Innovating building materials and relevant criteria for the improvement of durability.

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Abstract :

The concept of energy in the building supports the use of materials characterized by their performances of thermal insulation containing the valorization of local materials.

Algeria is a hot country. In summer constructions need materials of heat insulation. The expanded polystyrene it is a material air-conditioner, which absorbs the excess of heat during the day. in summer, It offers a dry space and confortable: it eliminates the moisture which can condense on the walls. This material is also respectful to environment. Polystyrene is an ecological product, it is certainly not biodegradable. But it can be recycled. This work represents the results from the physical and mechanical side, then we have formulated a series of the expanded polystyrene Concrete, the method of formulation of the lightweight expanded polystyrene concretes is based on the replacement of natural sets by the complementary volume of artificial sets according to percentage quite selected, thus we have varied the ratio E/C in order to have its effects on the rheological, physical and mechanical properties such us : subsidence, density and resistance (compression, flexion and tensile). The obtained results of physico-mechanical characterization of the expanded polystyrene concretes show the importance of the process of formulation adopted, especially, for the manufacture of insulating building elements and insulting carriers.

Keywords: density , lightweight concrete, thermal properties, aggregate, polystyrene, thermophysical properties.

1 Introduction :

The light concrete belongs to the range of the special concretes, its characteristics suggest new application, the thing that distinguishes it from the ordinary concrete is its low density. Indeed the mass of a concrete of normal density varies from 2200 to 2600 Kg/m3, while that of the light concrete oscillates between 300 and 1850 Kg/m3 [1]. The light concretes, i.e. those whose density in a dry state is lower than 1800 kg/m3, are employed in the civil engineering since the beginning of the 20th century, in the developed countries of Europe (France, Germany), of America (the USA) and of Asia (Japan and ex the USSR). Since then, the applications do not stop multiplying because of the advantages which this product has whether on the economical or technical side. These concretes are normally carried out by three manners, by using the lightweight aggregates, ventilation or gas, or by reducing the thin part of the aggregate. In each of the three cases, the reduction of the density of the concrete is carried out by an increase in the air spaces in the concrete [3]. In ordre to develop such a concrete, two elements must be taken into account: the concepts related to the formulation of the lightweight concrete and the use of lightweight aggregates. In addition, it becomes increasingly interesting to evaluate the potential of light materials as a source of raw materials. [6]. due to the expanded polystyrene lightness we can reach very low densities. Moreover, thanks to the use of the cement matrices with ultra high strength. The polystyrene concretes can have the resistance of structural concrete. Consequently, they represent, thanks to their lightness, a technical solution interesting for the building domain, of the offshore rig and structures. In addition, the lightweight concretes of polystyrene have a low thermal conductivity particularly for a very significant rate of balls (about 70%).

Consequently, they can bring a very interesting technical solution to the problem of heat insulation in the buildings [5]. The lightweight concrete which is carried out using expanded polystyrene PSE gives the advantage of having a whole panoply of densities from 500 kg / m3 to 2200 kg/m3 [2]. The objective of this study is analyzing the influence of the lightweight aggregate properties on the physico mechanical behavior of the lightweight concrete. Our experimental approach is based initially on the choice of ultra lightweight aggregate which is the expanded polystyrene. Also, it dependes on the variation of the cement matrices characteristics, the percentage of the lightweight aggregates and the ratio E/C. we have changed these factors in order to study its effects on the rheological and mechanical characteristics of the lightweight aggregate of concrete.

2 The Characteristics Of The Raw materials :

2.1 The Binder

We have chosen to use products of everyday usage, the type of cement used is compound Portland cement CPJ-CEM coming from the cement factory of Ain-Touta, (Algeria).

2.2 Expanded Polystyrene:

The prodution of the polystyrene balls is carried out in ENL factory which is located in the industrial park of Wadi Smar Algiers, These balls are then treated by IBER CONSTRUCTION company in the same factory to obtain product POLYS BETO. POLYS BETO consists of polystyrene balls of diameters ranging from the 1,5 to the 4 mm and its surface is treated by a specific tensio-active material. This treatment ensures for the balls a homogeneous integration and a distribution in the mortar or in the concrete which we wishe to lighten by substituting them by typical or light sands.

