REAL TIME STRENGTH MONITORING OF CARBON FIBER REINFORCED PRECAST MEMBER USING STRAIN GAUGE SENSOR

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1. INTRODUCTION

In 2007, a tragedy happened at Minneapolis which was a Bridge collapse over the Mississippi River where 13 people were killed and more than 145 were injured. One of the reasons behind the tragedy was overloading which developed excessive strain on the bridge led to its collapse. Many structures undergone this failure and if overloading could be detected earlier, misfortune could have been prevented. Strain gauges are the electrical sensors that find their applications widely in the field of testing and measuring force. In our project, strain gauge sensor is fixed to precast beam to detect its deflection in Real Time. The Carbon fibers were added with caring percentages of 0.25%, 0.5%, 0.75% and 1% are tested to find its optimum percentage. Carbon fiber of 0.75% was found to be optimum to add for M35 grade precast beam member. The Nondestructive evaluation process can be automated, which is known as structural health monitoring, where materials or components can monitor enabling real-time condition assessment. Furthermore, these sensors are placed onto the surface,which adds technical and economic challenges when deployed at larger scales. Carbon fiber cement-matrix composites are structural materials that are gaining in importance quiterapidly due to the decrease in carbon fiber cost and the increasing demand of superior structural and functional properties. The effect of carbon fiber addition on the properties ofconcrete by comparing its results with conventional concrete. The strain is measured using linear strain gauge sensors during continuous loading on the member and real time strength of the member is calculated using the strain.

2. OBJECTIVES

- To identify the real time strength of the precast members using strain gauge sensors
- To study the effects of linear strain gauge sensors in carbon fiber reinforced precast members
- To find the optimum percentage of carbon fibres in precast beam members

3. METHODOLOGY

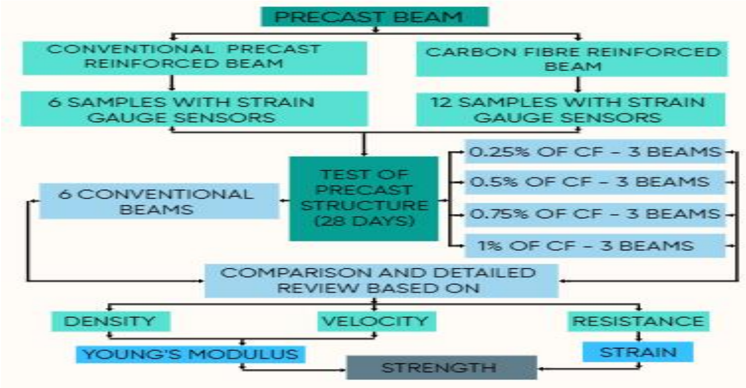

Fig. 3.1 Flowchart of methodology

Several tests were conducted on cement such as Initial setting time, Final setting time, Specific gravity etc.,. In Coarse Aggregate tests we conducted Specific Gravity by Pycnometer test. As per IS: 4031 (Part 4) 1988 initial setting time should not be less than 30 minutes and final setting time should not be greater than 600 minutes. IS 2720- Part 3, The value for specific gravity of Ordinary Portland Cement (OPC) is nearly 3.15

Casted 18 moulds of size 700mm*150mm*150mm of different proportions, 6 regular concrete beams of M35 strength, reinforcement of 8mm diameter were used of 650mm length with spacing of 25mm at both ends. Nominal cover spacing of 150mm were used and Strength of Reinforced used is Fe550 grade, the Spacers of 25mm were used both at top and bottom, and other 12 moulds with Carbon fiber shreds of 120mm finely chopped were used in proportions of 1%, 0.25%, 0.5%, 0.75% and 1% each proportion casted for 3 beams, we used these proportions to find the optimum percentage to get high strength. The casted beams were kept for curing for 28 days. Ultrasonic Pulse Velocity Test was conducted to determine its pulse velocity and Flexural strength test was conducted to find its deflection with respect to its change in resistance.

The Beams were tested after keeping the beams at Room temperature for a day after which sensors were attached to beams using Cement epoxy. The strain gauge sensors were attached to center of beam near the tension zone. Universal Testing Machine is used to test the Change in Resistivity from Multimeter which is attached to strain gauge. The strain gauge has 120Ω Resistance, but when a pointed load is applied to the beam, they undergo deflection and cracks at Centre which changes the Resistance which Increases gradually. the strain Gauge gives us the Strain values. Now to find stress values we use Youngs modulus of Elasticity through Ultrasonic Pulse Velocity.

