TEST RIG FOR EARLY AGE MEASUREMENTS OF THE
AUTOGENOUS SHRINKAGE OF A CONCRETE

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Abstract
A test rig designed for autogenous shrinkage measurements of concrete at early age is presented. It allows the recording of the deformations of a specimen protected against the desiccation at a constant temperature. Only one external displacement sensor is used. The specimens are cast in a flexible mould to avoid any friction. The test rig is immersed in a thermo controlled bath. Measurements can start just after the casting of the concrete. A series of four successive tests on the same concrete underlines the repeatability of the method. This equipment was developed for industrial and research applications. A metrological qualification gave the value of the uncertainty. The autogenous shrinkage of concrete is defined after an age of the concrete called $t_0$ or setting time. Methods are discussed for the determination of $t_0$.

Résumé
Un bâti de mesure du retrait endogène du béton au jeune âge est présenté. Il permet l'enregistrement des déformations d'une éprouvette protégée de la dessiccation à température constante. Un seul capteur de déplacement exterieur est utilisé. Les éprouvettes sont coulées dans un moule souple pour éviter tout frottement. Le bâti est immergé dans un bain thermostaté. Les mesures peuvent commencer peu de temps après le coulage du béton. Une série de quatre essais successifs, sur la même formulation de béton, souligne les performances de répétabilité de la méthode. Cet équipement a été développé pour des applications industrielles et de recherche. Une qualification métrologique a permis de chiffrer l'incertitude de la mesure. La déformation endogène du béton est définie après un âge appelé $t_0$ ou prise. Des méthodes de détermination de $t_0$ sont évoquées.

1. INTRODUCTION
At early age, a few hours or days after casting, the concrete is submitted to hydrous and thermal deformations which, if they are restrained, can lead to a crack development. The origin of these deformations is related to the hydration process.

The autogenous shrinkage is the component, beside drying and thermal deformations, which remains in a structure if it is protected against the desiccation, at a constant temperature and when boundary conditions are stress free. These conditions are called autogenous conditions. At early age, there are no drying deformations for the structures are still in the
forms or they are cured against drying. Frictions between the forms and the structures are not null and re-bars are always present. So there are always no stress free boundary conditions.

Predicting early age cracking risks of concrete, implies knowing both the evolution of the mechanical characteristics and the free deformations (autogenous and thermal deformations) since the setting time (t₀). The setting time is regarded as the age, after which, the stiffness increases rapidly. In restrained conditions, stresses can appear due to restrained autogenous shrinkage. Concretes with low water to cement ratio are more affected by this phenomena. Classical measurements of autogenous shrinkage start one day after the casting. Doing so, a great part of the shrinkage, according to Aïtcin [1], is “forgotten”.

The aim of this development is to provide the researchers and the profession an experimental tool for measuring the autogenous deformation of a concrete at early age, in autogenous conditions since the setting time. The test must be the simplest and reproducible.

This article deals with the design of a test rig able to provide information from a moment close to the casting until an age of one or two weeks. Some preliminary tests are shown from which it is possible to characterize the repeatability. As this apparatus has been developed for industrial or research applications, a metrological qualification has been performed so that the uncertainty has been estimated.

This method must be associated with another one which allows the determination of t₀. Some existing methods are examined.

2. DESIGN OF THE TEST RIG

The test is carried out on concrete, without drying and at a constant temperature. The sample is kept in the mould, free of external loading to avoid any cracking or loading.

Tests on concrete lead to sample dimensions greater than the coarser aggregates (x5 is a minimum) in order to take into account the heterogeneity of the material which is emphasized on moulded samples because of the wall effect (close to the walls of the mould, the density of the coarser aggregates is lower than in the core while the volume of mortar is greater). Although isothermal tests are impossible because there is always a temperature gradient to dissipate the heat of hydration, it is necessary to reduce the size to minimize this gradient. Previous tests showed that cylinders of about 120 mm in diameter were a good compromise between these two requirements.

Volumetric measurements are difficult on large samples so linear ones are preferable. The linear measurements can be horizontal or vertical. Several reasons led us to choose vertical one:

First, horizontal measurement on prisms leads to friction between the wall of the mould and the sample even if special cares are taken. J. Baron [2] showed that, before the setting time, the variations of the recorded strains are proportional to the length of the samples and become progressively equal when the concrete stiffen. One can imagine that in the transition between the two phases, the friction still affects the deformations. That is why Boulay & al. [3] and Jensen & al. [4] chose to cast the material in corrugated plastic moulds. For concrete samples, such a mould is too weak if it is installed horizontally.

