RESEARCH ARTICLE OPEN ACCESS

Combination Of The Non-Destructive Methods For Evaluating The Quality Of Concrete Used In Structures In Reinforced Concrete

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ABSTRACT
The study is aboutthe use and comparison of three non-destructive methods (dynamic auscultation, sclerometric auscultation and auscultation by RADAR (Radio Detecting and Ranging) to monitor and assess the quality of concrete. Samples of reinforced concrete panels, dimensions 200x100x30 cm of concrete dosed at 350 kg/m3 with diverse E/C ratio were achieved, conserved in the laboratory and subjected to various non-destructive test.
The synthesis of the results obtained by auscultation RADAR shows a decrease in the propagation speed of the electromagnetic wave with an increase of the E/C ratio and a decrease in resistance of concrete values measured and confirmed by other non-destructive techniques (sclerometric and dynamic auscultations).
This shows that more the dielectric constant is high, morethe concrete resistance is reduced, and conversely the opposite.
Keywords **-** non-destructive methods, auscultation RADAR, Evaluating The Quality Of Concrete

I. INTRODUCTION

The expertise and the testing of structures with reinforced concrete that are existingor under construction often require the evaluation of the quality of concrete [1]. The quality testing of concrete cured by destructive testing may be difficult to achieve sometimes (heavily reinforced structure, reduced accessibility for the use of a core drill...). So, the use of Non Destructive Testing (NDT) methods seemssufficient.
Nowadays, the non-destructive techniques generally used in Morocco to assess the quality of concrete consist in sclerometric auscultation and sonic auscultation.
This paper presents a comparative study of these two aforementioned methods coupled with the RADAR technique which is based on the emission of electromagnetic waves sensitive to the humidity condition of concrete (permittivity, conductivity) [2-3]. .
The purpose of this research is to validate the RADAR technique in relation to the acknowledged non-destructive inspection techniques

II. EXPERIMENTAL SITE

In 2013, the Laboratory of Structure and Rehabilitation presents a research program to assess the effectiveness of the RADAR technique to control the quality of concrete elements in reinforced concrete.
For this purpose, several concrete samples dosed at 350 Kg / m3 with various water contents were prepared and reservedwithin the laboratory, the samples were then subjected to the following tests:
• The sclerometric auscultation
• The dynamic auscultation
• The RADAR auscultation
The composition of the concrete of the samples in this study are exposed in the table below. It is worth mentioning that the only parameter that varies is the E / C ratio [4].

Constituents	Volume (liters)

Sand	249.24							
Gravel (5 /10)	64.09							
Gravel (10 /20)	398.78							
E/C ratio	0.40	0.50	0.55	0.60	0.65	0.70	0.75	0.80

Table 1. The composition of the concrete

III. RESULTS OF THE VARIOUS METHODS

1) Dynamic Auscultation

a. Dynamic auscultation principle (surface control)

The ultrasonic tests are non-destructive trials which permit generallyto appreciate the homogeneity and the strength of concrete in accordance with the Moroccan Norm MN 10.1.124 Moroccan and French Norm FN P18-418 [5].

The control of the concrete quality consists in making crossing the materials used for test by an ultrasonic wave and assess the transit speed of this wave. The latter is an intrinsic characteristic of the material [6].

b. Evaluation of the strength and the homogeneity of the concrete by Dynamic auscultation

• The Dynamic auscultation concernedthe concrete samples counting 80 points of dimensions, as shown in the table below:

Samples	E/C ratio	Total Points auscultated	V Mini (Km/s)	V Maxi (Km/s)	V Med (Km/s)	Rc (Mpa)	Coef.Var (%)
Sample 1	0.40	10	4.1	4.4	4.2	31.12	1.54
Sample2	0.50	10	3.9	4.5	4.1	28.26	2.81
Sample3	0.55	10	3.9	4.2	4.0	25.60	4.21
Sample4	0.60	10	3.8	4.1	3.9	23.13	3.53
Sample 5	0.65	10	3.5	3.9	3.7	18.74	2.34
Sample6	0.70	10	3.0	3.4	3.3	11.86	3.51
Sample7	0.75	10	3.0	3.6	3.3	10.49	4.33
Sample8	0.80	10	2.9	3.3	3.2	10.49	3.53

c. Interpretation of the results

In the light of our results, we notice the following:

• For an E/C ratio less than or equal to 0.55 the concrete strength is greater than 25 MPa, it is the least value required by the regulation BAEL 91 for structures carriers of reinforced concrete structures.

• For an E /C greater than 0.55 the concrete strength is less than 25Mpa.

2) sclerometric auscultation:

a. Basis of non-destructive testing:

The only control of the concrete strength provided by the FN EN 12504-2 [7], related to the measurement of the strength compression on standard cylinders, taken and stored in the laboratory.

b. valuation of the strenght by sclerometer

• The sclerometric auscultation has concerned concrete blocks totaling 216 measurement points, as shown in table below:

