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MINISTERIO DE MEDIO AMBIENTE Y MEDIO RURAL Y MARINO

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Alkali Aggregate Reaction – How long before it stops?

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ZARAGOZA

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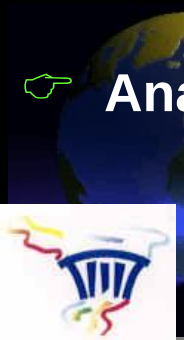
II International Congress on Dam Maintenance and Rehabilitation

THEME (III)- INVITED LECTURE 1

- Research seeking for a procedure [Method of Test] that indicates the time span the Reaction comes to and end
- Tests on Drilled Cores from Structures with AAR evidences
- Different maturity conditions to accelerate the Reaction
- Analysis and Interpretation of the measurements.



DISCUSSIONS CONCERNING A METHOD OF TEST TO EVALUATE THE TIME PERIOD TO FINALIZE THE AAR

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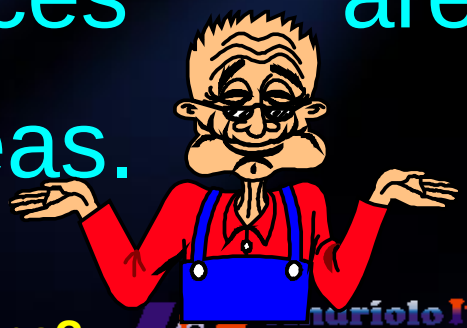
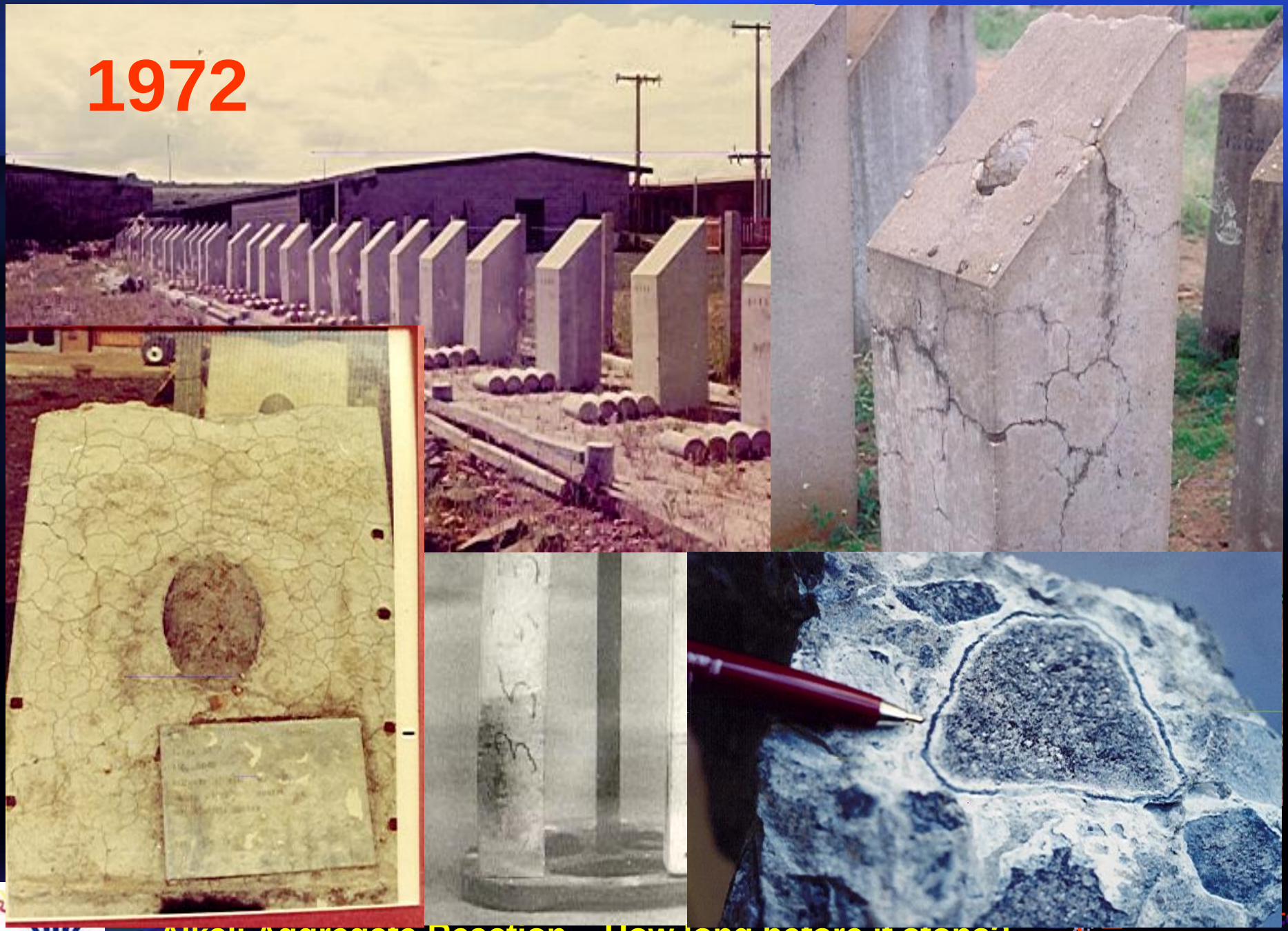
Alkali Aggregate Reaction