Second, horizontal measurements are made with two displacement transducers at each end of the sample, which make it difficult the passage of the rods bounded to the ends of the sample through the walls of a tank containing the water for the control of the temperature.
Furthermore, the use of a vertical corrugated mould facilitates the sealing of the sample in order to avoid any drying. In fact, it is easy to link two stiff ends to the mould, which are able to follow the important displacements of the sample before the setting time.

Finally, the deformation can be obtained with only one sensor placed at the top of the rig. This transducer is reusable unlike the expansive embedded strain gauge used by Boulay & al.[3]. Baron in 1977 [5] also proposed similar requirements.

The test rig (figure 1) is constituted of fixed parts (marks 1, 2, 3), of mobile parts (m. 4, 7, 8, 18), of a soft mould (m. 6) tightened on the 1 and 7 parts, with two collars and of a displacement transducer (m. 5). The mould is made of PVC (150 mm in diameter at the peaks waves, 125 mm in diameter at the valleys, thickness 1 mm). The base length of the sample is approx. 250 mm. The volume of the sample is approx. 3.4 dm$^3$. It is not reusable but its price is low.

The base (m.1 fig. 1 and fig 2) is made of stainless steel. A centred drilled hole allows the fixation (m. 11 to 14, fig. 2) of an insert in order to realize an anchorage at the bottom end of the sample. This insert is made with a threaded rod (Ø 14 mm, 25 mm in length) axially tapped (M8). A M8 threaded rod (m. 12, fig.2) is screwed through the insert and tightened with a knurled nut (m. 14, fig. 2) pinching a gasket (m. 13, fig. 2). This M8 threaded rod is drilled with a 3.5 mm in diameter hole that allows passing a thermocouple through the base of the test rig (silicon elastomer avoids any leakage). A cylindrical shape of 120 mm in diameter allows the fixation of the neoprene mould.

During the preparation of the test rig, the upper surface of the base is greased (the insert is kept dry). The base comprises 3 housings receiving 3 columns (Ø 12 mm) made of invar alloy. They are placed at 120 ° around the base (on the figure 1 they seem to be opposite but it’s a schematic representation). These columns (m.2, fig. 1), threaded at one end (M10), are 430 mm in length. At the top of the columns, a platen (m. 3, fig. 1) supports a displacement transducer (m. 5, fig. 1). This sensor is a numeric one with a stroke of 12 mm. Its resolution is of 0.05 µm while its accuracy is of 1 µm over the whole range. The stroke must be long enough in order to stay in contact of the upper rod whatever the packing of the concrete is before the setting time, in the fresh state.
Mobile parts are constituted of a special platen (m. 7, fig. 1 and fig. 3) and a cover (m. 8, fig. 1 and fig. 3). During the mounting operations, this platen is maintained in relation with the columns by the mean of 3 cylindrical positioning rings fixed rigidly to the columns (not represented in the figures). The bottom end of the platen has a cylindrical shape (same diameter than the base) for fixing the top end of the neoprene mould. The thermocouple (m. 9, fig. 1) is maintained in the centre of the mould by the mean of 2 strands of a nylon yarn pinched between the neoprene mould and this cylindrical shape of the platen. A wide hole, in the upper platen, allows pouring of concrete. The edges of the hole are conical and the upper level of the concrete is set to the mid height of this conical shape. This conical surface is not greased to ensure like a gluing of the concrete on the steel. Three holes allow the columns to pass through the platen. The adjustment is large enough in order to avoid any wedging of the platen. After pouring, placing (with a needle) and levelling of fresh concrete, the cover (8), equipped with an O ring, is tightened with 3 bolts (the internal face of the cover is greased during the preparation of the rig). This cover is surmounted by a 10 mm in diameter axial rod (m. 4, fig. 1) the top of which is receiving the sensor tip. A valve (18, fig. 1, not drawn on fig. 3) is fixed to the cover (8) which allows the balance between external and internal pressure when the difference is greater than 5 kPa. Without this precaution, the measurement of the central displacement can be wrong.

