***THE EVALUATION OF THE***

***POROSITY OF ORDINARY CONCRETE***

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***Abstract***

The porosity can influence the durability of structures indirectly by controlling the majority

Of physical, mechanical properties. As a result, it considered like a false who cause a lot of

Problem. The main objective of this investigation is to study how the different properties of

Concrete development with the change of porosity. The experimental study has been carried

Out on two granular classes: sand (0/4) and gravel of D max = 16 mm, this study is exploited

According to two approaches. The first one is based on the evolution of characteristic of

Ordinary concrete with a different value of water / cement ratio (0.45; 0.5; 0.6).The second

Approach consists to find the relation between the various characteristic of concrete (porosity;

Permeability; resistors and velocity of propagation of sound).And by method analytique of the

Different experimental results obtained, we can conclude that it exist correlation between the

Measured ultrasonic velocity and porosity of concrete of formulation given.

***Keywords:* C**oncre**te;** Standard; Mass Volumique; Porosity; Permeability; Resistors;

Ultrasound.

***01. Introduction:***

Porosity is the natural consequence of the quantity of water put in addition to that required for

Hydration and possible voids in the aggregates. The inconvenience of this

Porosity is marked at two levels: on the mechanical strength and on the durability of the concrete.

The amount of water that can be chemical

lly bonded by a Portland cement is about 25%

Of the cement mass. Moreover, an amount of water, approximately equal to 15% of the mass of

Cement, is physically linked. This water is adsorbed on the surface of the hydration products

Or constitutes a mono-molecular water film between the flat crystallization products

('Interlayer water'). The physically bound water evaporates completely in an oven at 105

° C, but despite this free bond, it is unable to react with the unbound cement.

In addition, the hydration products occupy an absolute volume lower than the sum of the

Absolute volumes of water and cement that have already reacted. Space has thus liberated itself: this

Are the capillary pores. These are empty or filled with water. Indeed, for a good

The E / C factor of the concrete is generally greater than 0.40.

The water is therefore not bonded chemically or physically, and is installed in the capillary pores

(Interstitial water), from which it may eventually evaporate. This formation

Of capillary pores means a mechanical weakening of the concrete. Given that

Aggressive substances can readily penetrate into the concrete via this capillary network, Sustainability is negatively affected (Concrete Technology, Brussels:

G B- Belgian Concrete Group, 2006).

So, concrete is among the porous materials. In other words, it has pores or

Empty. These pores are crucial for the strength and durability of concrete. Indeed, a

Low porosity is the best defense against concretes

Aggressive.

In the industrial context of our work, the aim of this thesis is to examine

The appearance of porosity in ordinary concrete, and to characterize experimentally the evolution

Of their mechanical and hydric properties, such as resistance to compression and

Permeability under the effect of varying dosage in water and cement.

In this research, we are also exploring the possibility of linking

Different indices of durability that are depending on the internal structure of concrete.

***02. METHODOLOGY:***

The essential properties of concrete are greatly influenced by the characteristics

Materials used to make the concrete under study, and the tests carried out according to

European standards, French

***02.1 Used materials***

***02.1.1 Cement:***

The cement used in our study is of type CEMI 42, 5 R (FORT), their

Characteristics are described.

***02.1.2 Aggregates:***

For the purposes of our study, only natural aggregates were used:

• Granular (0/4) sand from the quarry located.

• A gravel is of local origin

Gravel is of maximum diameter D max = 16mm.

***02.1.3 Water for mixing:***

The mixing water used in our study for the preparation of concrete is a water

Tap water

***02.2 Tests on aggregates:***

***02.2.1 Particle size analysis by sieving:***

Control Sieve, Nominal Sieve Dimensions

Necessary to cover the dimensions between 0.08 mm and 2D for sand, 0.63d and 2D for gravel (European Norm NF

EN 933-2, "Testing for the Geometric Characteristics of Aggregates: Determination of

Granularity - Control Sieve, Nominal Dimensions of Openings

The results of this analysis are given in the tables below and represented

Graphically in the following Figures (1.1) (1.2)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sieve (mm)** | **Refusl (kg)** | **Refusl %** | **Cumulative Refusal** | **Sievent %** |
| **31,5** | 0 | 0 | 0 | 100% |
| **20** | 0 | 0 | 0 | 100% |
| **14** | 1,4775 | 29,55 | 29,55 | 70, 45 |
| **8** | 2,5765 | 51,53 | 81,08 | 18,92 |
| **4** | 0,9405 | 18,81 | 99,89 | 0,11 |
| **Le fond** | 0 ,0052 | 0,104 | 99,994 | 0, 006 |