Table 1: Polystyrene characteristics POLYS BETO [4]

The Characteristics	**POLYS BETO**
Granulometry (mm)	1,5 à 4 mm
Apparent density after treatment (kg/m3)	28 à 32
absolute density (kg/m3)	33
Thermal conductivity (W/km)	0,045

2.3 Sand

The sand used in all the mixtures of the light weight concrete comes from the area of Lioua (wilaya of Biskra, Algérie). It is a siliceous fine sand of granulometry $\Phi < 4$ mm, its physical properties:
apparent density = 1678 kg/m3
Absolute density = 2572 kg/m3
The equivalent Sand = visual ES 86.2 %, ES piston = 79.3 % (clean Sand)

3 Description Of The Concretes

The purpose of the experimental program is to contribute to the valorization of the expanded polystyrene aggregates by incorporating them in a cement matrices.In this study, we are interested in the behavior of the mortar in which the sand was substituted by the expanded polystyrene aggregates. We varied the key factors (the ratio E/L, quantity of polystyrene).

3.1 The formulation

The sand was substituted by the expanded polystyrene aggregates for percentages of g =5% then 10, 20, 30, 50, 75 and finally 100 % from the unit volume of natural sets.

4 Study based on hardened concrete:

4.1 Apparent density of hardened concrete:

The mixtures have sufficient paste to eliminate the segregation and to give a reasonable external completion, but the reduction of the quantity of sand makes the mixtures very plastic according to the percentage of reduction.

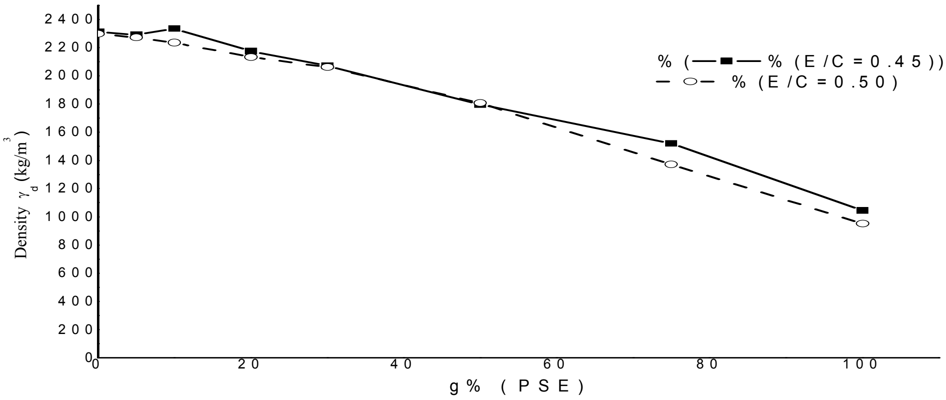

FIG. 1: Evolution of the density in the hardened state according to the content of polystyrene for E/C = 0.45&0.50

The dosage as in point g% = 5 does not bring great effects on the density but in the dosage g=10% the density goes up, then it goes down until A 950 Kg/m3. The two curves are almost identical what means that the ratio E/C does not have a great effect on the density of each mixture as we have already showen, we can notice that this factor is not radical in the variation of the density because the density of water equals 1.

4.2 Mechanical resistances:

4.2.1 Measurements of the Compressive Strength:

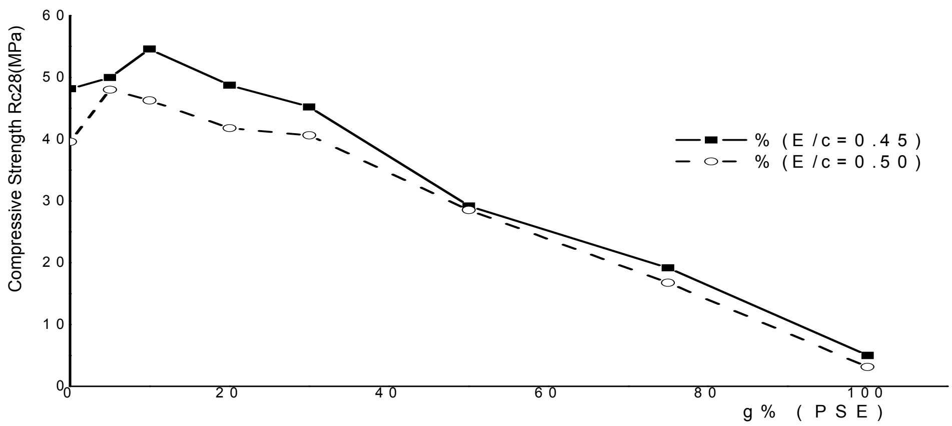

Fig. 2: Evolution of the compressive strength at 28days according to the content of polystyrene for E/C = 0.45&0.5

For a content of expanded polystyrene PSE from 0 to 100%, the compressive strength decrease from 48,125 MPa to 5 MPa. Is a reduction of about 90%.