After having tightened the cover, the test rig is placed inside the cylindrical tank (m 15 fig 1) which is filled with water till the mid height of the valve (18) and the 3 positioning rings are released. A cover with its gasket is set at the top of the tank to reduce the evaporation of the water (16 & 17, fig.1). Then, the sensors are connected. The length of the sample is measured at the end of the test after the removal of the mould. A circulator bath, used to keep constant the temperature of the water measured inside the tank, is switched on and the data acquisition can start. The sensors for each channel are the central displacement, the temperature of the sample with a thermocouple, the temperature of the surrounding water in the tank with a platinum probe and the temperature in the air above the cover of the tank, near the displacement transducer, with a platinum probe also. This circulator must be able to heat or cool the water bath. At the end of the test, temperature steps of 1 or 2 °C around the constant temperature of the test are imposed in order to estimate the thermal coefficient of expansion of the concrete. The effects of the temperature changes on the test rig must be taken into account so a characterization of these effects must be carried out before using the rig for concrete.

When measurements are completed, one or two weeks (longer tests can be achieved with more classical methods) after casting, the autogenous deformations $\Delta \varepsilon_t$ at the age $t$, can be
estimated according to Bentur [6], quoting the J.C.I. definitions. These deformations include a thermal part ($\Delta e_0$) and cumulated shrinkage and swelling deformations ($\Delta e_e$):

$$\Delta e_t = \Delta e_e + \alpha_0 \Delta \theta_0$$  \hspace{1cm} (1)

Where:

- $\alpha_0$: CTE of the concrete sample ($\alpha_{0b}$) or the stainless steel rod ($\alpha_{0i}$) used for the thermal characterization of the test rig. Conventionally, $\alpha_{0b}$ is considered, according to Laplante et al. [7], constant since the setting time and equal to the one determined at the end of the test.

- $\Delta \theta_0$: Temperature variation of the samples between $t$ and $t_0$, $t_0$ being the setting time. All the increments in this expression are due to differences between these two ages.

The user chooses whether he wants to express the results with or without the thermal part, knowing that this part is almost negligible when the temperature is kept constant into the tank.

After having recorded the displacement of the head of the sample, the measurements include a part due to the influence of the temperature variations on the rig itself inside the tank (in the case of temperature variations at the end of the test or if realistic temperature histories are applied) and a little part due to the influence of the temperature of the room on the displacement transducer located above the cover of the tank. This location has been chosen because the air temperature is influenced there, near the displacement transducer, not only by the temperature of the room but also by the temperature of the water of the tank when temperature changes are imposed. These temperature changes are seen by the displacement transducer whose temperature sensitivity is, however, small (around 0.5 µm/°C).

The corresponding analytical relation between these parameters is:

$$\Delta e_e + \alpha_{0b} \Delta \theta_0 = (C_{\theta e c} \Delta \theta_{ec} + C_{\theta sc} \Delta \theta_{sc} - \Delta l_m) / L_0$$  \hspace{1cm} (2)

With:

- $L_0$: Base length measured at the end of the test. See fig. 1.
- $C_{\theta e c}$: Thermal coefficient giving the sensitivity of the displacement to temperature changes in the water of the tank.
- $\Delta \theta_{ec}$: Temperature variations of the water inside the tank between $t$ and $t_0$.
- $C_{\theta sc}$: Thermal coefficient giving the sensitivity of the displacement due to temperature changes above the cover of the tank near the displacement transducer.
- $\Delta \theta_{sc}$: Temperature variation of the air measured above the cover of the tank between $t$ and $t_0$.
- $\Delta l_m$: Displacement measured between $t$ and $t_0$. By convention, the sign is positive when the probe tip goes out of the transducer.

Thermal coefficients are obtained by replacing the concrete sample by a stainless steel rod (240 mm in length, 14 mm in diameter, CTE = 10.5 ± 0.4 µdef/°C) whose coefficient of thermal expansion is known. By measuring the temperature, the deformation can be calculated. $C_{\theta e c}$ is obtained with a room temperature constant and steps of temperature imposed to the water inside the tank. $C_{\theta sc}$ is determined with a constant temperature of the water inside the tank and steps of temperature imposed to the air of the room.
Assuming that the CTE of the concrete is known and if it is chosen to remove the thermal part of the concrete deformation, equation (2) becomes:

$$\Delta \varepsilon_e = \left( C_{\text{ec}} \Delta \theta_{\text{ec}} + C_{\text{sc}} \Delta \theta_{\text{sc}} - \Delta \varepsilon_m \right) / L_0 - \alpha_{0b} \Delta \theta_0$$

(3)

In that case, \( \alpha_{0b} \) must be determined. The temperature steps applied at the end of the test produce deformation steps which can be completely removed, applying the equation (3), when the value of the CTE is adjusted at the right value. It’s the method used for this purpose.

