CONCRETE CREEP WITHOUT AND WITH DRYING UNDER TENSILE AND COMPRESSIVE LOADINGS

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ABSTRACT

The present paper concerns an experimental work related to the relation between basic and drying creeps in tension versus basic and drying creeps in compression. The principal results obtained can be summarized as following:

- The basic creep in compression is a lot more important than the one in tension. The difference increases with the decreasing of the concrete age when it is loaded.
- The creeps in compression and in tension in drying conditions are similar.

INTRODUCTION

Creep behaviour of concretes is an important phenomenon to be taken into account for evaluating and analysing the behaviour of a lot of concrete structures.

The Institut Français des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux (IFSTTAR, Paris, France) has for objective to study the physical mechanisms related to the basic creep of concrete to develop a numerical modelling (finite element approach) based on realistic physical assumptions.

A very important campaign of experimental studies has been performed to reach this objective.
The present paper concerns the relation between basic creep and creep in drying conditions related to compressive and tensile loadings.

EXPERIMENTAL PROCEDURES

Concrete studied

The mix design of the studied concrete is given in table 1.

In order to evaluate the basic mechanical characteristics (compressive and tensile strengths) of the studied concrete, uniaxial tensile and compression tests were realized. Concerning the compression tests, they were carried out at different ages, 7, 14, 28, 64, 90, 180 days, to study the evolution in time of the concrete strength, whereas for the uniaxial tension tests, 1 expiry at 64 days were taken into account. 6 specimens per concrete age were tested both for compression and uniaxial tension tests. Table 2 summarizes the results obtained

Table 1. Mix design of the studied concrete

Components	kg/m^3
Cement : CEMI 52.5N PMES CA2	340
Dried sand-lime aggregate 0/4	739.45
Dried sand-lime agregate 6.3/20	1072.14
Added water	184.22

Table 2. Mechanical characteristic of the concrete

Mechanical characteristic (MPa)	Compression						Tension
Concrete age (days)	7	14	28	64	90	180	64
Average value (MPa)	31.2	35.1	39.9	42.2	44.4	51.2	2.8

The creep tests set-up

➢ <u>Creep test in compression</u>

The creep tests are performed on frames designed at IFSTTAR. The technology of the IFSTTAR creep frame and the test procedure have already been published in detail [1-4] and therefore will not be presented in detail in this article.

The tested specimens are cylinders, 160 mm in diameter and 1000 mm high, and protected from drying throughout the test (the condition for a basic creep test) by a double thickness of self-adhesive aluminium-paper sheet glued to the specimen (method developed by IFSTTAR [5]). Concurrently, autogeneous shrinkage tests are performed on specimens identical to those for the creep test (and also protected from drying in the same way). The basic creep strain is therefore classically determined by subtracting from the total strain, the instantaneous elastic strain due to the loading of the specimen and the strain due to the autogeneous shrinkage.

The basis of the strain measurement is 50 cm at the middle of the specimen.

➢ <u>Creep test in tension</u>

The creep test in tension is a much more recent one for IFSTTAR. Other creep tests in tension have been previously developed by other researchers [6, 13] The IFSTTAR creep test in tension has been designed and developed in 2008 in the frame of an industrial contract research conducted for the Institut (French) de Radioprotection et de Sureté Nucléaire (IRSN). This contract involved the study of endogenous tensile creep Pierre Rossi Page 2 30/06/2011of the creep device in tension has focused on a frame-type flail arm lever (figures 2 and 3). To reduce the maximum load to handle and to maintain a good sensitivity with a reasonable size, a ratio 5/1 was adopted for the lever arms. The tested specimen is cylindrical. It has a diameter of 13 cm and a length of 50 cm.

As for the specimens related to creep test in compression, the specimens related to creep test in tension are protected from drying throughout the test by a double thickness of self-adhesive aluminium foil bonded on the specimen.

The specimen is connected to the machine frame by bonding and bolting. The specimen is glued to aluminium helmets which are connected to the machine frame by bolting (figures 2 and 3).

