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Influence of Rubber Aggregates on the Delayed Deformations Under Constant Load of Eco-Concrete

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ABSTRACT

The Concrete rubber allow recycle important quantities of transport waste and bring mechanical solutions (regions exposed to the earthquake) and thermal (good thermo-physical characteristics), but because of differences in elastic modulus between the matrix and aggregates rubber, it is interesting to study their behavior in service and therefore delayed behavior under constant load. Indeed, the nature of the aggregates plays a preponderant role in modifying the properties of concrete and for rubberized concrete we have not information. In order to evaluate the influence of the nature of the rubber aggregates of the delayed deformation under constant load, two types of aggregates (aggregates of compact and expanded rubber) have been selected. The role of the nature of aggregates has been demonstrated through the experimental study by measuring the delayed deformation under constant load for two composite that can be differentiated that by the nature of rubber aggregates.

INTRODUCTION

The concrete is the excellent construction material. The simplicity of its manufacture, its financial low costs and its performances are among the primary reasons of its notoriety taking into consideration market of the building and public works. From their low capacity of deformation, the cementing materials are considered fragile. In addition, they have a resistance in relatively weak traction what makes them very sensitive to cracking [S. Bonnet, 2003]. In the absolute the solution is to have a sufficiently deformable concrete. Among the solutions considered, one can quote the incorporation of the rubber aggregates in cementing material. Indeed, the modulus of elasticity of the voluminal aggregates and their proportions influence enormously the modulus of elasticity of the concrete

[D.Fedroff & al,1993] studied the mechanical behavior of the concrete rubber and highlighted the positive contribution of the rubber aggregates to the elastic behavior of the concretes. [A.H. Toutanji,1996] it highlighted not linearity of the relation between the fall of the compressive strength and the voluminal content of rubber aggregates. Moreover, the decrease is faster than for the flexural strength. It in addition showed that the deformation of the concrete under loading is clearly improved in the presence of aggregates of rubber. [D.Raghavan & al, 1998] studied the influence of the form of rubber inclusions on the rheological and physicomechanical properties of mortars in a fresh and hardened state. In the form of fibres, they improve the mechanical resistances and the withdrawal of drying. Work was also undertaken [N. SERGE & al, 2000] to improve adherence of fine powders of worn tires to the cementing matrix. A treatment by an aqueous NaOH solution makes it possible to increase the roughness of surface of the rubber particles and improves the absorbent character of surface by hydrolysis of the acids and/or the groupings carboxyls present [D. M. SMITH & al, 1995; Z. LI & al, 1998]. It results a clear improvement from it from the connection rubber-paste of cement which has as a consequence an improvement of the mechanical performances. The reduction in porosity to the interface decreases the absorption of water by the cementing composite. The authors also observed a better cohesion of the matrix. The improvement of the behavior to freezing was the subject of studies undertaken in particular by the Pieri company [PIERI – GUMIX, 1992] and B.Z. Sava [B. Z. SAVA & al, 1995]. Contents from 10 to 15% of fine powders of worn tires clearly improve the factor of durability of the concretes subjected to the cycles of freezing/thaw.

The Engineering Materials and Processes (EMAP) of LTI (EA 3899) was also interested in valorization of the worn tires in cementing composites and showed the improvement of the physicomechanical and thermal properties of composites cement-rubber [H.G. ESSOBA & al, 2005; F. LABBANI & al, 2005; B. LAIDOUDI & al, 2003]. However, the behavior in time under constant load had not been studied to date in spite of its importance in the anticipation of the behavior of materials in service. An experimental study of the influence of the nature of the rubber aggregates was thus undertaken.

2. Materials used

The compact rubber aggregates are obtained by crushing of worn tires. Metal and the textile are eliminated. Crushed rubber is filtered in order to have various granulometry. We used a size range: 1-3 for the compact aggregates. Expanded aggregates of class 1-3 were also used to appreciate the effect of the cellular character of the aggregates. Cement used for this study is of type CEM I 52,5 R produced by the factory Gourain (company of Belgian cements). The choice of this type of cement is justified by the fact that it develops high resistances and thus makes it possible to compensate for the negative influence of the rubber aggregates on the resistance of the cementing composite.