The effect of Alkali Aggregate Reaction (AAR) has been reported and studied extensively during the last 40 or 50 years, and although the effects can be conspicuously damaging in a concrete structure, the occurrences are concentrated in certain local areas.

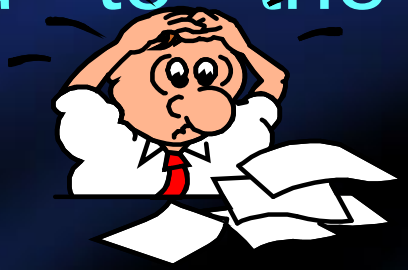




Alkali Aggregate Reaction – How long before it stops?

PRESENTATION - PROPOSAL

¿ What can we do when an AAR expansion is observed in a Concrete Structure, related to the Maintenance Period of Time?



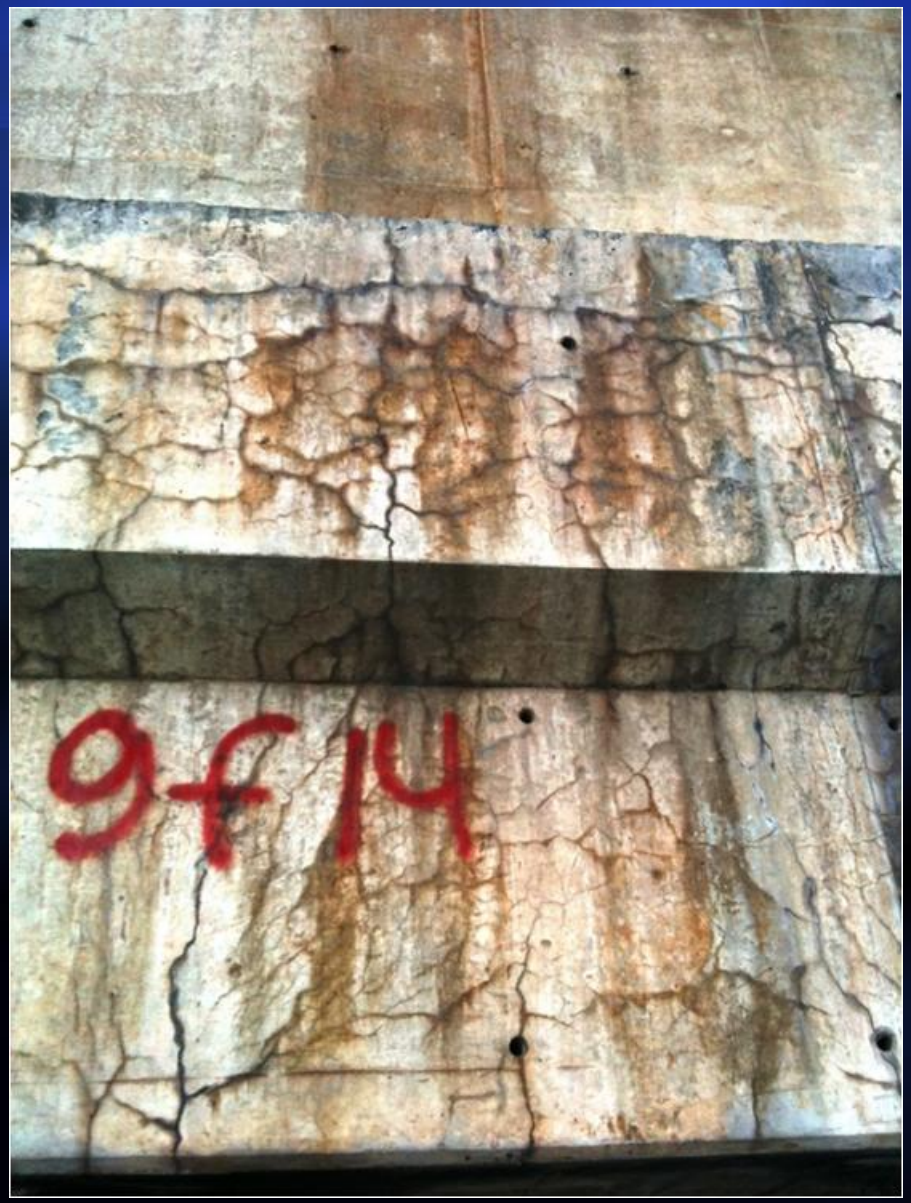
¿ When does the AAR expansion end?