The setting time, \( t_0 \), must be obtained by other means. This point is discussed after having presented the performances of the test rig.

3. **PERFORMANCES OF THE TEST RIG AND THE PROTOCOL**

3.1 **Uncertainty of the test rig and the protocol**

These experimental setup and protocol have been developed to transform the whole concept in something proposed for sale. Among the different necessary verifications involved in the development, a metrological study has been done. The estimations of the enlarged uncertainties (coefficient of enlargement equal to 2) related to equations (2) and (3) are equal to 6 and 8 \( \mu \)strains respectively. These estimations were done with the elementary uncertainties given in the table 1. Moreover, during this development, it was possible to check every single detail of the hardware and the protocol.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Name ( u_i )</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water temperature</td>
<td>( \theta_{\text{ec}} )</td>
<td>0.10 °C</td>
</tr>
<tr>
<td>Air temperature</td>
<td>( \theta_{\text{sc}} )</td>
<td>0.10 °C</td>
</tr>
<tr>
<td>Displacement</td>
<td>( \varepsilon_m )</td>
<td>0.05 µm</td>
</tr>
<tr>
<td>CTE stainless steel rod</td>
<td>( \alpha_{0i} )</td>
<td>0.4 ( \mu \text{def}/°C )</td>
</tr>
<tr>
<td>Base length</td>
<td>( L_0 )</td>
<td>0.00034 m</td>
</tr>
<tr>
<td>Concrete Temperature</td>
<td>( \theta_0 )</td>
<td>0.11 °C</td>
</tr>
<tr>
<td>Concrete CTE</td>
<td>( \alpha_{0b} )</td>
<td>0.5 ( \mu \text{def}/°C )</td>
</tr>
</tbody>
</table>

3.2 **Repeatability tests on a first material**

The first tests were carried out at a constant temperature of 20 °C. Four samples with the same mix design were tested successively. For each sample, the autogenous shrinkage was recorded during two weeks. The aims of these tests bore on the repeatability and the search of a method in order to initialize the deformations.

The table 2 gives the mix proportions of this first material. This concrete was designed for field application (precast concrete slab anchoring). The w/c ratio was 0.37. Before casting, the cement and the aggregates are mixed during 1 mn before adding the water and the plasticizer after which the blend is mixed during 2.5 mn. The slump is 21 cm. Two layers of the fresh concrete are then placed inside the moulds and vibrated respectively 5 and 8 seconds. The 28 days compression strength is 75 MPa.
Table 2: Mix proportions of the concrete (kg/m³).

<table>
<thead>
<tr>
<th>Component</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand 0/4 / Crushed limestone</td>
<td>920</td>
</tr>
<tr>
<td>Gravel 4/10 / Crushed limestone</td>
<td>280</td>
</tr>
<tr>
<td>Gravel 10/20 / Crushed limestone</td>
<td>560</td>
</tr>
<tr>
<td>Cement CEM III</td>
<td>490</td>
</tr>
<tr>
<td>Water added</td>
<td>175</td>
</tr>
<tr>
<td>Super plasticizer Optima 100 (in solution)</td>
<td>6.5*</td>
</tr>
</tbody>
</table>

* Dry extract: 1.95 + water: 4.55.

The measurements started respectively at an age of 1 h 18mn, 1 h 55 mn, 1 h 50 mn and 1 h 42 mn after the addition of the water. The recorded temperatures in the centre of the sample are given by the figure 4. It shows a temperature rise of about 0.5 °C. Before plotting the strains, the thermal strains are removed assuming a constant coefficient of thermal dilation. This correction is minor. The figure 4 gives the evolution of the strains recorded by the new test rig initialized at the age of the beginning of the measurements. This diagram shows that the strains are very different in the first 24 hours. The curves become quite parallel after an age that is not yet determined but it underlines, once again, the necessity, as mentioned by Aïtcin [1], of recordings at very early ages. Indeed, between the setting time and one day, the elastic properties increase sharply while autogenous deformation amplitudes are greater than ever.

According to Weiss [8], the setting time, $t_0$, is really the time when elastic properties start to increase. At this moment, stresses can appear if existing strains are restrained. For our application, a remaining question is how determining $t_0$ to initialize the measurements?
3.3 Strain initialization with the observation of the strain rate or the swelling

On cement pastes, volumetric measurements obtained by hydrostatic weighing indicate clearly a sudden change in slope of the strain/age curve called “suspension-solid transition” (Barcelo et al. [9]). Is this transition so obvious on concretes?

