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Ultrasonic Pulse Velocity Investigation of Polypropylene and Steel Fiber Reinforced Concrete

Erjola Reufi, Jozefita Marku, Thomas Bier

***Abstract*—**Ultrasonic pulse velocity (UPV) method has been shown for some time to provide a reliable means of estimating properties and offers a unique opportunity for direct, quick and safe control of building damaged by earthquake, fatigue, conflagration and catastrophic scenarios. On this investigation hybrid reinforced concrete has been investigated by UPV method. Hooked end steel fiber of length 50 and 30 mm was added to concrete in different proportion 0, 0.25, 0.5, and 1 % by the volume of concrete. On the other hand, polypropylene fiber of length 12, 6, 3 mm was added to concrete of 0.1, 0.2, and 0.4 % by the volume of concrete. Fifteen different mixture has been prepared to investigate the relation between compressive strength and UPV values and also to investigate on the effect of volume and type of fiber on UPV values.

***Keywords*—**Compressive strength, polypropylene fiber, steel fiber, ultrasonic pulse velocity, volume, type of fiber.

I. Introduction

NONDESTRUCTIVE tests are widely applied to study mechanical properties and integrity of concrete structures. They are simple to use and often economically advantageous. They are suitable for taking measurements on site and taking continuous measurements [1]-[3]. These non-destructive methods are usually associated with each other to improve diagnosis and reduce the number of test. This method has been using for detecting internal cracking void and variation of the physical properties in concrete due to severe chemical environment, freezing and thawing and heat resistance [4]-[6].

The pulse velocity method is also used to estimate the strength of concrete test specimens UPV test is prescribed in ASTM C 597 and BS 1881: Part 203 [7]. These techniques have been grown during recent years especially in the case of construction quality assessment. The main advantage of non-destructive testing method is to avoid concrete damage or the performance of building structural components [8], [9]. Additionally, their usage is simple and quick.

The measurement of pulse velocity is affected by a number of factors which are [6], [7]:

1. Smoothness of contact surface under test: if the surface is not reasonably smooth, they should be ground smooth.
2. Moisture condition of concrete: In general, pulse velocity through concrete increases with the increased moisture content of concrete [10].
3. Influence of path length on pulse velocity: As concrete is inherently heterogeneous, it is essential that path lengths are sufficiently long so as to avoid any errors introduced due to its heterogeneity.
4. Temperature of concrete: It has been reported that variations of the ambient temperature between 5 and 30 °C do not significantly affect the pulse velocity measurements in concrete [11], [12].

At temperatures between 30 and 60°C, there is up to 5% reduction in pulse velocity [13]. This is probably due to the initiation of micro cracking in concrete. At below freezing temperature, the free water freezing within concrete thus resulting in an increase in pulse velocity [13].

5. Presence of reinforcing steel: The presence of steel bars will tend to increase the pulse velocity because pulse velocity in steel is 1.2 to 1.9 times the velocity in plain concrete.
6. Age of Concrete: For a give pulse velocity, the compressive strength is higher for older specimens [14].

In the present investigation, the effects of type and length of polypropylene and steel fiber effect on the UPV values measured on concrete specimens were examined.

II. Methodology

Based on ASTM C597-09 Standard Test Method for Pulse Velocity Through Concrete" this method based on the wave generated by an electro mechanical transducer placed on the surface of the test specimens [15]. This test method can be applied to assess the uniformity and relative quality of the concrete in order to indicate the presence of the void and cracks. The accuracy of the results greatly depends on various factors such as:

- the ability of the operator to interpret the results
- surface roughness
- alignment of the two transducers
- temperature and moisture content (condition of storage of concrete. Un ultrasound equipment consist of un pulser receiver transducer, display device to measure the time.

The test begins when an ultrasonic pulse is generated and transmitted for an electro-acoustic transducer placed in contact with the surface of the concrete. After traversing through the material the pulses are received and converted into electrical energy by a second transducer.