¿ Or can it be “less dangerous” to the Structure Performance?

The main purpose was:

- To look for a procedure (Method of Test) to show in a "quite precise" range, the time that remain to the AAReaction end, after knowing that the phenomena has installed in the Concrete Structure !

PHENOMENA



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Engenharia

METHODOLOGY

The procedures employed in the ongoing tests presented herein are not based on standardized norms or existing codes.

Because of this, they are inserted in the context of the type of ***Service Simulation*** to simulate potential conditions that permit to, based on statistical and mathematical grounds, estimate with a certain degree of confidence, the potential expansion of existing structural concrete elements.

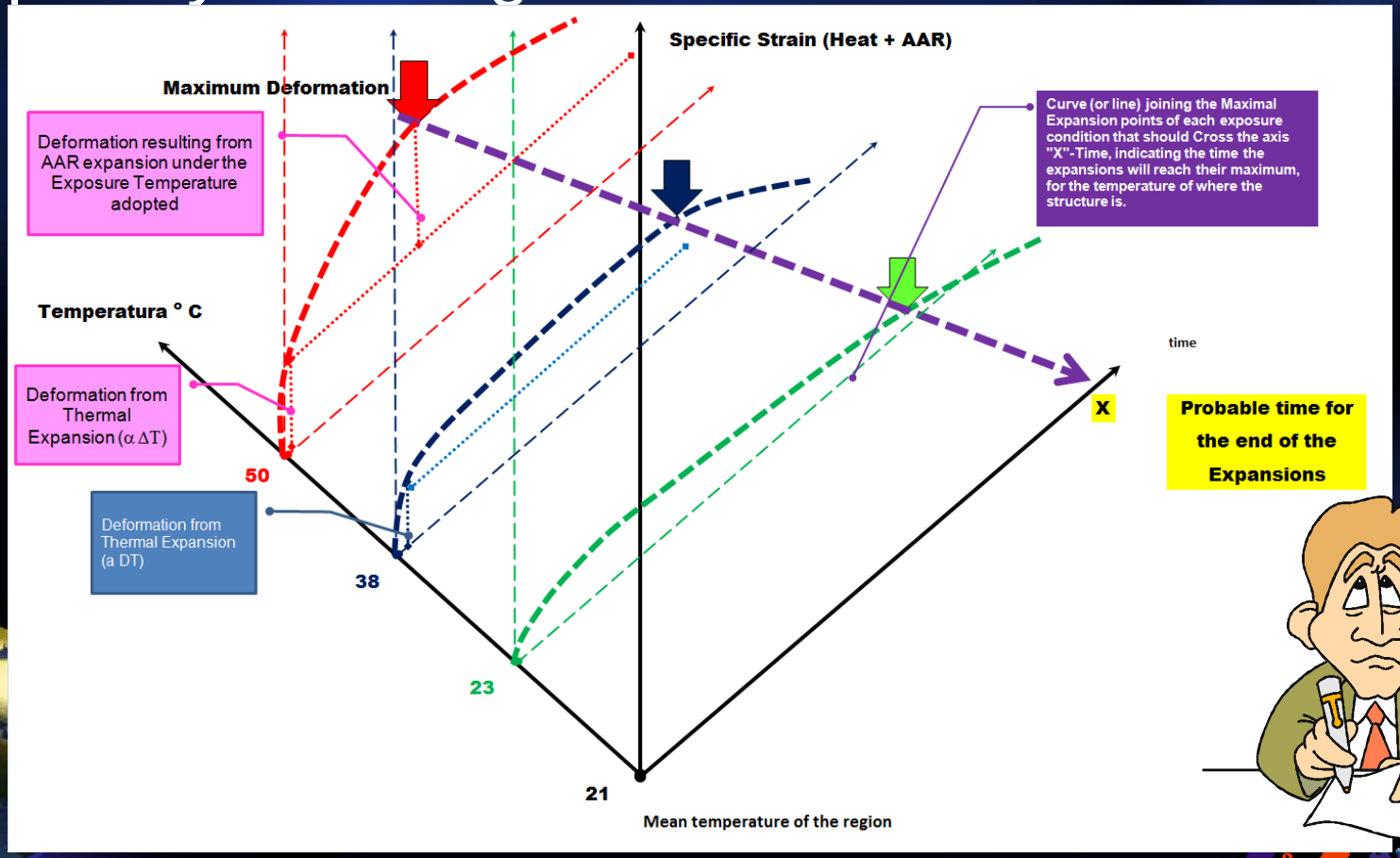
Given the novelty of the tests (little similarity at global level, and uniqueness in Brazil), it is to be expected that adjustments and/or adaptations be made during the course of testing, and;