Fig. 3.2 Measurement of Resistance

Fig. 3.3 Measurement of pulse velocity and Density

Table 3.1 Strain gauge sensor and Ultrasonic Pulse Velocity test on Beams

Percentage of CF added (%)	Change in Resistance(Ω)	Velocity in m/sec	Density in Kg/m3	Load at Failure point in kN	Accuracy % in detection
0	**0.9**	**829**	**2480**	**64**	**99**
0.25	**0.95**	**830**	**2496**	**68**	**99.2**
0.5	**1.05**	**831**	**2502**	**75**	**99.87**
0.75	**1.3**	**833**	**2510**	**94**	**99.53**
1	**1.1**	**834**	**2522**	**79**	**99.3**

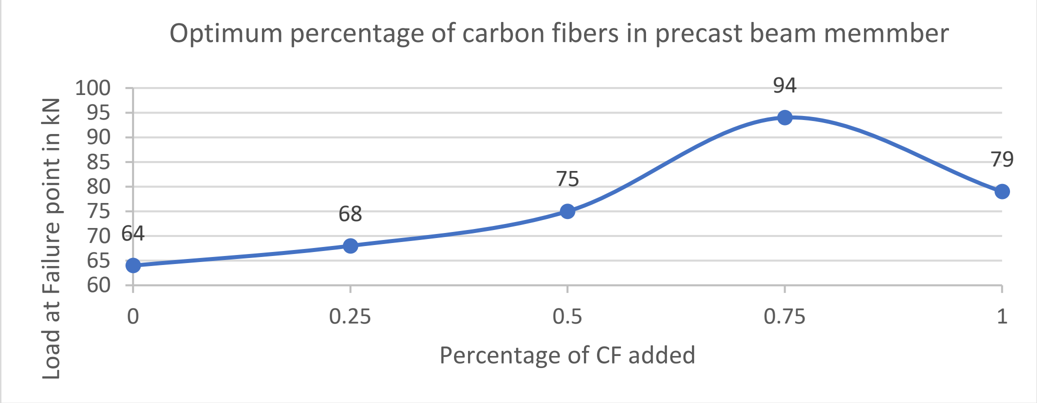

Fig 3.4 Optimum Percentage of Carbon Fiber in Precast Beam Member

Percentage of CF added: The Percentage of CF were added to find the optimum percentage which gives the high loading Failure point and also is comparison between the conventional beam with no CF with CF added Beams.

Change in Resistance: The Strain gauge that we are using is 120Ω resistant at normal OR No Deflection phase but as soon as load is Applied the Deformation and crack case change in resistance. During Tension the Strain Sensitive Area Narrows and Resistance Increases But whereas when the Strain sensitive area undergoes Compression Resistance Decreases. But we are finding flexural test and results will be in Increase in Resistance. This test is conducted on both conventional and Carbon Fiber Reinforced Beam.

Velocity in m/sec: The velocity of the signals to reach the receiver after leaving the Transducer. The transit time of ultrasonic pulses depends on the density and elastic properties of the Beam.

Load at Failure point in kN: The Failure was Calculated based on ultimate load the beam could carry by reaching the point of Failure in Beam where in it was found that conventional Beam carried less load when compared to Carbon fiber reinforced Beam.

Density in Kg/m^3: Density is the measurement of how tightly a material is packed together. It is defined as the mass per unit volume. Density Symbol: D or ρ Density Formula: $\rho = m/V$, where ρ is the density, m is the mass of the object and V is the volume of the object.

Graphical notation:
Percentage of CF added: The conventional Beam is denoted with 0%for 6 Beams and Carbon Fiber with increase in 0.25% with every 3 beams is used to find the Failure point when load

is applied on these beams. The purpose of conduction is to find the optimum Percentage.

Load at Failure point in kN: when Load is applied to beams using UTM (Universal Testing Machine) using single point load at the center the deflection helps is finding the resistance but when the beams fail at some point the readings are taken which is used to find optimum percentage.

Hence, From the graph we could easily conclude that 0.75% is the optimum percentage of Carbon fiber reinforcement that can be used in construction for better load carrying Capacity in Structures where as when we use more Carbon Fibre than 0.75% its load carrying capacity decreases but its is Uneconomical too when compared.

Fig.3.1 Flowchart of Methodology: The Image speaks about the working Parameters of designing and conduction of test. The use of Conventional 6 beams and CF reinforced Beam of 0.25% increasing at every 3 beams casted total of, 12 beams under CF. Totally 18 Beams are Casted. The 28 days Curing is done because it is precast beam After which conduction of Test through UTM and Ultrasonic Pulse Velocity to find Youngs modulus of Elasticity and stress values to find Strength.

Fig.3.2 Measurement of Resistance: The Resistance Value is obtained when load is applied to beam and crack or deflection appears on beam. The load is applied to it through UTM machine using point load.

Fig.3.3 Measurement of pulse velocity and Density: The Density and Velocity are Obtained using Ultrasonic Pulse Velocity which gives Youngs modulus of Elasticity which is used in finding Strength of Beam.

4. CONCLUSION

- M35 grade concrete precast beams were casted and tested for its failure condition. Sensors were placed on the linear cracks and its strength at any given time was noted at regular interval of time.
- The real time strength of the pre cast beams was found using the velocity and density in ultrasonic pulse velocity, resistance using strain gauge sensors. Monitoring the same regularly helps in identifying the failure in the member at the early stage.
- 0.75% Carbon fibre was found to be optimum percentage for a precast beam of M35grade concrete

5. SCOPE FOR FUTURE WORK

- Use of embedded sensors in the precast members to identify real time strength of the structure
- Research can be done using high sensitivity, wifi based sensors for structural health monitoring

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