R.E. is with the University of Tirana, Faculty of Natural Science, Department of Industrial Chemistry (phone: +355 666692449, e-mail: reufierjola@gmail.com).

M.J is with the University of Tirana, Faculty of Natural Science, Department of Industrial Chemistry

B.T is with the TU Freiberg, Institut fur Glass and Keramik

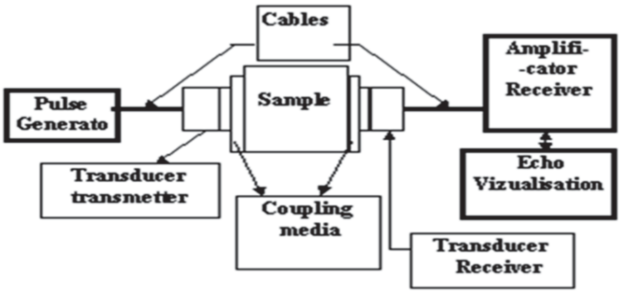

Fig. 1 Ultrasound equipment

Fig. 2 Ultrasound equipment

III. Materials and Mix Proportions

A. Materials

The cement used in concrete mixtures was ordinary Portland cement of 32.5 grade. The properties of cement are given in Table III. Fine aggregate and coarse aggregate of river of Milot with maximum size of 25 mm are used. Natural river sand from Milot river is used with maximum size of 5mm. The specification of sand and aggregate are given in Tables IV and V respectively. Two types of fibers were used for present investigation as shown in Fig. 3: Polypropylene fibers with 12 mm, and hooked end steel fiber of length 5 cm. The properties of hooked steel fiber and polypropylene fibers are given in Tables I and II respectively.

Fig. 3 Polypropylene of length 12 mm and Steel Fiber of length 5 cm

TABLE I
PROPERTIES OF STEEL FIBER

Type of fiber	Length of Fiber	Width of fiber	Aspect Ratio	Tensile Strength
Steel Fiber 5 cm SF1	**50 mm**	**0.75mm**	**67**	**>1100 MPa**
Steel Fiber 3 cm SF2	**30 mm**	**0.75 mm**	**44**	**>1450 MPa**

TABLE II
PROPERTIES OF POLYPROPYLENE FIBER

Type of fiber	Modulus of Elasticity	Extensibility	Melting Point	Electrical Conductivity
Polypropylene fiber 12 mm, P1	**3900 N/mm^2**	**400 N/mm2**	**170^{0}C**	**Zero**
Polypropylene fiber 6 mm, P2	**3700 N/mm2**	**370 N/mm^2**	**170^{0}C**	**Zero**
Polypropylene fiber 3 mm, P3	**3500 N/mm2**	**320 N/mm^2**	**170^{0}C**	**Zero**

TABLE III
MIX PROPORTION OF CONCRETE

Components	Specific gravity Kg/m^3
Sand	900
Sand	900
Cement	400
Coarse Aggregate 10-25 m	670
Coarse Aggregate 5-10 mm	300
Water	200
Super plasticizier	1
Steel Fiber	**0.25%, 0.5 %, 1 %** by the volume of concrete
Polypropylene Fiber	**0.1%** 0.2, % 0.4 % by the volume of concrete

IV. Results

Below are represented the results of this investigation. All the sample are investigated at room temperature.