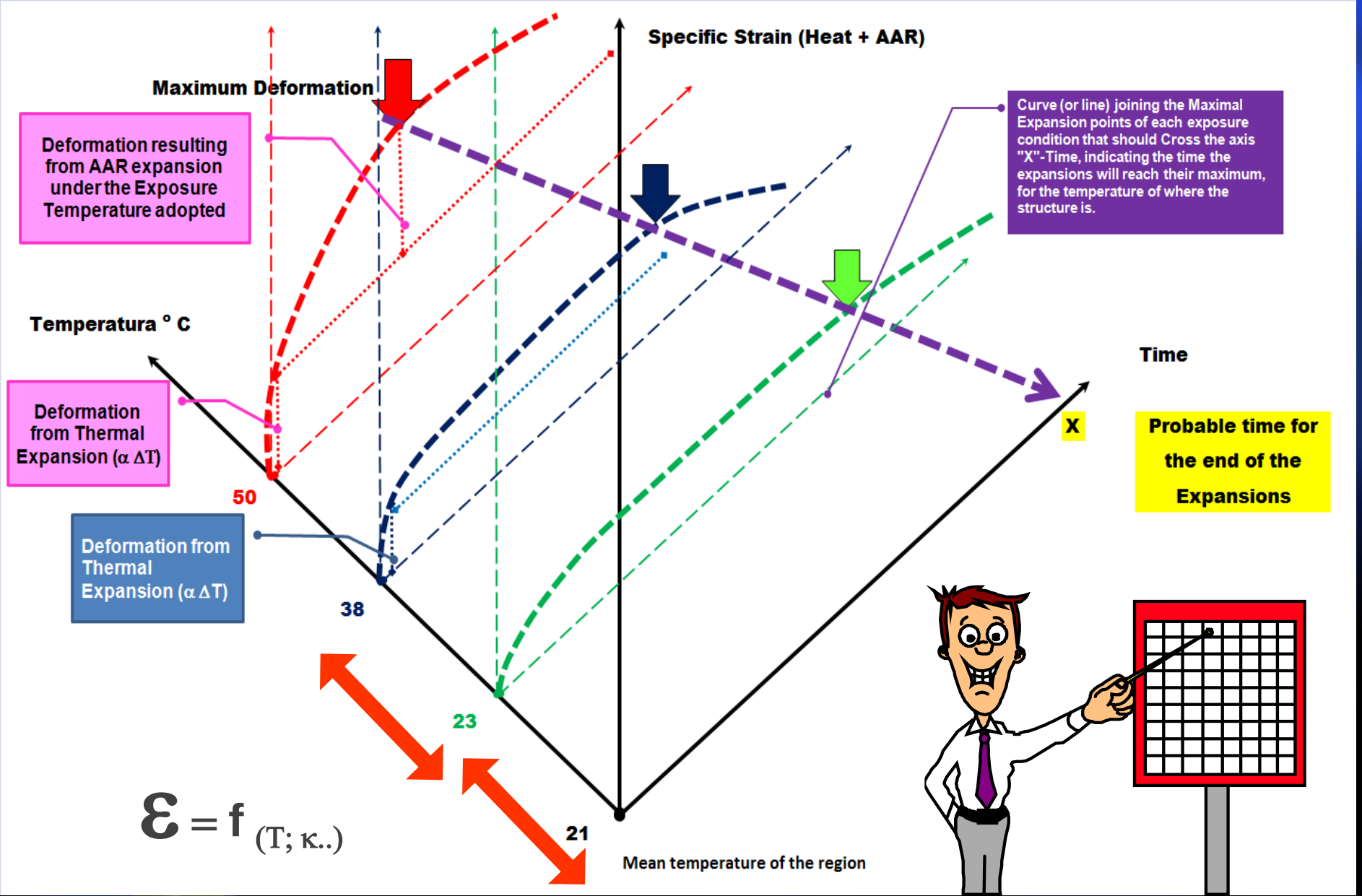
The main goal here is to obtain, based on expansion accelerated tests, an estimate of the time necessary for expansion to cease under natural environmental conditions in which the structures are placed.