Three displacement transducers are fixed at 120° on the central part of the specimen. The basis of measurement is 30 cm (figure 3).

As for the study relative to basic creep in compression, in parallel and simultaneously to the basic creep tests in tension, autogenous shrinkage tests on specimens identical to those used for creep are made (the same technique to protect against drying is used).

The creep strain is, as for the creep in compression, conventionally determined by subtracting to the total strain, the instantaneous elastic strain due to loading and the strain due to autogenous shrinkage.

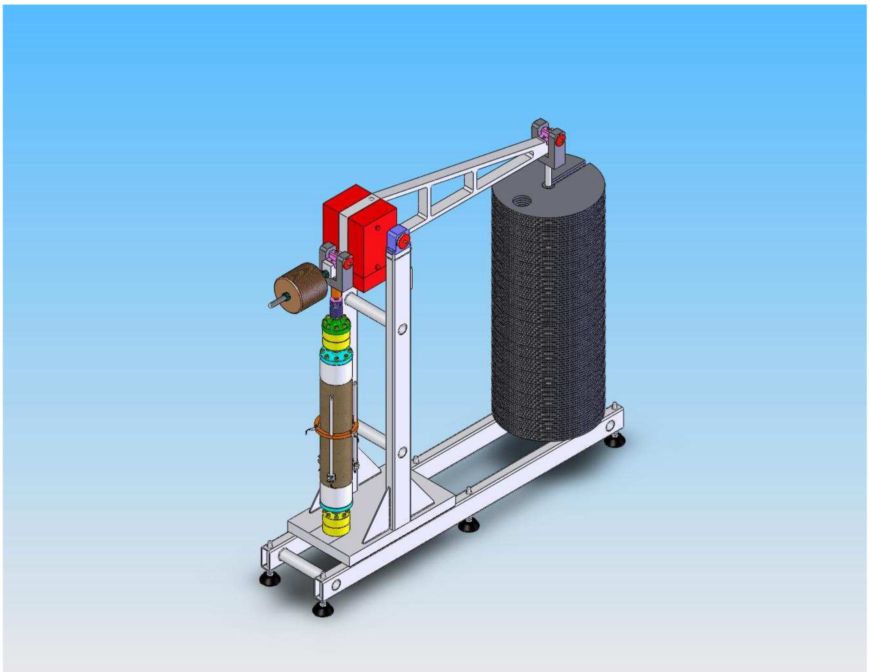

Fig.2. Schematic overview of the tensile creep machine.

Fig.3. Photo of entire tensile creep machine and of displacement measurement on specimen.

TESTS PROGRAM

Compression tests

➢ <u>Basic creep</u>

2 specimens are tested, 2 at a concrete age of 64 days, one is loaded at 50% of the concrete average compressive strength (at 64 days) during 185 days, the other one is loaded at 70% of the concrete average compressive strength during 67 days.

➢ <u>Creep in drying conditions</u>

2 specimens are tested at a concrete age of 64 days, one specimen is loaded at 50% of the concrete average compressive strength (at 64 days) during 30 days, the other one is loaded at 70% of the concrete average compressive strength during 30 days.

To permit the creation of creep in drying conditions, the self-adhesive aluminium foil bonded on the specimens (see above) is removed just before putting the specimens into the creep frame.

The same thing is doing concerning the specimens related to the determination shrinkage in drying conditions (see above).

Tension tests

➢ <u>Basic creep</u>

2 specimens are tested. They are loaded at a concrete age of 64 days, one is loaded at 50% of the concrete average compressive strength (at 64 days) during 30 days, the other one is loaded at 70% of the concrete average compressive strength during 30 days.

➢ <u>Creep in drying conditions</u>

2 specimens are tested at a concrete age of 64 days, One is loaded at 50% of the concrete average compressive strength (at 64 days) during 30 days, the other one is loaded at 70% of the concrete average compressive strength during 30 days.

As for creep and shrinkage in drying conditions related to compressive loading, the self-adhesive aluminium foil bonded on the specimens is removed just before putting the specimens into the creep frame.