TABLE IV
RELATION BETWEEN DENSITY, UPV AND COMPRESSIVE STRENGTH OF STEEL REINFORCED CONCRETE AT ROOM TEMPERATURE

	Density Kg/m^3	UPV m/s	Compressive Strength N/mm^2
Standard	1975	4063	30.52
SF1 - 1%	2575	4856	33.5
SF1 - 0.5 %	2437	4640	32.7
SF1-0.25 %	2015	4128	30.4
SF2-1 %	2332	4469	34.7
SF2- 0.5 %	2492	4734	33.5
SF2-0.25 %	1983	4083	29.52

TABLE V
RELATION BETWEEN DENSITY, UPV AND COMPRESSIVE STRENGTH OF POLYPROPYLENE REINFORCED CONCRETE AT ROOM TEMPERATURE

Mixing Ratio	Kg/m^3	UPV m/s	Compressive Strength N/mm^2
Standard	**1975**	**4063**	**30.52**
PP1-0.4 %	**2317**	**4551**	**38.78**
PP1-0.2 %	**2286**	**4427**	**37.6**
PP1-0.1 %	**2173**	**4182**	**32.47**
PP2-0.4%	**2001**	**3769**	**31.81**
PP2-0.2%	**1984**	**3894**	**35.54**
PP2-0.1%	**1905**	**3390**	**27.76**
PP3-0.4%	**2122**	**3775**	**27.76**
PP3-0.2%	**2267**	**3951**	**34.9**
PP3-0.1%	**2083**	**3765**	**28.85**

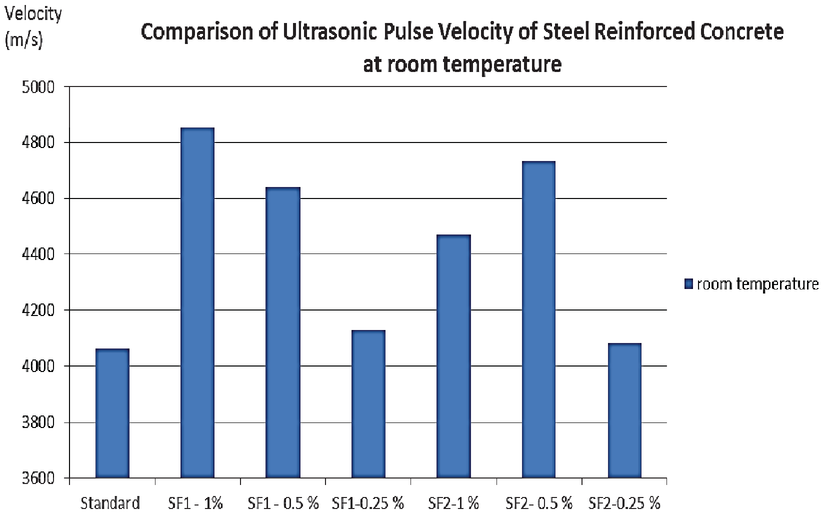

Fig. 4 Comparison of UPV of Steel Reinforced Concrete at room temperature

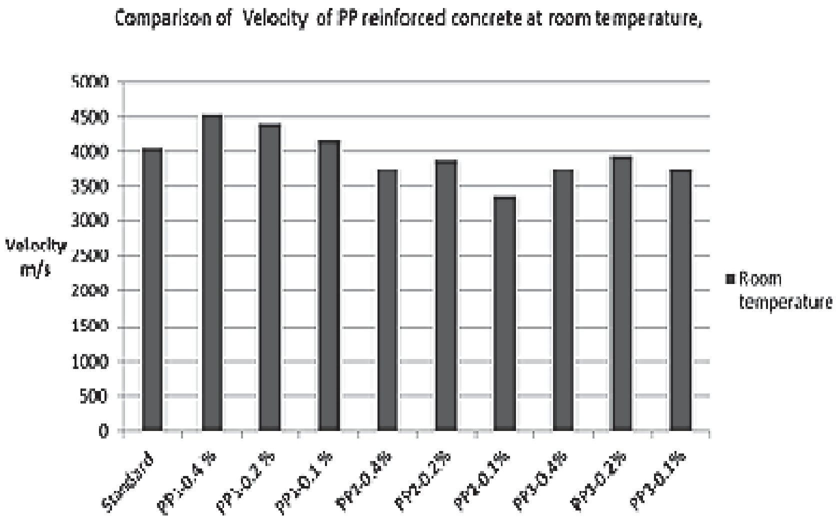

Fig. 5 Comparison of UPV of Polypropylene Reinforced Concrete at room temperature