The curves of the figure 5 represent the derivatives of the figure 4 curves. For this concrete it can be observed that the strain rates are very different before an age of approx. 15 h corresponding to the dormant period. The test rig was not designed to give reliable measurements in this period. More precisely, strain rates become positives (zoom fig. 5) for the samples at an age comprised between 15.5 and 17.5 h. In other words, a swelling starts at these points (15.5, 15.75, 16, and 17.5 h at ± 0.25 h). Nevertheless, on the zoom, no special event can be observed on the strain rate curves.

The swelling can be considered as a good indication of the setting. Indeed when a continuous path of hydrates is formed, movements are restrained, the consumption of water is still continuing due to the chemical reactions. Just after this point, the bled water starts to be absorbed inside the concrete. The self desiccation does not start because this water is filling continuously the matrix porosity and, on the contrary, the apparent volume of the solids increases. When no more bled water is absorbed, the self desiccation can appear and the strain rate becomes negative (between 26 and 29 hours on the figure 5). The apparent volume starts to decrease. Between the setting time and the beginning of the shrinkage, there is approx. 15 hours during which elastic properties increase sharply while the porosity is permanently saturated with water. Coupled models should take such a scenario into account.

A swelling appears for this concrete but it is not systematically the case for other concretes. So, even if the beginning of the swelling seems to be well correlated to the t₀, it cannot be generally used for the determination of t₀ on concretes. The concrete under investigation here is a material for which the examination of the strain rate at early age cannot be used to detect the setting time. So this parameter, even if it is a good indicator for cement pastes [9], or may be mortars [10], cannot be systematically used for the determination of t₀ on concretes.

3.4 Global uncertainty for this first material used in BTJADE.

Initialized at the beginning of the swelling, the four recordings (figure 6) become much closer than the curves given by the figure 4.

For each age, the standard deviation (SD) can be computed. An interval is given on the figure 6 which is calculated at ± 2 SD around the mean value of the 4 strains measurements. Knowing the global uncertainty and the measurements uncertainty, it is possible to obtain an estimation of the uncertainty attached to the material itself (figure 5). The value rises up to 8 µm/m at the beginning of the test, when the swelling takes place, and decreases progressively down to 4 µm/m in the second part of the test. Generally, when uncertainty estimations are done, the maximum value is retained. In conclusion, the uncertainty of the measurement can be estimated at 4 µm/m and it is estimated to 8 µm/m for the first material tested with this test rig.

The sensitivity to the initialisation time has also been analysed. In order to do so, the standard deviation is calculated at 10 days when the initialization time is adjusted between the age of the first measurement and 30 hours. Better and stable results are observed after 15 hours. One can quote that this result is well correlated with a t₀ fixed at the beginning of the swelling. It does not mean that this parameter could be adopted for the determination of t₀. It underlines the fact that strain measurements, prior to the setting time, are scattered with this
type of equipment, inside which the axial strains are governed by the lateral stiffness of the mould. Conversely, strains are well grouped when the concrete starts to stiffen and when deformations can be considered isotropic after the setting time. The stiffness of the mould is very low and negligible as soon as the concrete starts to stiffen.

Figure 6: Strains initialized at the beginning of the swelling (fine lines). The coarse lines give the limits of a ± 2 standard deviations interval.

Figure 7: Uncertainty on the autogenous shrinkage for the 4 batches. It is calculated knowing the uncertainty on the measurement and the global uncertainty.

4. STRAIN INITIALIZATION: OTHER PARAMETERS

4.1 Temperature analysis

Are there particular events on temperature recorded in the centre of the samples? The figure 8 shows that the temperature recordings of the 4 samples are superimposed. After an initial period, during which an equilibrium is reached between the initial temperature of the fresh concrete and the constant temperature imposed in the tank, a temperature rise occurs at about 4 hours. This age marks an acceleration of the hydration process. After this particular event, the temperature increases at an almost constant speed and reaches a plateau at about 15 to 16 hours. It marks a deceleration probably due to a change in the regimen of the hydration process. It passes from a dilution/precipitation process to a diffusion process [11]. For this concrete, this deceleration corresponds to the beginning of the swelling and the setting. This event could be a sign of the setting. For other concretes, shapes of temperature recordings are not similar to this one. It is difficult to draw general rules about the events on this type of curve. A question remains: is this rupture of slope a significant event? Further investigations must be carried out because temperature measurements are more related to chemical reactions than to mechanical evolutions.
Figure 8: Temperature in the middle of the 4 specimens made of the first material. Of this study.