3. Experimental techniques

Table 1 gives the composition of the various composites used in this work.

Table 1: Mix Design

Components	Unit	Pure Paste	CGCC 1-3 30%	CGCC 1-3 40%	CGCC 1-3 50%
Cement	Kg/m^3	1632.65	1324.45	1198.84	1058.20
Water	Kg/m^3	489.79	408.72	375.59	338.62
Water / Cement		0.3	0.308	0.313	0.32
GCC 1-3	Kg/m^3	0	228.11	321.19	425.26
GCC 4-6	Kg/m^3	0	0	0	0
GCE 1-3	Kg/m^3	0	0	0	0

Components	Unit	CGCE 1-3 30%	CGCE 1-3 40%	CGCE 1-3 50%	
Cement	Kg/m^3	1299.83	1167.63	1022.07	
Water	Kg/m^3	419.71	391.85	361.20	
Water / Cement		0.322	0.335	0.353	
GCC 1-3	Kg/m^3	0	0	0	
GCC 4-6	Kg/m^3	0	0	0	
GCE 1-3	Kg/m^3	198.45	277.31	364.11	

It is specified that ratio E/C is given to have a constant handiness The percentages of rubber aggregates used in this work are 30,40 and 50%. The rubber aggregates and cement are mixed at the dry state in a mixer standardized (standard EN 196 - 1) of capacity five liters. Dry malaxation lasts two minutes in order to ensure a good dispersion of the rubber aggregates. The mixing water is added gradually at slow speed during two minutes, malaxation continues one minute at fast speed.

The resulting mixture is set up in moulds of dimensions 3 X 10 mm. The test-tubes are preserved before and after the release from the mould in room at temperature and hygroscopy controlled (20°C, HR = 98%) during 28 days then dried until constant mass before the tests. To measure the delayed deformations under constant load we designed and dimensioned a bench of creep. The objective was to virtually test the resistance of each part to support the load necessary without disturbing measurements of delayed deformation under load.

The device of measurement is composed of several elements, whose sensor is the first link. Its choice is determining and depends mainly on the physical size to measure what means that the quality of measurement is related in major part to quality of the sensors.
We used sensors of the numerical feeler type `'digital probe' '. The feelers have the advantage of the robustness and reliability. They are of a high degree of accuracy and allow absolute measurements because they do not require to be re-initialized in the event of power cut.

The system of acquisition is also an important part of the device of measurement. We chose the chart network orbits. The chart is designed to adapt in a slit PCI on the mother chart of a computer having at least a processor, functioning to 700 MHz and having a RAM of at least 128MB. The chart accepts 62 numerical feelers. Each sensor connected on the network is identified by its single address. Measurements of these 62 feelers are done simultaneously. Just as the numerical feelers, the chart network orbits has a high degree of accuracy; its setting goes request from there certainly more efforts but it is very definitely less expensive than the traditional power stations of acquisition.
The follow-up of the variation height of the cylindrical test-tubes with a diameter 3 cm and height 10 cm according to time is made in a room air-conditioned and maintained with 20°C. The test-tubes are subjected to a uniform compressive force maintained constant over one long period. The pressure applied corresponds to 30% of the mechanical resistance in compression, the acquisition of the values is computerized.