EXPERIMENTAL RESULTS

In the figure 4 are presented the compliance curves (strain vs. time per unit of applied stress) related to the basic creep tests in compression and in tension for the concrete age of 64 days.

In the figure 5 are presented the compliance curves related to the drying creep tests performed in compression and in tension for the concrete age of 64 days.

In the figure 6 are presented the compliance curves related to the basic and drying creep tests in compression for the concrete age of 64 days (loading levels equal to 50 and 70%).

In the figure 7 are presented the compliance curves related to the basic and drying creep tests performed in tension for the concrete age of 64 days (loading levels equal to 50 and 70%).

Considering these figures 4 to 7, the following comments can be made:

- The compliance curves related to the basic creep in tension for the two loading conditions (50 and 70%) are similar. That means that basic creep in tension can be considered as visco-elastic linear until, at least, a loading level of 60%.
- The compliance curves related to the loading levels of 50 and 70% in compression are closed and present the same evolution.
- The basic creep in compression is a lot of higher than the basic creep in tension.
- The creeps in compression and in tension in drying conditions are more important than basic creeps in compression and in tension.
- The creeps in drying conditions related, respectively, to compressive and tensile loadings seem equivalent. As the matter of fact, the small difference between the curves can be attributed to the natural scattering existing for this type of test and material.

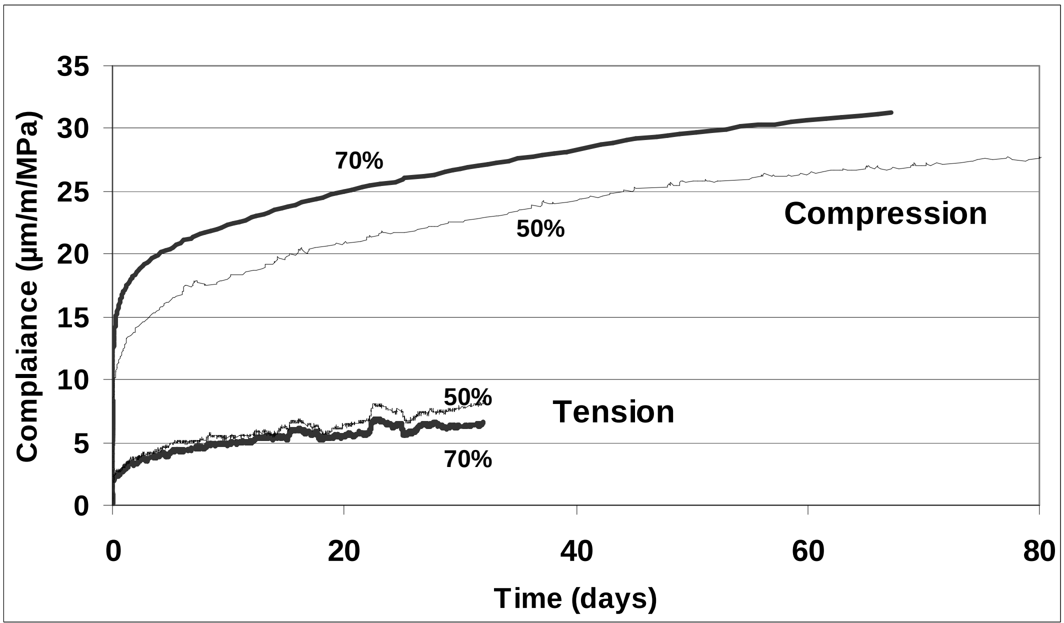

Fig.4. Compliances curves related to the basic creeps loaded in compression and in tension at respectively 50% and 70% of the compressive strength and of the tensile strength of the studied concrete.