Sample	E/C ratio	auscultated Total points	Rc min (Mpa)	Rc max (Mpa)	Rcmed (Mpa)	Coef measurement variation (%)
Sample **1**	0.40	27	27.4	30.3	**29.1**	**4.3**
Sample**2**	0.50	27	26.3	29.4	**28.7**	**3.4**
Sample**3**	0.55	27	25.4	29.4	**24.5**	**6.2**
Sample**4**	0.60	27	23.5	27.4	**24.3**	**5.3**
Sample **5**	0.65	27	21.3	24.5	**22.5**	**4.2**
Sample**6**	0.70	27	19.2	23.0	**21.5**	**2.6**
Sample**7**	0.75	27	18.5	21.1	**19.9**	**2.4**
Sample**8**	0.80	27	17.1	19.7	**18.6**	**3.2**

c. Interpretation of the results

The same synthesis of this of the results obtained by dynamic auscultation

3) Auscultation RADAR

a. Means

The non destructive meansused for the control of the concrete is a RADAR of structure equipped with an antenna that the frequency I about 1500 MHZ with penetration depth of approximately 50 cm.

b. Georadar method

Figure 1: RADAR equipment used

RADAR (Radio Detecting and Ranging) is an appliance of electromagnetism. The system emits electromagnetic energy (EM) thatpropagates in the surroundings and reflects on the interfaces with a contrast of EM properties. The analysis of the recorded signal (rapidity and shrinking) may provide relevant information such as the position of the target or the EM characteristics of the propagation surroundings. More, the RADAR has many advantages. Indeed, the technique is easy to use, fast, allows the auscultation of huge areas. Furthermore, the system of measurement is manageable, lightweight and little cumbersome.

The sensitivity of the RADAR waves in moisture condition of the material (eg, soil, concrete) has been reported by several authors [8]. The increaseof the concrete water content leads to a great variation of the parameters of the RADAR signal. This is usually due to the increased permittivity and conductivity of the concrete.

The untreated data are acquired and recorded according to parallel profiles and maybe treatedin order to improve the readability of radargrams.

c. Tests on samples of reinforced concrete panels realized with dimensions200x100x30 cm

In these samples realized in the laboratory, we made grid profiles (mesh) covering the entire surface of panels,

d. Results and Interpretation

Samples	Report **E/C**	dielectric constant **(F/m)**
Sample 1	0.40	**4.00**
Sample2	0.50	**4.50**
Sample3	0.55	**6.00**
Sample4	0.60	**7.50**
Sample 5	0.65	**8.12**
Sample6	0.70	**9.00**
Sample7	0.75	**10.00**
Sample8	0.80	**12.25**

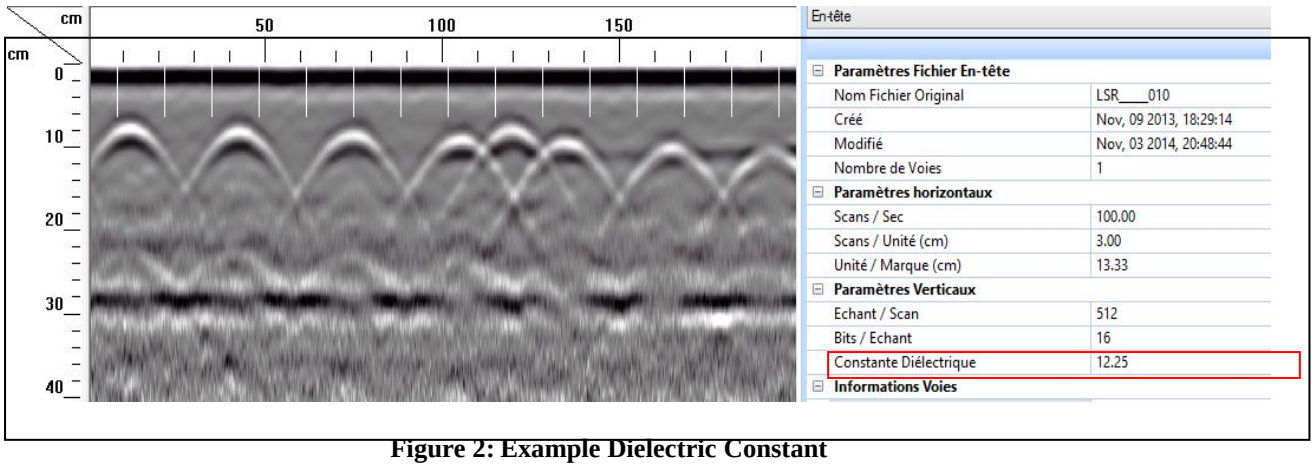

Figure 2: Example Dielectric Constant

The treatment of radargrams of the panels tested with different E/C ratio shows that:

- For a E / C ratio less than or equal to 0.55, the propagation speed of the electromagnetic wave in concrete being checked, is very high and therefore the dielectric constants of concrete being checked are very low and are between 4 and 6 F/m ;
- For a E / C ratio greater than 0.55, the propagation speed of the electromagnetic wave in the auscultated concrete is very low and therefore the dielectric constants are higher than concrete auscultated more than 6 F/m.

IV. CONCLUSION

In the context of tests carried out within the laboratory with the mastery of conditions and parameters for the preparation of concrete by taking the variation of a single parameter, which is the E/C ratio.
The comparison of the results by the various non-destructive techniques shows a decrease in the speed of propagation of the electromagnetic wave (RADAR technique) with an increase of the E / C ratio and a decrease of the concrete resistance values measured by the other non-destructive techniques (sclerometric and dynamic auscultations).
This shows that the higher the dielectric constant, the greater the strength of the concrete is reduced and conversely the opposite.
Taking into account the site conditions, this technique can be tested for preliminary measurements on site coupled with other complementary methods, this for its validation and taking decision about its future application in the nondestructive testing of hardened concrete

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