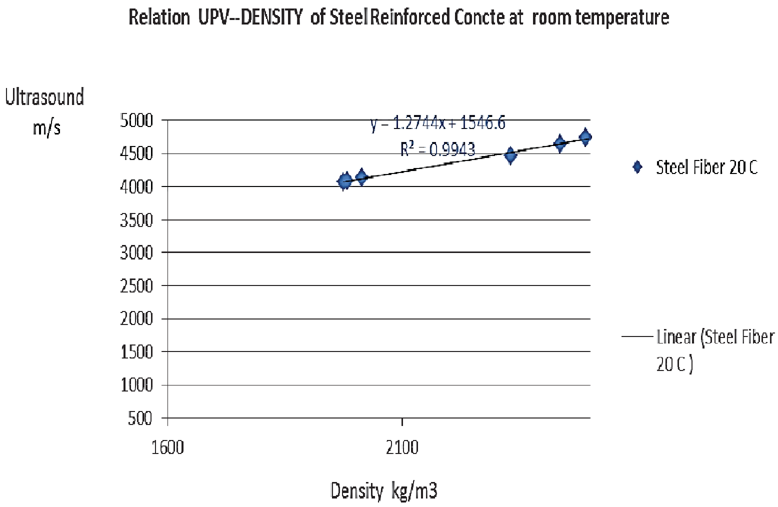

Fig. 6 Relation UPV-Density of Steel Reinforced Concrete at room temperature

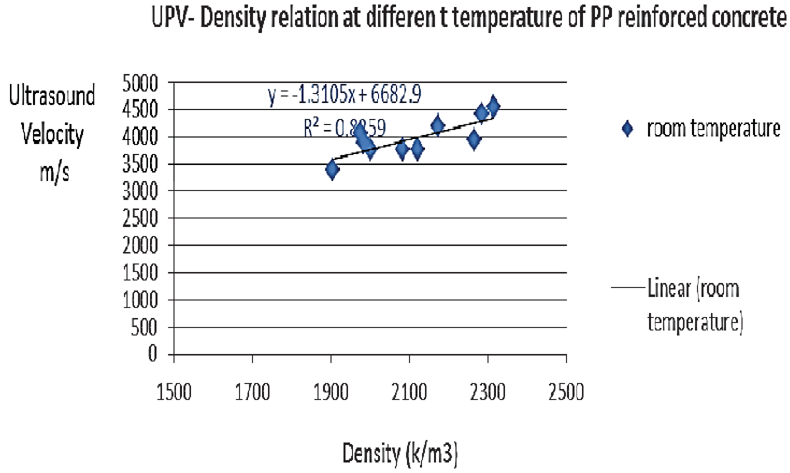

Fig. 7 Relation Ultrasound Velocity – Density of polypropylene reinforced concrete

V. Conclusion

- It was seen a significant effect of polypropylene and steel fibers, added to the mixture, on the UPV of steel reinforcement concrete.
- It was determined that the polypropylene fibers added to the mixture did not have a significant effect on the UPV of reinforced concrete. The optimum percentage of polypropylene fiber is 0.2 % by the volume of concrete for all types of polypropylene fibers used in this study.
- The effect of steel fiber on the compressive strength of concretes showed alteration based on the fiber volume. It can be said that the increased of percentage of steel fibers added to the mixture cause an important increase in compressive strength of composite.
- It was determined that the polypropylene fibers added to the mixture affect more than added of steel fiber on strength of reinforced concrete.

It has been found a linear relation between compressive strength and ultrasonic sound values for both polypropylene and steel reinforced concrete.

It has been found a linear relation between ultrasound velocity values and density of specimens of polypropylene and steel fiber reinforced concrete

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