Stiffness Detection of Carbon-Nanofiber Concrete with NDT Method

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Abstract: Concrete is the most widely used construction material, and carbon nano-fiber (CNF) has many advantages in both mechanical and electrical properties such as high strength, high Young's modulus, improved fatigue resistance, self-monitoring behavior due to the high tensile strength and high conductivity. In this study, pulse velocity method was used to characterize properties of concrete containing carbon nano-fiber. Concrete modulus correlations are presented in the form of regression equations.

1. Introduction

In recent years, more and more researchers are prone to use ultrasonic pulse velocity nondestructive technique to test the materials because this technique is easier and more economical than traditional tests. Current research utilized the pulse velocity method to evaluate the properties of the carbon nano-fiber concrete. Pulse velocity changes with many variables in concrete, including water content, mixing proportions, water content, aggregate type and size, age of concrete. The device used is ultrasonic pulse velocity meter (V-meter) as shown in Fig. 1. The V-meter can generate compressive waves traveling along the materials and record the shortest travel time. The wave travel depends upon the amount and dispersion of the carbon nano-fibers. The transit time can be measured with three methods, which are direct, semi direct and indirect method. Direct transmission method is used in this current research because it is more reliable than the other two methods.

Fig. 1. Ultrasonic pulse velocity meter (V-meter) test with direct transmission test.

2. Principle

The pulse velocity is calculated with the known distance and time as follows

$$V = L / T \quad (1)$$

Where as V is the pulse velocity, L is the distance between transducers, and T is the transit time.

Eq. (1) is used for the calculation of the modulus of elasticity as follows:

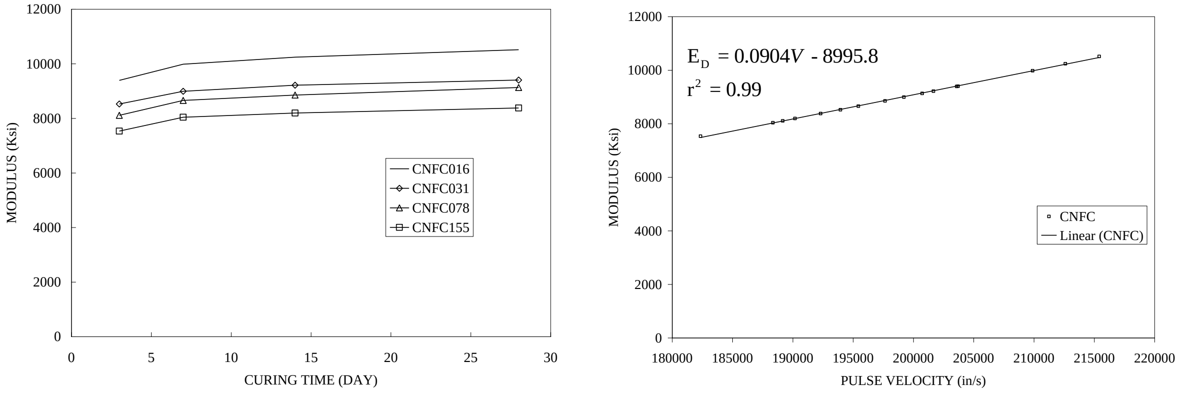
$$E_D = \frac{\rho V^2}{K} \tag{2}$$

Where as E_D is the modulus of elasticity, V is the pulse velocity, ρ is the mass density and K is the shape factor which has taken as 1 for the cylindrical specimen.

3. Mixture Proportions

The binder weight is the total weight of cement and CNF. Herein C denotes plain concrete; CNFC016, CNFC031, CNFC078 and CNFC155 denote concrete containing the CNF PR-19-XTPS in the amounts of 0.16%, 0.31%, 0.78% and 1.55% by volume of binder, respectively

4. Results



(a)

(b)

Fig. 2 mixture CNFC properties (a) modulus-curing time (b) modulus - pulse velocity

The measurement of pulse velocity, dynamic modulus at ages 3, 7, 14, and 28 days and corresponding modulus at different ages are shown in Fig 2(a). Stiffness is increasing with the increase of the curing time (Fig 2(a)) and from this it is evident that pulse velocity through concrete has a direct relation with stiffness of the specimen. The modulus for each concentration in descending order is CNFC016 > CNFC031 > CNFC078 > C > CNFC155. Modulus is high when CNF concentration is 0.16%. This indicates the modulus of concrete decreases with increasing CNF concentration. The reason can be explained as with use of more amounts of CNF results the poor dispersion and interrupts the CSH gel formation which adversely affects the strength and modulus. Stiffness results are plotted against pulse velocity results as shown in Fig 2(b). This result shows that the linear correlations could be established for the concrete mixtures.

5. Acknowledgements

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6. References

1. ASTM standard C 597-97, “Standard Test Method for Pulse Velocity Through Concrete”.
2. The James V-meter manual, James Instruments INC. Non Destructive Systems.