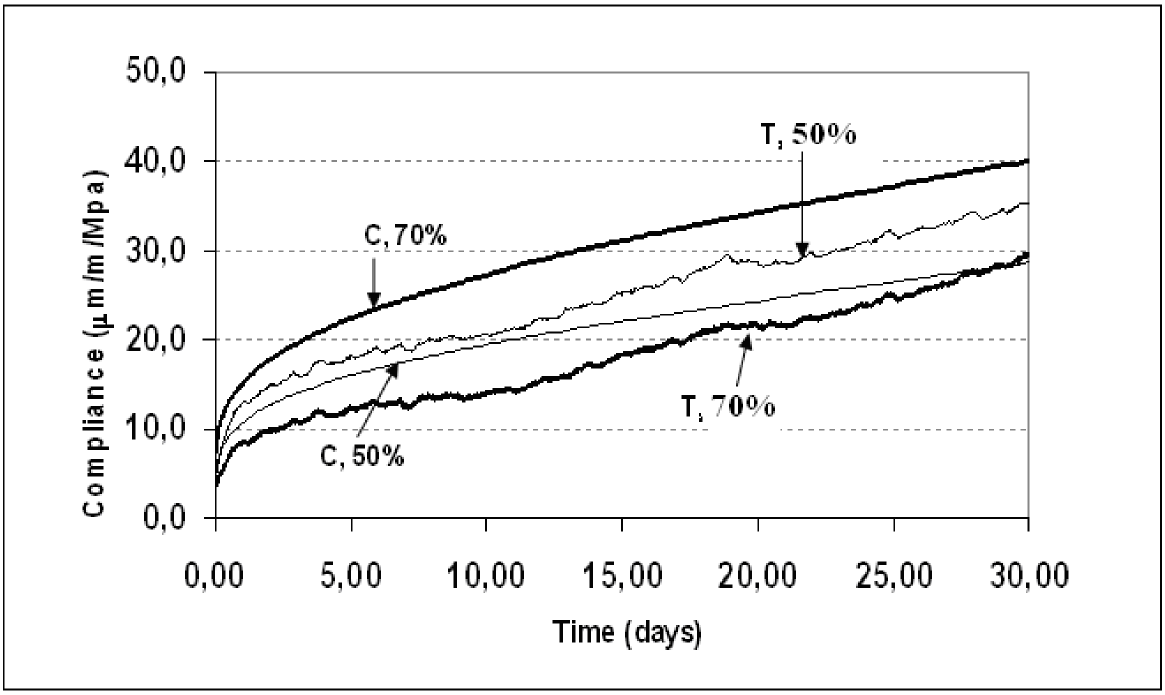

Fig. 5. Compliance curves related to the drying creep tests performed in compression and in tension for a concrete age of 7 days