4. Results and discussion

Figure 1 illustrates the conventional decomposition of the delayed deformations

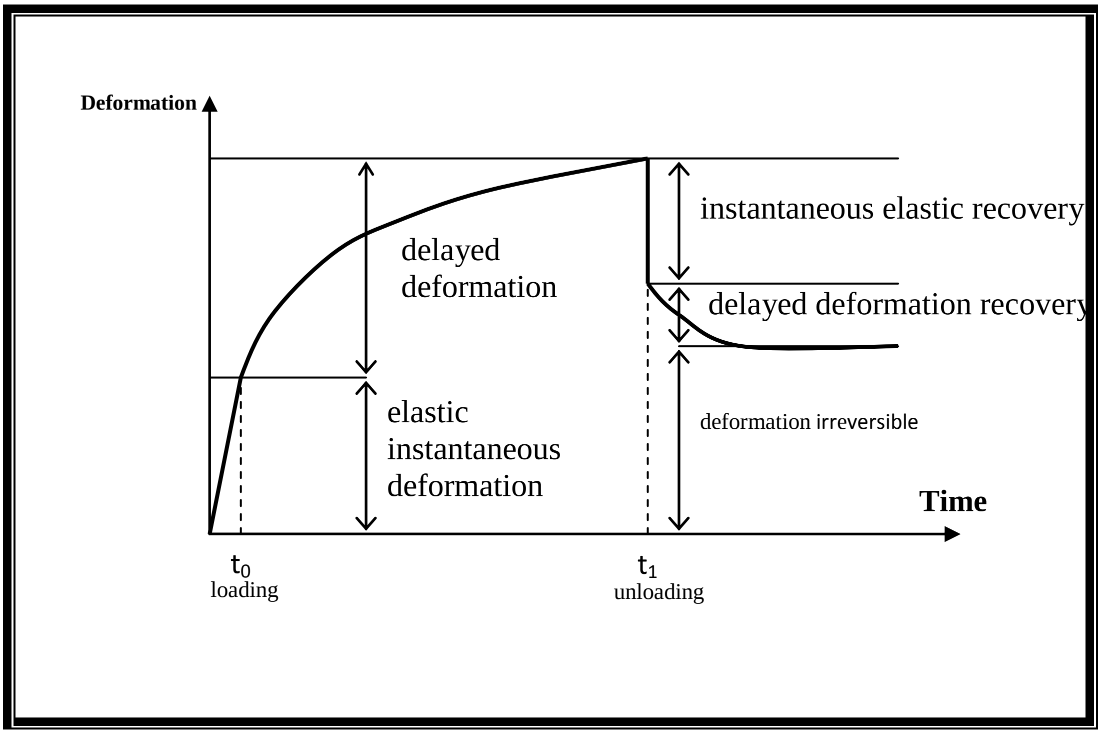

Fig.1. Conventional Decomposition of the Delayed Deformations

The delayed deformation measured on a test-tube charged is in fact the sum of several delayed deformations:

* Delayed deformation without load until the loading
* Elastic instantaneous deformation at the time of the loading
* Combination of the delayed deformation without load and the deformation due to the load after loading, during all the test.

Let us recall that

- The elastic instantaneous deformation is the deformation occurring simultaneously with the application of the constraint, it depends on the value of the constraint, the speed of application of the constraint and the age of the concrete.
- The delayed deformation without load starts at the beginning of setting and continuous for one long period.
- Creep is defined as the time-dependent deformation resulting from a sustained stress.
- The total deformation at the moment t and a constant temperature, is the sum of the deformation without load, the instantaneous deformation and creep
- The instantaneous elastic recovery is the deformation occurring simultaneously with unloading
- The recouvrance is the reversible part of the delayed deformation under load without instantaneous deformation after unloading

The study of the influence of the nature of the rubber aggregates was carried out for the various percentages of aggregates