Figure 9: E-modulus monitoring of another material, compared to the ultrasonic pulse velocity of P-waves.

4.2 Mechanical investigations: ultrasonic and cyclic loading testing

Mechanical methods are better candidates to give a reliable estimation of the setting time if results have to be used for stress field calculations of structures. In parallel to the development of the test rig for autogenous deformation measurements, ultrasonic measurements and cyclic loadings were tested. These methods were not applied on the previous material but on a different concrete whose mix proportions are given in table 3. Results obtained with these mechanical techniques are illustrated by the figure 9.

Table 3: Mix proportions of the second concrete.

<table>
<thead>
<tr>
<th>Components</th>
<th>Mass (kg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEMI 52.5 N PMES CP2</td>
<td>340</td>
</tr>
<tr>
<td>Sand (Bernières 0/4)</td>
<td>739</td>
</tr>
<tr>
<td>Gravel (Bernières 8/22)</td>
<td>1072</td>
</tr>
<tr>
<td>Total water</td>
<td>184</td>
</tr>
</tbody>
</table>

Ultrasonic measurements are used for early age monitoring of the setting ([12], [13], [14], [15], [16] and [17]). Ultrasonic pulse velocities of p or s-waves. (UPV) increases with the age and the curves have an S shape. Correlations can be found between events on the UPV monitoring curves and the setting time. N. Robeyst [16], working with p-waves, found that the conventional initial setting correspond to the inflexion point of this curve. The final setting (approximately when the first rigid path appears) is dated when the amplitude of the derivative of this curve decreases to 80% of the value reached at the time of the inflexion point. In the dormant period, the UPV is low compared to coarse estimations of the celerity.
obtained by homogenisation. Homogenisation gives a value approx. equal to 1300 m/s while UPV indicates values of about 300 m/s. These ultrasonic results (fig. 9) were obtained on a concrete with air trapped. In the case of a cure under vacuum during 30 mn just after casting [13], the results are closer to this estimation. Just after the setting time, in the case of cured or non cured concretes, the question remains to know whether the air trapped has still an influence on the celerity measurement or not. Always according to [13], ultrasonic measurements allow a calculation of the Young’s modulus and the Poisson ratio of the concrete if the UPV of p-waves and s-waves and the concrete density are known.

In order to get a set of data concerning the relation between UPV measurements and concrete E-modulus and Poisson ratio evolutions at early age, especially around the setting time, a study of samples loaded at regular interval has been performed [18]. The sample is cast inside a stainless steel mould and maintained at a constant temperature by a circulation of water around the mould. The effect of the confinement is taken into account by a numeric computation. A typical result, obtained on the concrete 2, is shown in the figure 9. The E-modulus evolution, compared to UPV measurement indicate a setting time, according to the Robeyst criterions, dated when the UPV rises above approx. 2800 m/s corresponding to an E-modulus of about 3 GPa. For such an E-modulus, concrete samples are just stiff enough to be handled without breaking the sample, indicating a practical limit for the setting time.

5. CONCLUSIONS

A test rig for the monitoring of the autogenous shrinkage of a concrete has been described. The test protocol is given together with the way the measurements are analysed.

The uncertainty of the test setup is given and an example of the repeatability on a concrete is observed.

The initialization of the strain at the setting time is discussed. Swelling, strain rate, temperature, UPV and cyclic loadings are examined. All these parameters can be used for the $t_0$ determination on concretes except the strain rate which doesn’t show any special event at the setting time of the concrete of this study. Temperature indications are related to the setting time but more experiments are needed to draw general rules.

ACKNOWLEDGEMENTS

The development of this test rig associated with the method has been done with the contribution of the development team of the CECP Rouen: N. Marty, G. Reverdy, F. Souday, K. Rousselle. The metrological qualification was supported by the metrology department of the IFSTTAR (A. Ghazi) and the LR Clermont-Ferrand (P. Dantec, P. Chagneau). Special thanks are addressed to the successive students who worked on the different tests: M Moroni and F. Meloni from the University of Cagliari (Erasmus program), Italy and B. Fourar from the University Paris XIII, Department of the materials sciences.

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