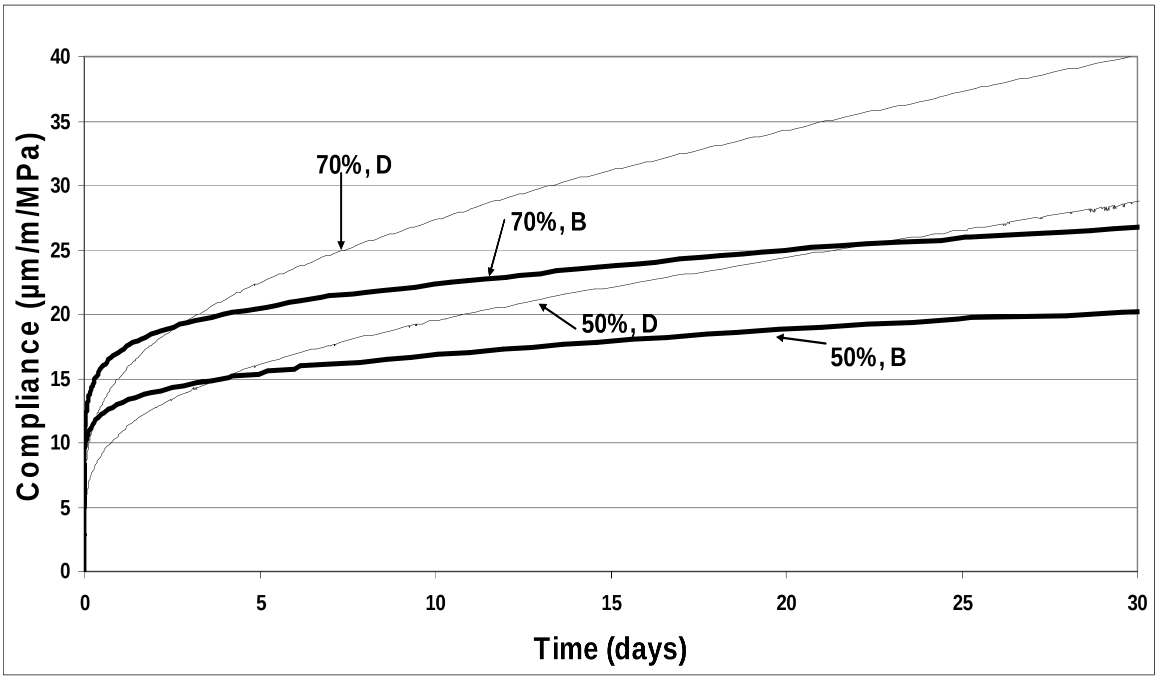

Fig.6. Compliance curves related to the basic and drying creep tests in compression for a concrete age of 64 days.

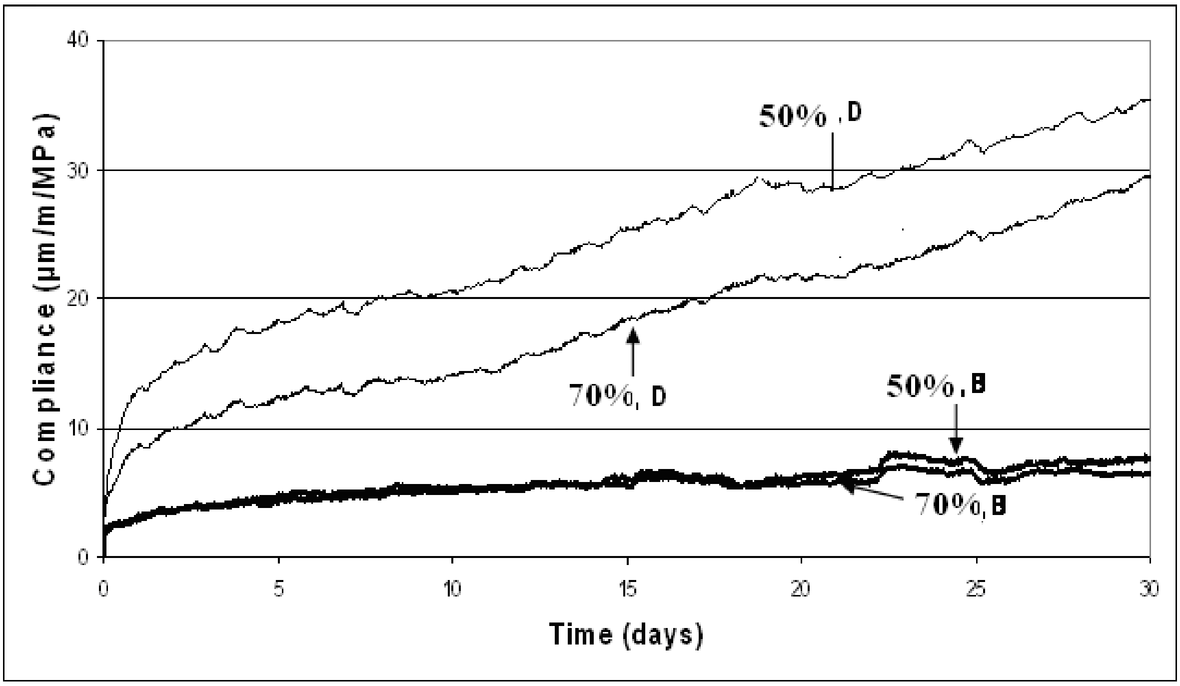

Fig.7. Compliance curves related to the basic and drying creep tests in tension for a concrete age of 64 days.

CONCLUSIONS

This paper presents comparison between creeps with and without humidity exchange related to compressive and to tensile loadings, that for a same concrete.

This comparison leads to the following conclusion: basic creep in compression is more important than in tension when tensile and compressive creeps in drying conditions are equivalent.

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