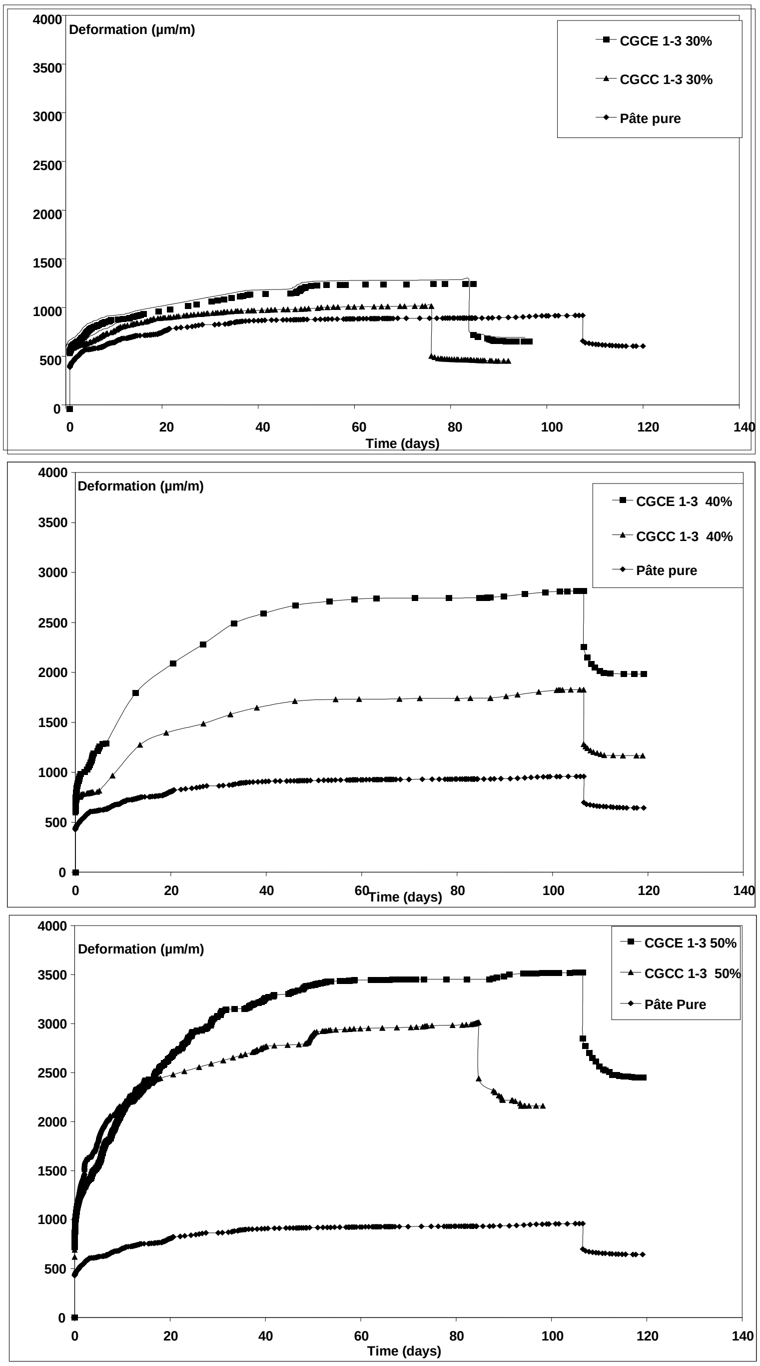

Fig.2. Influence Nature of the Rubber Aggregates on the Delayed Deformation

The figure (1) shows various evaluated deformations.

Table 2 summarizes the values of delayed deformations under load for the various composites

Table 2: Values of Delayed Deformations Under Load for the Various Composites

		elastic instantaneous deformation (µm/m)	total delayed deformations (µm/m)	instantaneous elastic recovery (µm/m)	delayed recouvrance (µm/m)	residual deformation (µm/m)
Pâte pure		427.74	958.68	260.93	54.63	643.12
30 %	CGC C 1-3	569.85	1055.11	511.76	52.37	490.98
	CGC E 1-3	582.14	1286.12	528.6	64.32	693.19
40 %	CGC C 1-3	597.63	1825.76	545.63	114.47	1165.66
	CGC E 1-3	611.45	2814.83	563.15	269.44	1982.24
50 %	CGC C 1-3	617.86	3014	573.76	279.16	2161.07
	CGC E 1-3	723.67	3520.87	671.56	399.17	2450.14

The results show that for the same percentage of aggregates, the instantaneous elastic deformation are more important when the aggregates have a cellular nature. They are also less important in the case of the pure paste than in that of a composite cement rubber. In the same way the total delayed deformations from the pure paste are less important than those of the composites cement-rubber and the nature of the aggregates seems to have a great influence on the total delayed deformations. For the various proportions one observes that the total delayed deformations increase with the use of the expanded aggregates.

With regard to the instantaneous recovery one notes that recovery is more important for the composites cement-rubber than for the pure paste. One sees for example whom for a composition with aggregate 40% the composites recover more than 90% of their elastic instantaneous deformations whereas the pure paste recovers only approximately 60% of them. There remains however partial whatever the proportion of aggregates and increases when expanded aggregates are used. In all the cases, paste cement or composite cement-rubber, the recouvrances remain lower than the delayed deformations under load

Conclusion

In this study, we showed the influence of the nature of the rubber aggregates on the delayed deformation under constant load. The results confirm the possibility of developing waste rubber in the form of light concrete, we studied the influence of the nature of the rubber aggregates for a size range: 1-3, one can widen the study for other size ranges.

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