Effect of Long Carbon Fibers on Deflection of One-way Members

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Summary

This paper describes laboratory tests on simply supported one-way members containing steel reinforcing bars and long (75mm) coated carbon fibers. Carbon fiber yarn is coated to provide 75mm long stiff fiber tape that readily disperses in the concrete matrix. The tests were conducted to compare response to immediate and sustained loads, of carbon fiber reinforced concrete (CFRC) members with the response of companion beams without fibers. The specimens are 3.66 m long supported on an 3.35 m span, 300 mm wide, and 125 mm deep with two #3 bars at an effective depth of 100 mm. The specimens were loaded with concentrated loads at mid-span to simulate live load. The applied loads were then removed and the beams were monitored for approximately one year to determine deflection response under sustained dead load. The tests clearly demonstrate the enhanced stiffness provided by carbon fiber under immediate and sustained loads.

Keywords: concrete, slabs, fibers, deflection

1. Introduction

Concrete containing fibers is known to improve the response of concrete under tensile stress. To evaluate the contribution of long carbon fibers to the flexural stiffness of slabs reinforced with regular deformed bars at low reinforcement ratios, tests were performed on slabs made with a standard concrete mix without fibers and slabs with the same steel reinforcement and a concrete mix containing long carbon fibers. All specimens were loaded with full live load at seven days. The live load was removed immediately and the specimens were monitored under sustained dead load for approximately one year. Deflections under immediate load application and sustained load are compared.

2. Specimen Details

Five slab specimens with the same dimensions and reinforcement were fabricated, two with carbon fibers in the mix and three with a standard concrete mix. Each slab is 3.66 m long, 300 mm wide, and 125 mm deep reinforced with 2-#3 bars at an effective depth of 100 mm. The specimens were simply supported at 150 mm from each end, providing a simple span of 3.35 m.

The slabs made using the standard concrete mix were designed according to ACI 318-05[1] to resist a concentrated load (unfactored) of 2.67 kN at midspan in addition to the self weight of the slab, assuming a 28 day compressive strength of 27.6 MPa.

3. Test Procedures

Standard 150 mm by 300 mm cylinders were cast from the standard concrete batch used to cast the slabs. Compressive strength, split cylinder tensile strength, and elastic modulus were obtained from cylinder tests at 28 days. The material properties of the fiber reinforced concrete were determined in the research program completed by Moser[2] and Musselman[3].

https://doi.org/10.2749/222137908796293857

Deflection measurements were made on all specimens under immediate application and removal of live load as well as under sustained application of dead load. For the standard concrete specimens and one CFRC specimen, the full value of the concentrated live load (2.67 kN) was applied and removed at seven days immediately after setting the specimens on the supports. The second fiber specimen was loaded until the deflection at midspan matched the deflection from the control specimens. Deflection readings were then taken periodically under the sustained dead load.

4. Test Results

4.1 Immediate Deflection due to Live Load Applied at Seven Days

Load deflection plots for the two fiber concrete beams and the average of the three standard concrete beams are given in Fig. 1. These results indicate the significant contribution of the carbon fibers to the tensile response, cracking behavior, and stiffness at service load level. The results suggest that a reasonable estimate of deflection for beams loaded with these long carbon fibers could be obtained assuming an uncracked section under full live load.

4.2 Time-dependent Deflection due to Sustained Load

The time dependent response of the slab specimens loaded at seven days under sustained load is illustrated in Fig. 2. The fiber concrete beam loaded at seven days with full live load (2.7 kN) shows considerably smaller long-term deflection than the overloaded fiber concrete beam and the standard concrete beams. The long-term deflection of the standard concrete beams is significantly greater than the long term deflection of the fiber concrete beams. Similar trends would be expected for beams loaded at ages other than 7 days.

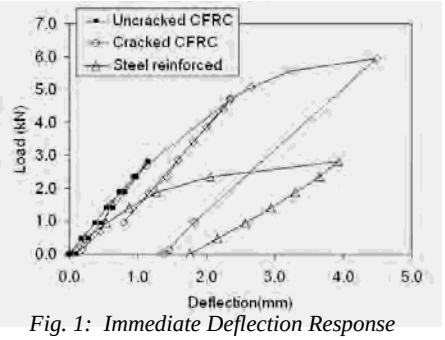

Fig. 1: Immediate Deflection Response

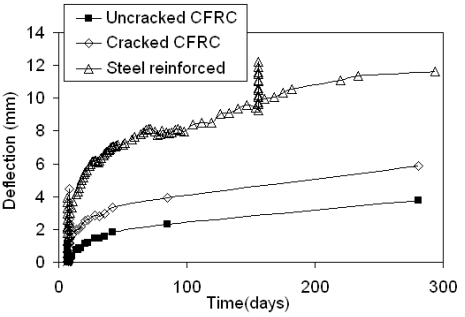

Fig. 2: Time-dependent Deflection Response

5. Conclusions

Based on the limited tests reported in this paper it is clear that the long carbon fibers used in the fiber concrete beams significantly enhance the flexural stiffness under immediate load and sustained load. The long carbon fibers could be considered as a possible design solution when deflection control is a critical consideration. The data provided could be used to evaluate analytical models of fiber concrete beam response to immediate and long time loading.

References

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