For this, concrete cores, drilled from the structure, and after being exposed at different temperatures and subsequently, the regression concept applied in order to analyze the observed results.

The expansion readings be taken continuously and observations made until the readings are proven to be statistically stable.

To this end, the maximum expansions measured for each exposure temperature will be selected assuming higher values than predicted will not be measured during the exposure period as shown conceptually in the figure.





The technical advice resulting from previous experiences (***Kevin J. Folliard and Michael D.A. Thomas***) led us to consider a trial period of approximately one year.

However, due to the novelty of these tests, it is prudent that the tests be conducted for a longer period (a year and a half to two years) or until the strain readings were stable (observed from the asymptotic trend)

INSPECTION AND DRILLED CORES

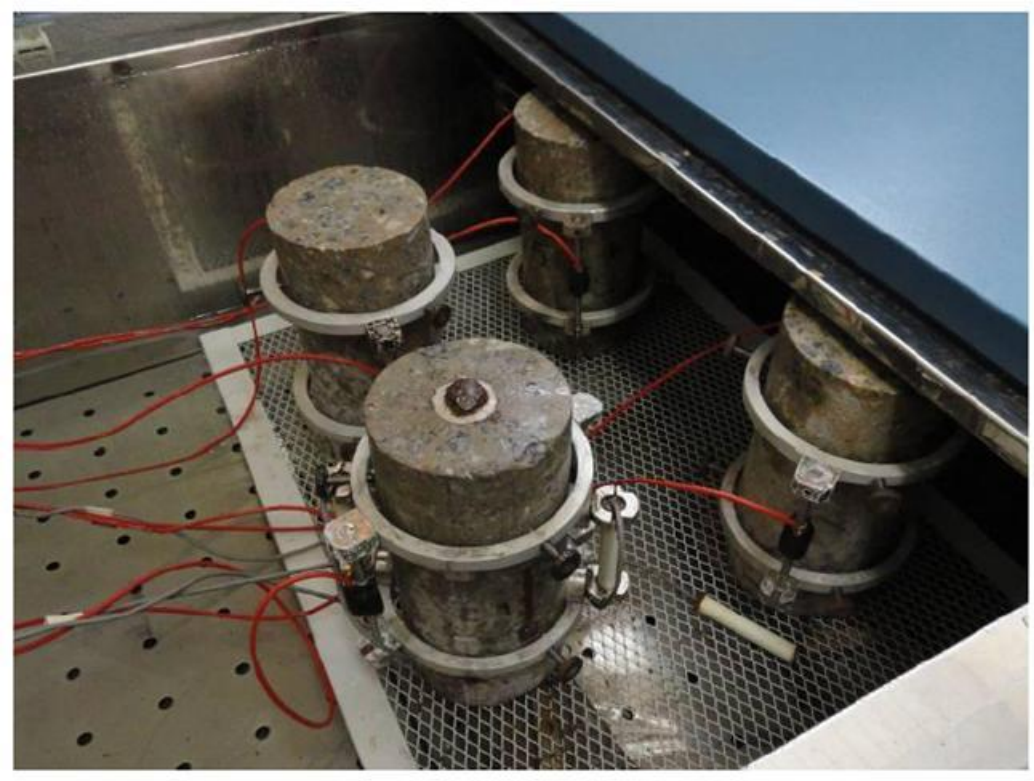
Cores drilled randomly from the structures