**Board (1.1):** **Gravel analysis results**.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sieve (mm)** | **Refusl (kg)** | **Refusl %** | **Cumulative Refusal** | **Cumulative sifter** |
| **4** | **0** | **0** | **0** | **100**  |
| **2** | **0,0355** | **1,925** | **1,925** | **98,075** |
| **1** | **0,1395** | **6,975** | **8,9** | **91,1** |
| **0, 5** | **0,6045** | **30,225** | **39,125** | **60,87** |
| **0, 2** | **1,0860** | **54,3** | **93,425** | **6,575** |
| **0,1** | **0,1035** | **5,175** | **98,6** | **1,4** |
| **80Nm** | **0,0085** | **0,425** | **99,025** | **0,975** |
| **Le fond**  | **0,0155** | **0,775** | **99,8** | **0,2** |
| **La somme**  | **1,999** | **99,95** | **440.8** | **359,195** |

 **Board (1.2):** Result of particle size analysis of sand.

Figure (1-1): granulometric curve for sand.

Figure (1-2): gravel granulometric curve.

* It Can be seen from the granulometric curves of the aggregates that:

• The sand used is a medium particle size sand fits into the permissible spindle for ordinary concrete.

• According to the modulus of fineness of this sand (2.30), it can be said that it is acceptable for the making of concrete.

• Gravel is of discontinuous grain size.

***02.2.2 Apparent Density and Absolute Density:***

D apparent = M / V (kg / m3)

Where M is the mass of the granulate filling a container of volume V.

Apparent D apparent densities of sands were determined according to the procedure of European Standard NF EN 1097 – 3

Absolute densities of gravel and sand were determined in accordance with the procedure of the graduated specimen method (Dupain, R et al., 2000).

The results are summarized in the following table:

|  |  |  |
| --- | --- | --- |
| **Density (kg / m³)** | **Sand** | **Gravel** |
| **Apparent Density** | 1173 | 1388.5 |
| **Absolute Density** | 2600 | 2500 |
|  |

* It Can be seen from the table Apparent Density and Absolute Density :
* The values of the apparent densities are respectively the lowest. On the other hand, those of absolute densities are respectively the largest for aggregates, which makes sense.

***02.2.3 Water Absorption***

The water absorption coefficients "A b" were determined in accordance with P 18-555 for sand, and P 18-554 (Aggregates - Measurements of Density, Absorption Coefficient Porosity and Gravel and Gravel Water Content) for gravel.

***02.3Tests on gravel:***

***02.3.1 Porosity:***

|  |  |
| --- | --- |
| **Porosité** | **Gravier** |
| **P (٪)** | **3.95** |

The gravel porosity test was carried out in accordance with the French standard P 18-554

The result is shown in the following table:

* It is noted that the gravel used is not very porous, this confirms its hardness, and its low absorption.

***02.3.2 Surface cleanliness:***

The test was carried out in accordance with French standard P 18-591

It consists of determining the superficial cleanliness of aggregates greater than 2 mm by eliminating dust and clay particles less than 0.5 mm.

The removal is carried out by washing the sample on the corresponding screen.

The ratio of the 0.5 mm to the total weight of the sample represents the surface cleanliness of gravel:   P = 100 x (m / M s)

The cleanliness value of this gravel is equal to 1.18%, it indicates that it is clean according to the French standard XP P 18 - 540

***02.4. Dosage of compositions:***

***02.4.1Cement dosage:***

We have E / C = 0.5 → C / E = 2 and by the projection of the C / E value (in our case it was proposed that the collapse equal to 9 cm) we read the cement dosage value C ≈322 Kg / m



 Cement dosage according to C / E and workability.

***02.4.2 Water dosage:***

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Diameter in mm** | 10 | 12.5 | 16 | 20 | 25 | 31.5 | 40 | 50 |
| **Correction en ٪** | +9 | +6 | +4 | +2 | 0 | -2 | -4 | -6 |

On a C /E = 2 → E = C /2 = 322/ 2 → E = 161 kg

 Correction de dosage en eau (DREUX. G, 1979).