The compressive strength develops with the addition of the expanded polystyrene and it arrives at its peak at 10%of aggregates, but it is reduced quickly by exceeding the value of 30% of the content of PSE. The effect of the ratio E/C on the compressive strength is remarkable when the added polystyrene does not exceed the 30% because the reading of the graph shows that from 50% of the content of PSE the values of the resistance of the two ratios remain close to each other whatever the percentage.

4.2.2 Measurements of the Flexural Strength:

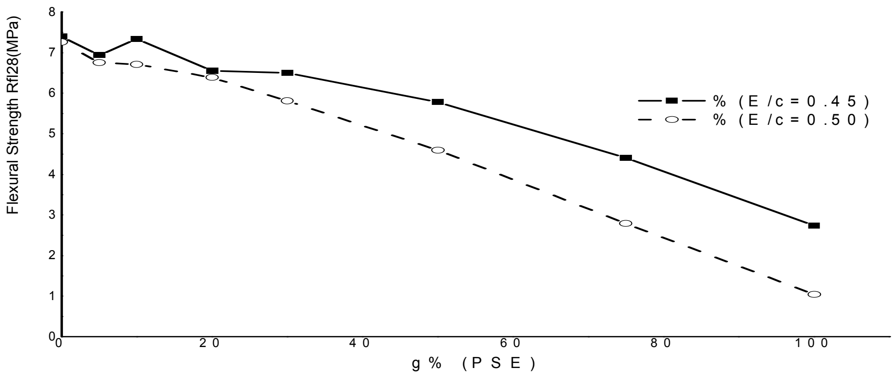

Fig. 3.: Evolution of the flexural strength at 28days according to the content of polystyrene aggregates and E/C = 0.45&0.5

The flexural strength ranges from 7,433 to 2,733 concerning the ratio E/C=0,45 and from 7,256 to 1,04 MPa concerning the ratio E/C=0,50. It results a reduction of about 86%. The curve number 3 shows that the flexural strengths increases when the ratio E/C decreases, the ratio E/C = 0,45 . Therefore,when the ratio E/C is small, this leads to an improvement of the materials'quality by this method of formulation.

4.2.3 Measurements of the Tensile Strength By Inflection:

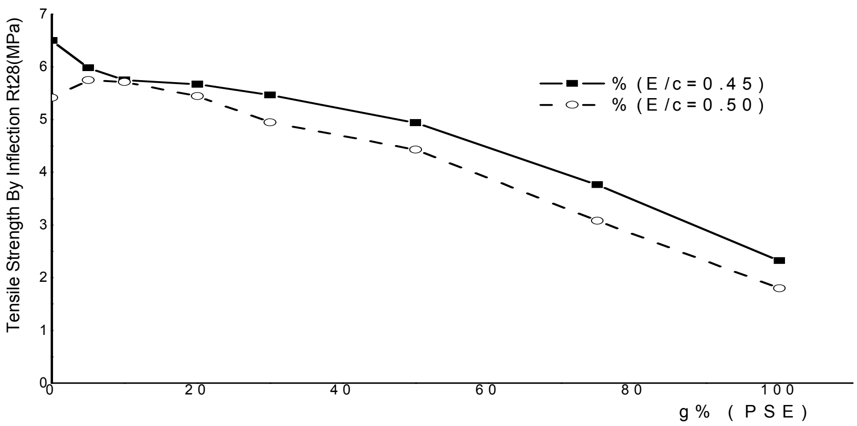

Fig. 4: Evolution of the tensile strength by inflection at 28 days according to the content of polystyrene for E/C = 0.45&0.5

- according to figure 4 we have noticed that: A fast fall of the tensile strength by inflection before the percentage of polystyrene reaches g%=30 then the rate/rhythm of the decrease becomes weak, and in particular for great contents of PSE.
- curve 4 shows that the tensile strengths by inflection grows when the ratio E/C decreases, but they are close for g%=10 and 20. Therefore when the ratioE/C is small this leads to an improvement of the quality of material.

4.3 Dynamic Modulus Of Elasticity:

The determination of the dynamic modulus of elasticity of the composite is based on the non-destructive tests, it was carried out by ultrasonic sounding, in accordance with the standard NF P 18-418 using a device of sonic sounding of the structures.