EQIPMENTS & APPARATUS


1239.4
Volta Readout
scroll
μ Sec
Digit
Temp
με 4000
με 4200
Other Strain Gauges
enter
SISGEO
MILANO - ITALY

(a) (b) (c)

TESTS

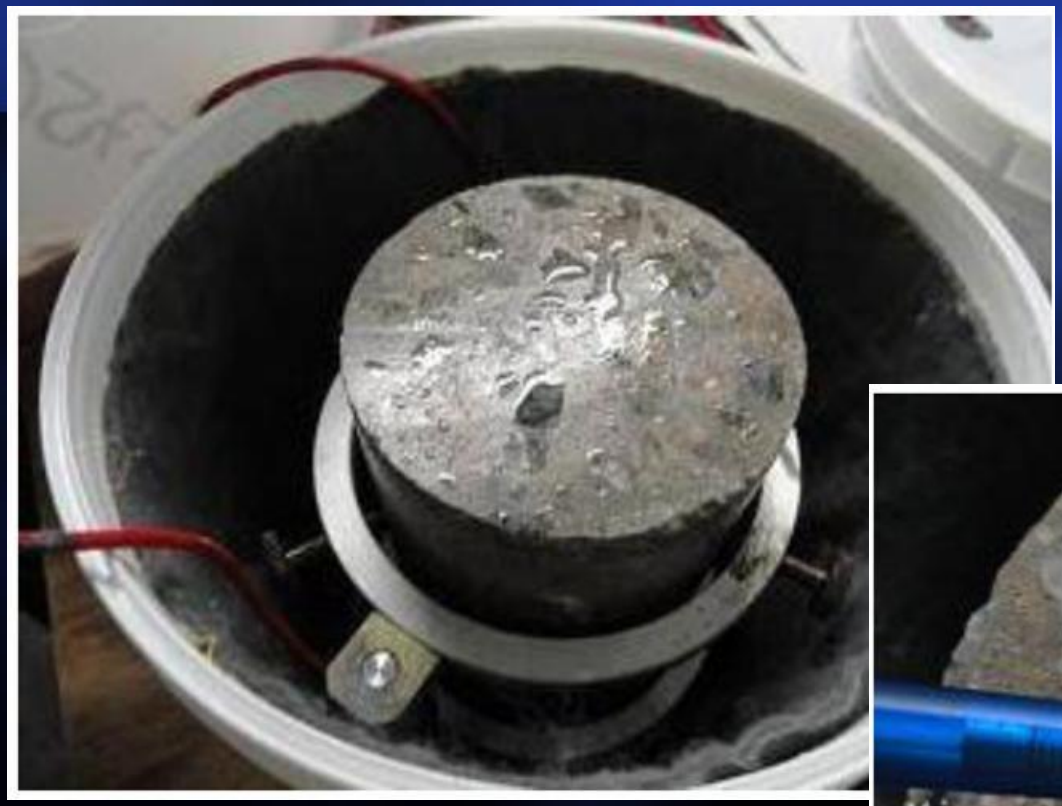


TESTS

(a)

(b)