For D = 20 mm, the correction is + 2%, in addition to the calculated water quantity,

E = 161 x 1.02 = 164.22

→ E = 164.22 Kg / m3

***02.4.3 Determination of aggregates:***

The method of calculating the proportions of aggregates:

- On the abscissa: D / 2 = 20/2 = 10

- Y = 50-√D + k 'or K' = K + Ks + Kp

K, depending on the shape of the aggregates, the vibration mode and the cement dosage. (DREUX, G, 1979).

K s = 6 x MF -15 for 2.2≤MF ≤ 2.8

K p = 0 (non-pumpable concrete).

For a non-pumpable concrete made with crushed aggregates with gravel having a diameter, D = 20 mm, the sand has a fineness modulus MF = 2.3, a cement dosage of 322 kg and put in place by a vibrating needle, K = 2.88; K s = -1.08

 Y = 50- √20 +2.88 -1.08 = 47.33٪

V aggregate absolute = Percentage of aggregates (γ -Cement volume)

With γ = 0.795

To conclude therefore the approximate values of the compositions in volume as follows:

    V c = 0.114 m3

    V s = 0.232 m3

    V g = 0.4495 m3

***• Mass dosing:***

Where the mass = the absolute volume x the absolute density D abs

With D abs for sand = 2600 kg / m3.

  And D abs for gravel = 2500 kg / m3.

Thus, the dosage of the compositions for 1 cubic meter in kg:

E = 164,182; C = 322; S = 605,056; G = 1122.5

G / S = 1.85

By the same method the dosages for E / C = 0.45 and 0.6

|  |  |  |
| --- | --- | --- |
| **Dosage of compositions** | **0.45** | **0.6** |
| **Cement** | 377.293 | 272.27 |
| **Water** | 169.952 | 164.02 |
| **Sand** | 571.15 | 657.216 |
| **Gravel** | 1112.5 | 1120 |

 **Dosage of compositions**

***02.4.4 Manufacture of test specimens and tests:***

Molds for specimens:

According to the European standard NF EN12390, for the purposes of our study and according to the nature of the tests, the following molds were used for making the test pieces:

Cubic mold (10x10x10) cm,

Cubic mold (15 x 15x15) cm,

Cylindrical mold (16x32) cm.

***02.4.4.1Manufacture of test specimens***:

The mixing stages comply with the French standard NF P18 - 404 ("Concretes - Study, Convenience and Control - Confection and Conservation of Test Specimens", 1981).

 Mix the gravel, cement and sand aggregates for 1 min.

 Add the water and mix the whole 2 to 3 min in the cement mixer

 T = 90 √D (horizontal axis).

                                         T = 120 √ D (inclined axis). (DREUX, G, 1979).

In our work, the concrete mixer used is of diameter cm and speed 28 rpm, it is with inclined axis, so approximately t = 120 √....

The resulting mixture was homogenized and the desired quantity was taken for the filling of the molds in two layers for the cubic molds and in three layers for the cylindrical molds. The tightening of the concrete must be carried out immediately after the vibrating needle has been filled for each layer of the concrete being introduced.

***02.4.4.2 Conservation of specimens:***

After placing the concrete, the test pieces are held for 24 hours in their molds inside the laboratory. After demolding, the test specimens are placed in water until the time of the test, or in a laboratory room at ambient temperature.

***02.5. Presentation of the tests carried out on the concrete:***

***a. The density:***

The density of fresh concrete was determined for the various concrete constructions in accordance with European Standard NF EN12350 - 6 ("Fresh Concrete Testing - Part 6: Volumetric Mass", 1999).

It was determined by the placement of the fresh concrete in a rigid and watertight container of 5 liter volume, the concrete to be put in three layers, consolidated by 25 strokes by a stem of stitching for each layer.

The density of fresh concrete is therefore given by the following formula:

D = (m₂-m₁) / V (kg / m³).

***b- Slump test:***

The workability of the various composite concretes was evaluated on the basis of the slump consistency measurements at Abrams connection (Slump-Test) was carried out in accordance with European standard NF EN12350-2 ("Fresh concrete tests - Part 2)

In the cured state:

***02.6 Non-destructive testing:***

  The evaluation of the mechanical properties of concrete by non-destructive techniques is one of the most provocative tasks in modern civil engineering.