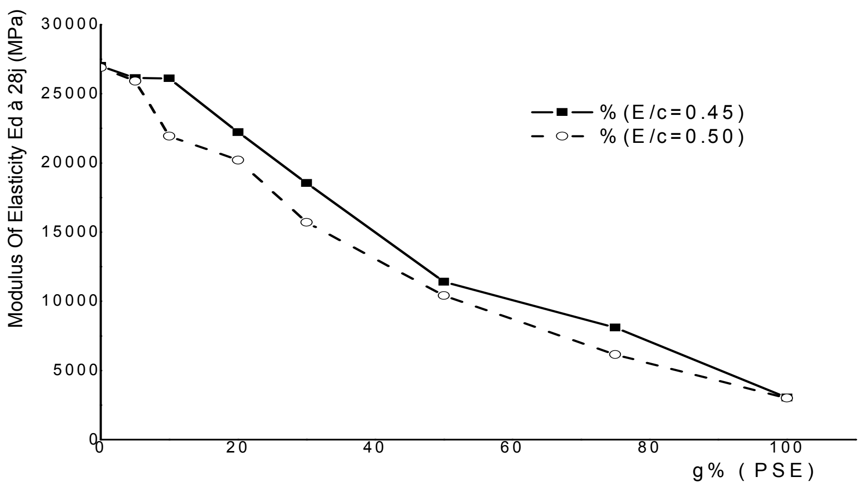

Fig. 5: Evolution of the dynamic modulus ED at 28days according to the content of polystyrene for E/C = 0.45&0.50

- the dynamic modulus of elasticity ranges from 26,53 GPa to 3,03 GPa, for the ratio E/C=0,45 and from 26,381GPa to 3 GPa for the ratio E/C=0,45 with a content of expanded polystyrene from 0 to 100%. Therefore g% increases and ED decreases.
- the effect of the ratio is obvious according to the curves in figure 5, then the dynamic modulus of elasticity increases conversely with the ratio E/C.

The propagation speed of the impulses of the pilot concrete where g=0% are definitely superior than that of the expanded polystyrene concrete for different percentages of various densities, For g=100% the propagation speed remains the smallest.

Generally, we notice that the polystyrene pearls took part to decrease the propagation speed of the impulses emitted by the sonic device of sounding which reflects an improvement of the properties of the concretes. Consequently, the expanded polystyrene pearls increased the insulating properties of the concrete due to its closed cellular structure thatlocks up imprisons the air in the form of small volumes.

4.4 Evaluation of compressive strength according to the density:

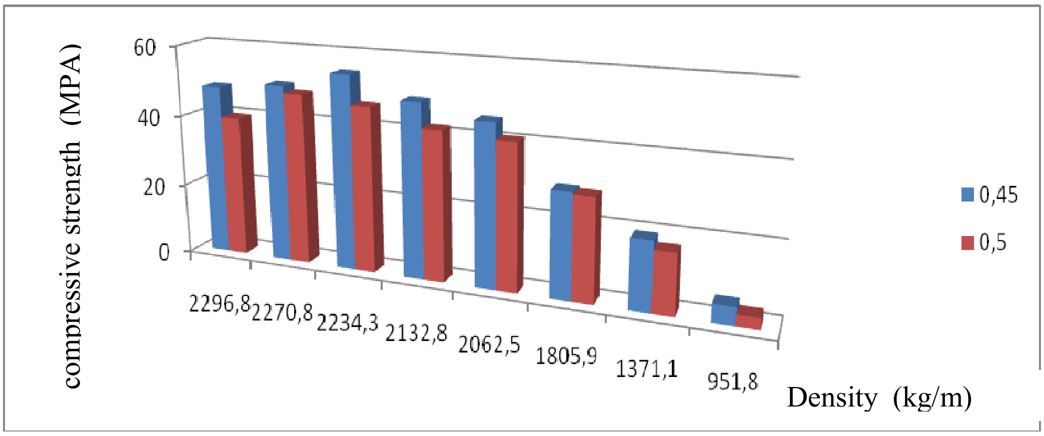

Fig. 6: Evolution of the compressive strength at 28days according to the density of the mixtures for E/C = 0.45&0.50

The densities obtained are close when the percentages of the PSE are small consequently , the resistances become better in the case where E/C is small, we can explain it by the presence of a sufficient cement matrice to give acceptable resistances in spite of the presence of the polystyrene PSE.

5 Conclusions

The objective of this study consists of the formulation and the Physico-mécanical characterization of the light expanded polystyrene concretes (BLPSE).

The whole tests carried out made it possible to draw the following conclusions

- the light concrete carried out using the PSE gives the advantage of having a whole panoply of densities go from 500 kg / m3 to 2000 kg/m3.
- a concrete of low density can be obtained only by using a significant proportion of light ultra aggregate (> 70%).
- the alleviation of material is accompanied by a loss of mechanical resistance, but it is possible to obtain acceptable mechanical resistances with small dosages in PSE.
- the decline of the flexural strength is less important than that with compression.
- the module E_D decrease according to the growth of the percentage of the expanded polystyrene
- These concretes do not consume much watre which results in having a reduction in the possible steel corrosion.

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