

Key words: Carbon fibre reinforcement, structural health monitoring, Thermocouple sensor, Temperature

1. INTRODUCTION

Structural health monitoring refers to process of implementing a damage detection and characterization strategy for the structures. A typical health monitoring system is composed of a network of sensors that measure the parameters relevant to the state of the structure and its environment, such as temperature, stress, delamination, strain, vibration, and humidity. To properly manage civil infrastructure, its condition, or serviceability, needs to be assessed. Many variables can be monitored and used for the assessment. Tunnels are being monitored for traffic accidents and air quality. The Urgent Earthquake detection and Alarm System Measurement and proper data processing are expected to give a reasonable assessment of serviceability can then be improved based on the assessment. Sensing physical quantities in detail offers the potential to better estimate structural conditions. For river bank protection, for instance, water level may be monitored and the associated load estimated. Precipitation rate and

groundwater level are an important indicator to predict slope failure.. Structural condition assessment is, however, not always straightforward; such is the case in Structural Health Monitoring (SHM) of buildings, bridges, and towers

1.1 Health Assessment of Engineered Structure.

The concept is widely applied to various forms of infrastructure, as countries all over the world enter into greater period of construction of various infrastructure bridges to skyscrapers. Especially when damages to structure are concerned, note that there are stages of increasing difficulty that required the knowledge of previous stages, namely;

- A) Locating the damage
- B) Quantifying the severity the damage
- C) Detecting the existence of damage on the structure
- D) Identifying the types of damage

1.2 Textile reinforcement

Textile reinforced concrete is a type of reinforced concrete in which the usual steel reinforcing bars are replaced by textile material. Materials with high tensile strength, with negligible elongation properties are reinforced with woven or non-woven fabrics. . The fibres used for making the fabric are of high tenacity like jute, glass, fibre, Kevlar, polypropylene, polyamides (Nylon) etc. Textile reinforced concrete is generally thinner than traditional steel reinforced construction is 100 to 300 mm thick. TRC is much thinner due to an extra protective layer of concrete that is not needed for its design.

2. MATERIAL PROPERTIES

In this study, the following materials are used and testing of materials such as materials cement, M-sand and Coarse aggregate to determine the following properties fineness of cement, consistency and initial setting time of cement, specific gravity, fineness modulus of Fine aggregate and Coarse aggregate.

2.1 Concrete materials

2.1.1 cement

Ordinary Portland cements (OPC) the basic Portland cement and is best suited for use in general concrete construction. It is of three types 33 grade, 43 grades and 53 grades. In this study 53 grade of cement is used.

Table 1 physical properties of 53 grade ordinary Portland cement.

Properties of cement	values
Fineness of cement	9.2%
Specific gravity	3.12
Consistency	32%
Initial setting time	26 minutes

2.12 Fine aggregate

According to IS 383:1970 the fine aggregate is being classified into four different zones that is zone-I, zone-II, zone-III and zone-IV. Manufactured sand is crushed aggregates produced from hard granite stone which is cubically shaped with grounded edges, washed and graded with consistency to be used as a substitute of river sand. Tested conducted on fine aggregate are specific gravity, fineness modulus and water absorption.

Table 2 physical properties of manufactured sand

Properties of fine aggregate	values
Specific gravity	2.55
Fineness modulus	2.81
Grading zone	II

2.1.3 Coarse aggregate

The coarse aggregate is the strongest and the least porous component in concrete. The optimum size of coarse aggregate used for carbon fibre mesh with 5mm grid size was found to be 20mm and hence it was adopted. The specific gravity test, fineness modulus test and water absorption test are conducted on coarse aggregate

Table 3 physical properties of coarse aggregate

Properties of coarse aggregate	Values
Specific gravity	2.55
Fineness modulus	6.71
Water absorption	1.45%

2.1.4 Carbon fibre mesh

To improve the tensile reinforcement high strength fabrics made of textile Reinforcement can be used. The multifilament yarn made of carbon fibre mesh was used in study. Carbon fibre mesh was used as reinforcement and other materials properties are listed below

Table 4 properties of carbon fibre mesh

Name	Carbon fibre mesh
Tensile strength	1762N/mm ²
Elongation of fibre	1.81%
Modulus of elasticity	8200N/mm ²
Diameter of fibre	1mm
Size of grid	5mm×5mm



Fig1 carbon fibre mesh

2.2 Thermocouple sensor

Thermocouple is an electrical device consisting of two dissimilar electrical conductors forming electrical junctions at differing temperatures. A thermocouple produces a temperature-dependent voltage as a result. The voltage generated at a single junction of two different types of wire is what is of interest as this can be used to measure temperature at very high and low temperatures. The magnitude of the voltage depends on the types of wire being used. Generally, the voltage is in the microvolt range and care must be taken to obtain a usable measurement.



Fig2 thermo couple sensor

2.3 Concrete

Table 5 shows mix proportion of concrete for compressive strength of 25MPa.

Table 5 mix proportioning of concrete

Components	Quantity
Water	220.48 litres
Cement	400.87kg/m ³
M sand	782.62kg/m ³
Coarse aggregate	922.64kg/m ³

3. EXPERIMENTAL INVESTIGATION

3.1 Test specimen

Three specimens of 1200mm ×150mm×200mm were casted with thermocouple sensor embedded at the middle and one third of the prism, along the transverse direction. Carbon fibre mesh placed in box like sandwich shape having cover of 15mm on all sides.



Fig3 Test Specimen

3.2 Experimental setup and loading

The 3 prisms were tested to failure in a two point loading system with a clear span of 50mm and effective span 400mm. the load was applied using the universal testing machine. Two dial gauges were used to measure deflection. The testing of prism was carried out in universal testing machine of 1000KN load capacity. The load was applied in specimen and corresponding change in temperature was noted.



Fig 4 Specimen testing setuo



Fig 5 Monitoring Setup

3.3 Result and discussion.

For the applied load corresponding change in temperature was noted. The load change for carbon fibre reinforced concrete at one third and mid distance. The relation between internal concrete temperature and applied load for specimens has been arrived as below. And for every change in load the corresponding change in temperature has noted.

Relation arrived

$$Y = -31.818x^2 + 1804.1x - 25555$$

x- Temperature ($^{\circ}$ c)

y- Load (KN)

CONCLUSION

From the testing, the internal load temperature of the concrete also increases which can be used as means of warning and it can be inferred that with increases in

loading. From the relation it is known that temperature variation remains the same for various specimens of same kind. Further studies and experiment have to made different specimens and different sizes to arrive global relation between the temperature and load thereby make health monitoring system more economical with thermocouple sensors.

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