 Density in the hardened state:

The density of the hardened concrete was determined for the various concrete constructions according to European standard NF EN12390 - 7 ("Test for Concrete Durci - Part 7: Density of Concrete", 2001).

She determined at the age of 28 days after passing in the oven up to a constant,

Then the density is given by the formula:

Generally, concrete with a density greater than 2000 kg / m3 and less or equal to 2600 kg / m³ is a normal concrete according to European Standard NFEN 206-1 ("Concrete - Part 1: Specification Performance, Production and Compliance" , 2002).

 Dynamic Auscultation Test:

  The fundamental principles of nondestructive ultrasonic testing lie in the analysis of the influence of defects, of the heterogeneous type of structure, on the propagation of vibratory waves in concrete.

The tests can be carried out on specimens in laboratory or on structures according to French standard P18 - 418 ("Concrete - Auscultation Sonique, Measurement of the Time of Propagation of Sonic Waves in Concrete", 1989).

Many factors influence the results:

• The surface on which the test is carried out.

• The path should preferably be at least 30 cm in order to avoid any mistake caused by the heterogeneity of the concrete.

• Sensitivity to the maturity of concrete (state of hydration, occluded water, etc.).

• The presence of reinforcement in the concrete disrupts the propagation speed.

|  |  |
| --- | --- |
| **Qualité**  | **Vitesse de propagation m/s** |
| Excellente | Supérieure à 4000 |
| Bonne | 3200-4000 |
| Douteuse | 2500-3200 |
| Mauvaise | 1700-2500 |
| Très mauvaise | Inférieure à 1700 |

 Concrete quality as a function of sound propagation speed (\*.).

***02.6.1 Sclerometer analysis:***

  This test was carried out according to standard NFP 18-417, on cylindrical specimens (16 × 32) cm, that they are held between the plates of a press under a stress of 0.5 MPa. The sclerometer being placed perpendicularly to the axis of the test piece, there are 27 measurements distributed over 3 generators at 27 distinct points and separated by 30 mm, no measurement shall be located within 40 mm of the plane faces of the test piece. Of the specimen.

***02.6.2 Test porosity accessible to water:***

The purpose of this test is to evaluate the percentage of vacuum connected to the concrete surface, in accordance with NF EN 12390-7 ("Concrete Test - Part 7: Density of Concrete", 2001), on cubic specimens (15 × 15) cm. It consists of determining the mass in three states below:

(A) in the "saturated" state of water;

B) in the open air

(C) dried in an oven.

\* Determination of mass in different states: (European Standard NF EN 12390-7, "Test for Hard Concrete - Part 7: Density of Concrete", 2001)

A- Mass of the sample in the "saturated" state in water:

Immerse the sample in water at (20 ± 2) ° C until the mass variation between two open air weighings is less than 0.2% within 24 hours. Wipe the sample before each weighing to remove excess water. Note the value of the mass of the sample in the wet state (ms), in kilograms. (European Standard NF EN 12390-7, "Test for Hard Concrete - Part 7: Density of Concrete", 2001).

***02.6.3 Sample mass in the open air:***

Determine the mass of the sample in the open air following the procedure described below:

Remove the sample from the stirrup and remove excess surface water with a damp cloth. Place the sample on the scale, and record the mass of the sample in the open air (ma), in kilograms.

Mass of the dried sample in an oven:

Dry the sample in a ventilated oven at (105 ± 5) ° C until the change in weight between two weighings is less than 0.2% in 24 hours. Before each weighing, bring the sample to a temperature close to room temperature by placing it in a closed and "dry" enclosure or in a desiccator. Record the mass of the sample in the dried state (mo), in kilograms. (European Standard NF EN 12390-7, "Test for Hard Concrete - Part 7: Density of Concrete", 2001).

 The porosity accessible to water is given by the following formula:

Skin = (M a-M o) / (M a-Ms)

***02.6.4 Air permeability test:***

The objective is to measure the flow of gases passing through the specimen body under pressure. And depending on the time read on the device one can know the degree of protection of the concrete. The method of measuring the gas permeability consists in applying a constant relative pressure of the gas until stabilization of the flow of the gas through the material (steady state). The gas used is dry oxygen (O2) Since it remains inert vis-à-vis the constituents of the concrete, unlike water .The sample has been drilled at the center of the upper surface, the gas is injected at this level at a pressure P, the injection is carried out via a tube, which connects the gas supply bottle . The time required for the flow of gas to reach the steady state, considered as a sign to indicate the quality of protection of the concrete.

