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Effect of temperature on ultrasonic pulse velocity in hybrid reinforced concrete

M.sc. ERJOLA REUFI
Faculty of Natural Sciences, University of Tirana
St. "Blv. Zogu I", Tirana, Albania
Prof. Assoc. ILIRJANA BOCI
Faculty of Natural Sciences, University of Tirana
St. "Blv. Zogu I", Tirana, Albania

Abstract:

Effects of high temperatures on the velocity of ultrasonic pulses in concrete have been studied experimentally. Concrete prisms made of different mixes of fibers (polypropylene and steel fiber) were heated in an electric muffle furnace to varying temperatures up to 600°C and pulse velocity was measured before and after heating.

Hooked end steel fiber of length 50 mm and 30 mm was added to concrete in different proportion at 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 at 0.1, 0.2, and 0.4 % by the volume of concrete. Fifteen different mixtures have been prepared to investigate the relation between compressive strength and UPV values and also to investigate the effect of volume and type of fiber on UPV values.

The compressive strength of the concrete was determined later by crushing the cubic specimens.

Key words: ultrasonic pulse, polypropylene fiber, steel fiber, reinforced concrete, temperature.

1. 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][2][3].These non-destructive methods are usually associated with each other to improve diagnosis and reduce the number of tests. This method has been used 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][5][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 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°C- 30 °C do not significantly affect the pulse velocity measurements in

concrete [11], [12]. At temperatures between 30- 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 freezes 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 given pulse velocity, the compressive strength is higher for older specimens [14]. In the present study the effects temperature, type and length of fiber on the UPV values measured on concrete specimens, are examined.

2. MATERIALS AND METHOD

The work methodology is performed according to ASTM C597-09 “Standard Test Method for Pulse Velocity Through Concrete” which is 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 (storage condition of concrete). An ultrasound equipment consists of a pulser receiver transducer and 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.

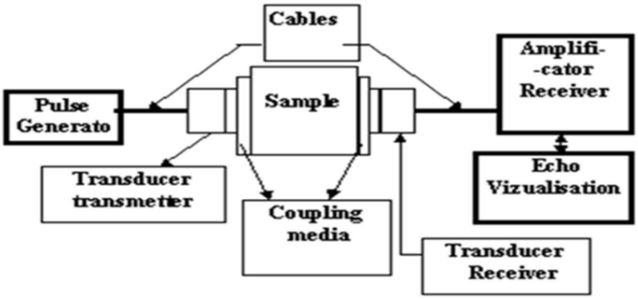

Figure. 1 Schematic ultrasound equipment

Figure. 2 Ultrasound equipment

The cement used in concrete mixtures was ordinary Portland cement of 32.5 grade. Fine aggregate and coarse aggregate with maximum size of 25 mm of Milot River in Albania are used. Natural river sand with maximum size of 5mm from Milot river is used as well..Five types of fibers, polypropylene fibers with 12 mm 6mm 3mm, and hooked end steel fiber of length 5 cm and 3 cm were used in this study as shown in Fig.3. The properties of hooked steel fiber and polypropylene fibers are given in Tables 1 and 2 respectively. Proportion of cements and aggregates and fibers added in the mixture are given in Table 3.

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

Table 1. Properties of steel fiber

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

Table 2. 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/mm^2	120^0 C	Zero
Polypropylene fiber 6 mm P2	3700 N/mm^2	370 N/mm^2	170 ^{0} C	Zero
Polypropylene fiber 3 mm P3	3500 N/mm^2	320 N/mm^2	170 ^{0} C	Zero

Table 3 . Mix proportion of concrete

Components	Specific gravity Kg/m^3
Sand	900
Cement	400
Coarse Aggregate 10-25 mm	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

3. RESULTS AND DISCUSSION

It have been prepared three series of mixtures each of them has 15 different mixture which different by the volume of polypropylene and steel fiber added. These series of mixtures has been investigated at room temperature, 200 ^{0}C and 600^{0} C.

It has been investigated the ultrasonic pulse velocity as it is described in ASTM C597-09 and compressive strength as it is described in ASTM C 39 M.

Prismatic sample have been prepared by dimension 16x16x40 mm to measure ultrasonic pulse velocity. On the other hand cubic specimens have been prepared by dimension 150mmx150 mm to measure compressive strength. Tables 4,5,6,7,8,9 show the results obtained for compressive strength and ultrasonic pulse velocity at room temperature, 200^{0}C, 600^{0}C.

Table 4 . UPV measurement results and compressive strength of steel fiber at room temperature

Mixing Ratio/Number of sample	Ultrasonic Pulse Velocity (m/s)	Compressive Strength (N/mm2)
Standard	4063.67	33.52
SF1 1 %	4856.33	33.5
SF1 0.5 %	4640.33	32.7
SF1 0.25 %	4128.00	30.4
SF2 1 %	4469.00	34.7
SF2 0.5 %	4734.67	33.5
SF2 0.25 %	4734.67	29.52

Table 5. UPV measurement results and compressive strength of steel fiber at 200^{0} C

Mixing Ratio/Number of sample	Ultrasonic Pulse Velocity (m/s)	Compressive Strength (N/mm2)
Standard	3236	32.09
SF1 1 %	3225.67	30.02
SF1 0.5 %	3245.33	30.29
SF1 0.25 %	3154.67	26.7
SF2 1 %	3361.67	31.41
SF2 0.5 %	3032.33	26.7
SF2 0.25 %	3115.00	25.9

Table 6. UPV measurement results and compressive strength of steel fiber at 600 ^{0}C

Mixing Ratio/Number of sample	Ultrasonic Pulse Velocity (m/s)	Compressive Strength (N/mm2)
Standard	570.37	26.81
SF1 1 %	731.67	27.09
SF1 0.5 %	584.67	32.21
SF1 0.25 %	403.33	19.22
SF2 1 %	962.67	37.58
SF2 0.5 %	833.33	31.97

Table 7. UPV measurement results and compressive strength of polypropylene samples at room temperatures.