OBSERVATIONS



OBSERVATIONS

OBSERVATIONS

OBSERVATIONS

OBSERVATIONS

OBSERVATIONS

OBSERVATIONS

OBSERVATIONS DURING THE TESTS

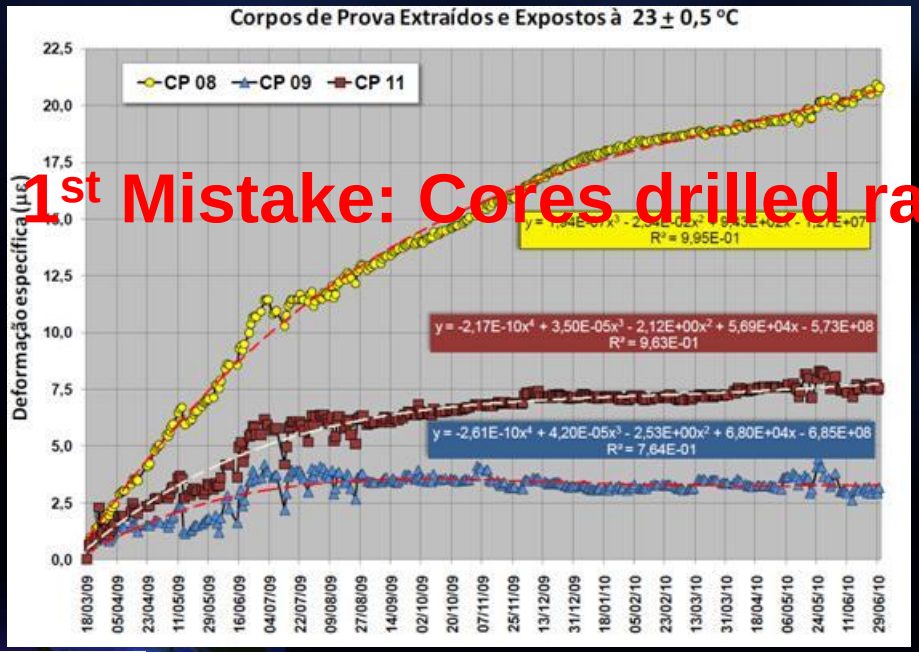
Figures show the formation of “gel” from Alkali-Aggregate Reaction on the surface (prepared after extraction) of the specimens.

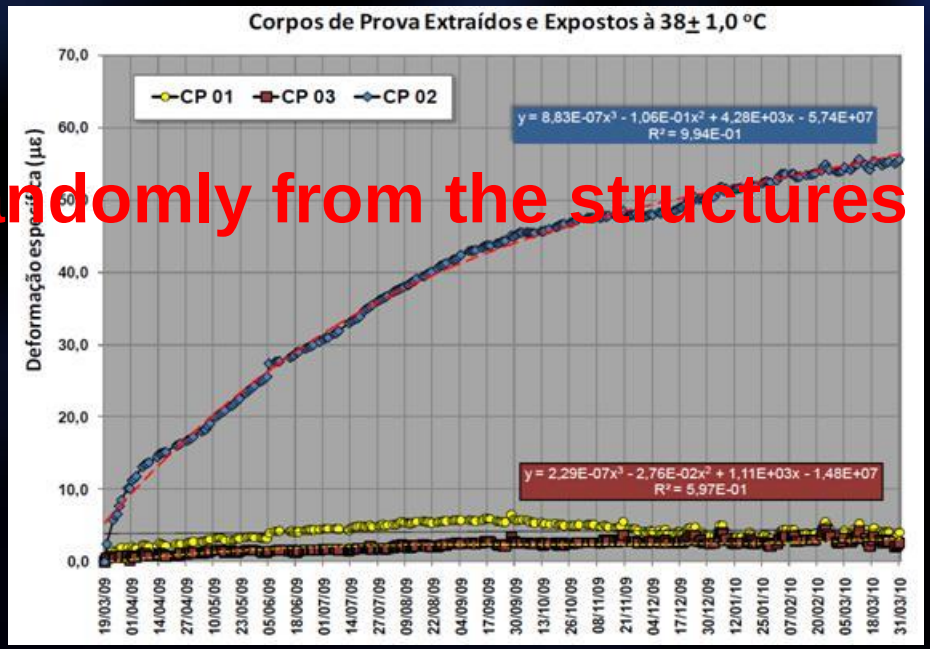
The formation gel observed in specimens exposed to three exposure conditions, especially at 23 ^{o}C and 38 ^{o}C points to the fact that the reactions were still going on, since the gel was being expelled.