\* The air value required for the test calculated by the formula 19.05x (t / v).

***02.6.5 Destructive Testing***

***02.6.5.1 Compressive strength test***

Compressive strength is generally considered to be the most

Concrete, since it generally projects an overall picture of its quality.

Since it is directly connected to the structure of the hydrated cement paste (Neville Adam.

M, 2000). The compression strength test of the concrete was carried out in accordance with the standard European NF EN12390 - 4, by the application of a loading force on a test piece,

In the direction perpendicular to the casting axis until breaking in a test machine

The compressive strength of the concrete is given by the following formula:

Rc = F / S to (MPa)

***CONCLUSIONS:***

At the end of this work, we studied the influence of porosity on the physic - mechanical properties of ordinary cement - based concrete CEM I 42.5 R, with values ​​of ratio E / C vary (0.45, 0. 5; 0.6), and by the use of the formulation method of "DREUX-Gorisse" for the calculation of the compositions of this concrete.

 The experimental results and their interpretations, we can advance for the continuation of this work the following perspectives that can be formulated as follows:

• The characteristics of the aggregates used have a great influence on the properties of concrete.

• The nature, type and strength class of cement play a very important role especially in the evolution of mechanical characteristics such as the compressive strength of concrete.

• The water / cement ratio changes directly on all properties of the concrete, either fresh or hardened.

• Ultrasound and sclerometer are devices that approximate the resistance of concrete to compression.

• The porosity accessible to water was influenced by the concrete density and the W / C ratio.

• The air permeability is varied as a function of water / cement ratio, and the porosity, ie a porous concrete is a permeable concrete.

• The increase of the E / C ratio leads to an increase in the porosity, the latter having a negative influence on the strength of the concrete.

• The durability of a concrete is ensured if the water / cement mass ratio, the porosity and the permeability are low.

          In general, and from all the previous results, it can be said that the porosity manages all the properties of concrete that is to say that it conditions their durability.

Low-porous concrete is generally more durable since its low permeability delays the penetration of water and other potentially aggressive agents. This durability also, with a relation with the resistance, is for this reason if one seeks a better durability, one must choose the class of resistance of the concrete according to the aggressiveness of the environment.

      → so less porous concrete is a more resistant and durable concrete and this is the aim for the realization of modern works.

***References***

* European Standard NF EN 206-1.Feb. 2002. Concrete - Part 1: Specification Performance,

Production and Compliance. Editions AFNOR. Paris, 2002.

* European Standard NF EN 933-1. Dec.1997.Test to Determine the Characteristics

Geometric Analysis of Aggregates - Part 1: Determination of Granularity - Analysis

Granulometric by Sieving. Editions AFNOR. Paris 1997.

* European Standard NF EN 933-2.May 1996. Test for Determine Characteristics

Sampling, Testing and Assessment of Ability to Use, including

Processes of the Concrete Industry, such as Mixing Water for Concrete. Editions AFNOR.

Paris, 2003.

* European Standard NF EN 1097-3. August, 1998. Test for Determine Characteristics

Mechanics and Physics of Aggregates - Part 3: Method for Determination of

Bulk density and Intergranular Porosity. Editions AFNOR. Paris.1998.

* European Standard NF EN 12350-2. Dec.1999. Tests for fresh concrete - Part 2: Test

Of Sagging. Editions AFNOR. Paris, 1999.

* European Standard NF EN 12350-6.Dec.1999.Fresh Concrete Testing - Part 6: Mass

Volumic. Editions AFNOR. Paris, 1999.

* European Standard NF EN 12390-1. Oct. 2001. Test for Concrete Durci + Part 1: Form.

Dimensions and other Requirements for Specimens and Molds. Editions AFNOR;

Paris, 2001.

* European Standard NF EN 12390-7. Sept. 2001. Test for Concrete Durci - Part 7: Mass

Volume of Concrete. Editions AFNOR. Paris, 2001.

* DREUX Georges .New guide to concrete.Edition Eyrolles, 61 boulevard Saint-Germain,

75005 Paris, 1979.

* Dreux G. and Festa J. New Guide to Concrete and its Constituents. Edition, Eyrolles.
1. *Israa University – Gaza - Palestine* [↑](#footnote-ref-1)