Assessing Quality Polypropylene Fiber Concrete By Ultrasonic Method

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Abstract:

The reinforced concrete is a composite material (cement, aggregate, fibers) which may be regarded as a composite material isotropic (equal strength in all directions). Quality problems encountered in concrete structures at different stages appear of the execution of works, for that reason an increased demand for more accurate methods, at the same time more flexible for assessment of quality of concrete. For this reason we resort to non-destructive testing: ultrasonic, rebound hammer ... etc. Our work is considered as a frame of velocity measurements with ultrasonic method for different concrete composition by varying the percentage of fibers and the water / cement ratio to establish a relationship between mechanical strength and the speed of sound.

Keywords: Non-destructive testing, speed of sound; fiber, polypropylene, resistant to compression.

1 Introduction

Quality problems encountered in concrete structures appear at different stages of the execution of works, if for that reason for a long time an increased demand for more accurate methods and, at the same time more flexible to assess the quality concrete. For that reason we resort the non-destructive testing (NDT) of concrete which have great scientific and practical importance. The topic has attracted increasing attention for years; particularly the need to characterize quality of buildings damaged [1,2]. Our work will be based on the ultrasonic method to measure the velocity of sound through concrete with a generator and a receiver. Tests can be carried out on samples in the laboratory or on site. Many factors influence the results, such as the surface and the maturity of the concrete, the travel distance of the wave, the presence of the reinforcement, the overall proportion of mix, type and size, and age of concrete, moisture, and influence on concrete strength [4]. According to Popovics the ultrasonic method is effective for testing other materials than concrete [5]. The test was described in the standard ASTM C597, EN12504-4: 2004, a critical comparison of several standards of different countries is given in a paper by Komlos [3]. Whitehurst suggested a classification of the quality of concrete with speed (density of about 2400 kg/m$^3$) presented in Table 1.

<table>
<thead>
<tr>
<th>Quality</th>
<th>Propagation velocity (km/s)</th>
</tr>
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<tbody>
<tr>
<td>Excellent</td>
<td>&lt;4.5</td>
</tr>
<tr>
<td>Good</td>
<td>3.5-4.5</td>
</tr>
<tr>
<td>Doubtful</td>
<td>3.0-3.5</td>
</tr>
<tr>
<td>Bad</td>
<td>2.0-3.0</td>
</tr>
<tr>
<td>Very bad</td>
<td>&lt;2.0</td>
</tr>
</tbody>
</table>

The Table 1 Classification of the quality of concrete [6]
2 Expérimental Détails

2.1 Materials
The choice of materials is focused on their availability in the region of Biskra (Algeria), the materials used are:

Aggregates: Sand of oued Biskra region: Two crushed gravel (3/7 and 7/15) of the career of Biskra
Cement: Used is compose of Portland cement type CEM CPJ-class 42.5 from the cement-Ain Touta (region in Algeria), density = 3.15 g/cm³ absolute
Adjuvant: In our study we use the prior adjuvant MEDFLUID (SF) Comes from the company Granitex-Oued Smar (region in Algeria) is a plasticizer. Thanks to its properties MEDFLUID (SF) to increase the mechanical strength of concrete, increase fluidity and thus facilitate its implementation permit to avoid the formation of honeycomb
Fibers: The fibers used in our study are polypropylene fibers, the main features provided by the manufacturer are: length: 12 mm with density: 0.9 Kg/m³
Water: For making our blends, we use a tap water.

2.2 Composition of mixtures
Cubes of 100 mm sides are molded with the method Scramtaiv with water / cement ratios of 0.45, 0.55, 0.65. This choice was made so that the only variables are the water / cement ratio (W / C) and dosage of fibers (0%, 0.5%, 1% and 1.5% of the total volume of concrete ) and day tests (All specimens are kept in the water until the day of the test: 7.14, 28.60 days).

2.3 Experimental Results
The results of the experiments carried out are:
Determining the compressive strength by destructive testing,
Determining the speed by of propagation of ultrasound waves by the ultrasound.
These properties have been determined for different ages and compositions of concrete. From the experimental results, we try to establish the relationship between the ultrasonic velocity and strength of concrete according to the influence of W / C ratios and the percentage of fibers.

2.3.1 The speed of sound by varying the W/C ratio for different percentage of polypropylene fibers

![Graph showing the change in sound velocity for different water / cement ratios based on a percentage of the fibers.](image)

Fig.1: Shows the change in sound velocity for different water / cement ratios based on a percentage of the fibers.

We note that the introduction of the fibers change the behavior of ultrasonic pulses where the low percentage of the fibers increases the compactness of the concrete (in our case 0.5% is the percentage of fibers positive or beneficial) and the introduction of high percentage of fibers includes decrease its speed.

2.3.2 Mechanical resistance to compression by varying the W/C ratio for
different percentage of polypropylene fibers

![Graph showing variation of compressive strength for different water/cement ratios](image)

FIG. 2: Shows the variation of the compressive strength for different water/cement ratios based on a percentage of the fibers.

We note that the resistance increases with the age of concrete regardless of the percentage of fibers. The E/C decreased included the increase in resistance. For a percentage of 0.5% fiber it there's an increase in strength / the other percentage.

### 2.3.3 Relationship between resistance and speed of sound

![Graph showing correlation between compressive strength and speed of sound](image)

FIG.3: Correlation between the compressive strength as a function of speed of sound for different percentages of fiber.

The general relationship between the strength and speed of sound is of the form:

\[ f_{cy} = A e^{bV} \]  

(1)

\( f_{cy} \) = compressive strength of cylinder \( V \) = speed of sound  \( A, b : \text{constants} \)

The resulting equation is as follows:

\[ f_{cy} = 0.24130 \cdot e^{(1.16583 \cdot V)} \]  

(2) and  correlation coefficient \( r=0.911 \)

### 2.4 Application

To validate our results, we apply our equation of cores (design in Table C1 AND C2) taken from a concrete fiber contains 0.5% fiber and W / C = 0.45 manufactured on site.

Table 2 Comparative results between the in situ and the results of the expression
Designation of carrots

<table>
<thead>
<tr>
<th></th>
<th>C10.5</th>
<th>C20.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPV : The speed of sound (km/s)</td>
<td>4,390</td>
<td>4,290</td>
</tr>
<tr>
<td>fc: The compressive strength by crushing (N/mm2)</td>
<td>42.00</td>
<td>38.50</td>
</tr>
<tr>
<td>fcy: The compressive strength with the expression (N/mm2)</td>
<td>40.29</td>
<td>35.86</td>
</tr>
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</table>

3 Conclusions
This work consisted in the study of the influence of the variation of W / C ratios and percentages of polypropylene fibers on the compressive strength and the measurement of ultrasonic velocities.

The analysis of this study showed that the parameters which influence significantly the resistance of fiber concrete can influence, in the same way the results of the speed of the ultrasonic velocities increase with decreasing water / cement (same remark concerning the resistance to compression).

The compressive strength of 0.5% percentage is more beneficial whatever the E / C is that to control concrete (0%) percentages or other fibers.

It establishes an equation between the compressive strength is the speed of sound that is shown encouraging for the estimation of the resistance of fiber concrete.

References