Mixing Ratio/Number of sample	Ultrasonic Pulse Velocity (m/s)	Compressive Strength (N/mm2)
Standard	4063.67	33.52
PP1 0.4 %	4551.00	38.78
PP1 0.2 %	4427.33	37.6
PP1 0.1 %	4182.33	32.47
PP2 0.4 %	3769.00	31.81
PP2 0.2 %	3894.67	35.54
PP2 0.1 %	3390.00	27.76
PP3 0.4 %	3775.00	27.76
PP3 0.2 %	3951.00	34.9
PP3 0.1 %	3765.33	28.85

Table 8. UPV measurement and compressive strength of polypropylene sample at 200 ^{0}C

Mixing Ratio/Number of sample	Ultrasonic Pulse Velocity (m/s)	Compressive Strength (N/mm2)
Standard	3236.00	32.09
PP1 0.4 %	3373.00	35
PP1 0.2 %	3050.67	30.4
PP1 0.1 %	3007.00	34.77
PP2 0.4 %	3318.67	32.62
PP2 0.2 %	3492.00	26.9
PP2 0.1 %	3037.67	34.52
PP3 0.4 %	3035.67	29.73
PP3 0.2 %	3325.00	27.63
PP3 0.1 %	3308.33	30.39

Table 9. UPV measurement and compressive strength of polypropylene sample at 600^{0}C

Mixing Ratio/Number of sample	Ultrasonic Pulse Velocity (m/s)	E-modul (GPa)	Compressive Strength (N/mm2)
Standard	570.37	0.62	26.81
PP1 0.4 %	630.00	0.70	29.05
PP1 0.2 %	550.33	0.58	26.93

PP1 0.1 %	506.00	0.47	25.08
PP2 0.4 %	467.33	0.41	24.07
PP2 0.2 %	659.00	0.88	30.13
PP2 0.1 %	436.33	0.39	23.67
PP3 0.4 %	662.00	0.94	30.67
PP3 0.2 %	726.33	1.12	31.37
PP3 0.1 %	613.00	0.66	28.73

4. CONCLUSION

i. It was noticed a significant effect of polypropylene and steel fibers added to the mixture on the ultrasonic pulse velocity of the reinforced concrete

ii. It was determined that the polypropylene fibers added to the mixture did not have a significant effect on ultrasonic pulse velocity of reinforced concrete. The optimum percentage of polypropylene fiber is 0.2 % by the volume of concrete for all types of polypropylene fiber used in this study.

iii. On the other hand for the steel fiber it has been found a linear correlation between percentage volume of steel fiber and ultrasonic pulse velocity value. The optimum percentage steel fiber is 1 % by the volume of concrete

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

v. Value of ultrasound and compressive strength decreases with the temperature increase for both polypropylene and steel reinforced samples.

REFERENCES

[1] Destructive and non destructive testing of concrete structures. J.Malek, M. Kaouther. Jordan Journal of Civil Engineering Volume 8 2014

[2] Guidebook on non-destructive testing of concrete structures. International Atomic Energy Agency Vienna 2002.
[3] Ultrasonic Pulse Velocity Evaluation of Cementitious Materials T.H.Panzera. Departament of Mechanical Engineering , Federal University of Sao Jaou de Rei
[4] Characterization of the air void system in concrete using thermography. Chao Xiao The Pennsylvania State University The Graduate School College of Engineering
[5] Freeze- Thaw resistance of concrete effect of curing conditions moisture exchange and materials . The Norwegian Institute of Technology Trondheim 2001
[6] Delamination – a state of the art review. D. Jona . Construction Material Consulant USA.
[7] ASTM C597 Standard Test Method for Pulse Velocity Through Concrete
[8] Application of the Combined Method for Evaluating the compressive strength of concrete on site. S. Hannachi M.N. Guteche. Civili Engineering Departament , Faculty of Engineering Science, Algeria.
[9] Quality Control and Evaluation Methods of Concrete Engineering X.Wang K.Jang Three Grorges China University
[10] Ultrasonic Testing of Concrete after Exposure to high temperatures H. W. Chunge NDT International . Elsevier
[11] Evaluation of Compressive Strength by non destructive Test Using Ultrasonic Pulse Velocity with Maximum size aggregate (10-20)mm College of Engineering Al Mustansiriya, Iraq Baghdad.
[12] Effect of Elevated Temperature on mechanical properties of high strength self- compacting concrete R. Vasumitha. Research Scholar College of Engineering India.
[13] Freeze- Thaw Damage and Water Uptake in Low water/cement Ratio Concrete D.Bager
[14] Methods for testing of early – age concrete properties T. Voigt Research and Technology Center