ACTUAL RESULTS

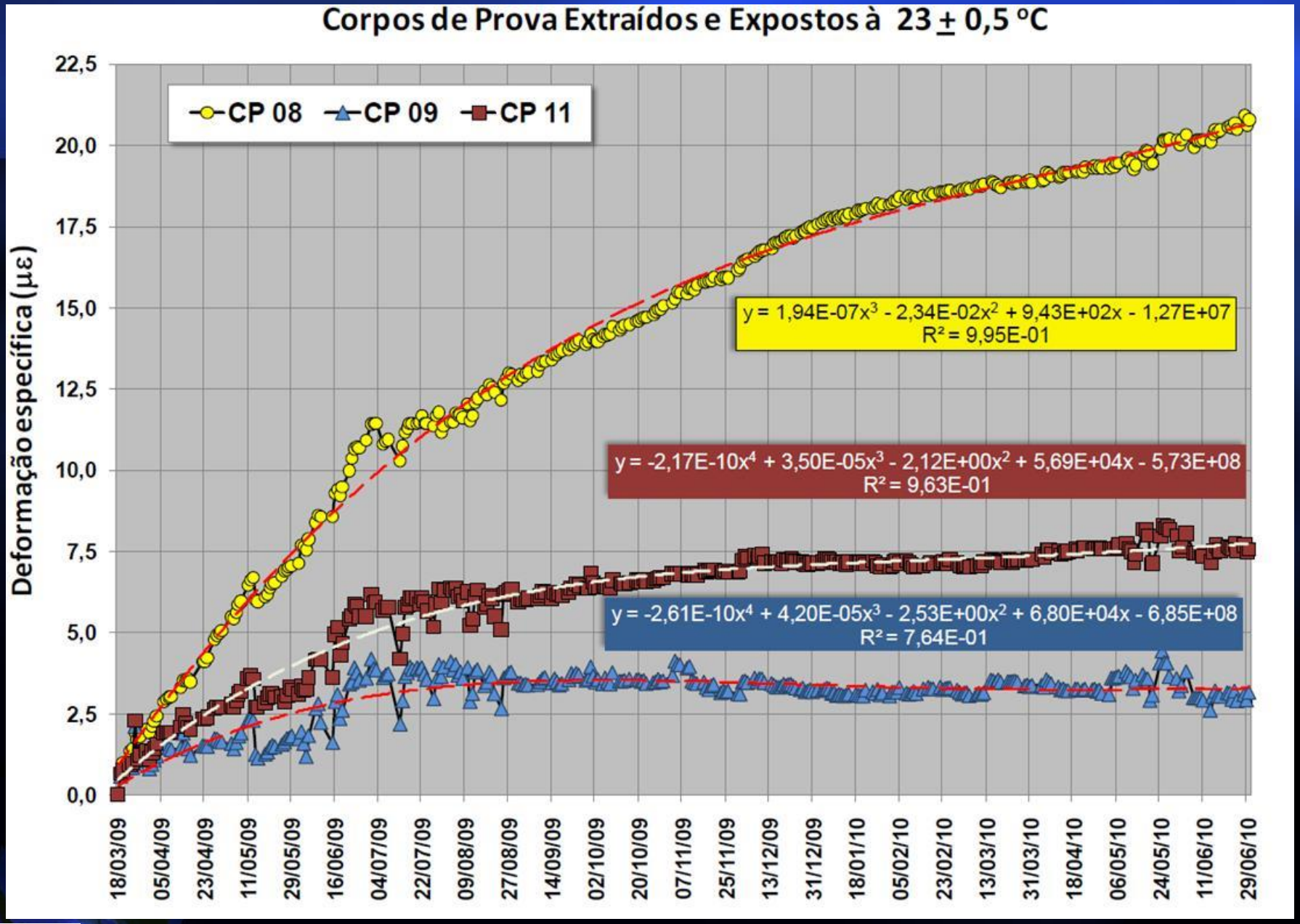
The graphs indicate:

- The specimens tested at temperatures of 23 °C and 38 °C were observed to present consistent deformations over time,
- Thus enabling the inclusion of trend curves which permit us to obtain numerical estimates of the specimen expansion





1st Mistake: Cores drilled randomly from the structures


Corpos de Prova Extraídos e Expostos à 23 ± 0,5 °C
CP 08
CP 09
CP 11
Deformação específica (με)
22,5
20,0
17,5
15,0
12,5
10,0
7,5
5,0
2,5
0,0
y = 1,94E-07x³ - 2,34E-02x² + 9,43E+02x - 1,27E+07
R² = 9,95E-01
y = -2,17E-10x⁴ + 3,50E-05x³ - 2,12E+00x² + 5,69E+04x - 5,73E+08
R² = 9,63E-01
y = -2,61E-10x⁴ + 4,20E-05x³ - 2,53E+00x² + 6,80E+04x - 6,85E+08
R² = 7,64E-01
18/03/09
05/04/09
23/04/09
11/05/09
29/05/09
16/06/09
04/07/09
22/07/09
09/08/09
27/08/09
14/09/09
02/10/09
20/10/09
07/11/09
25/11/09
13/12/09
31/12/09
18/01/10
05/02/10
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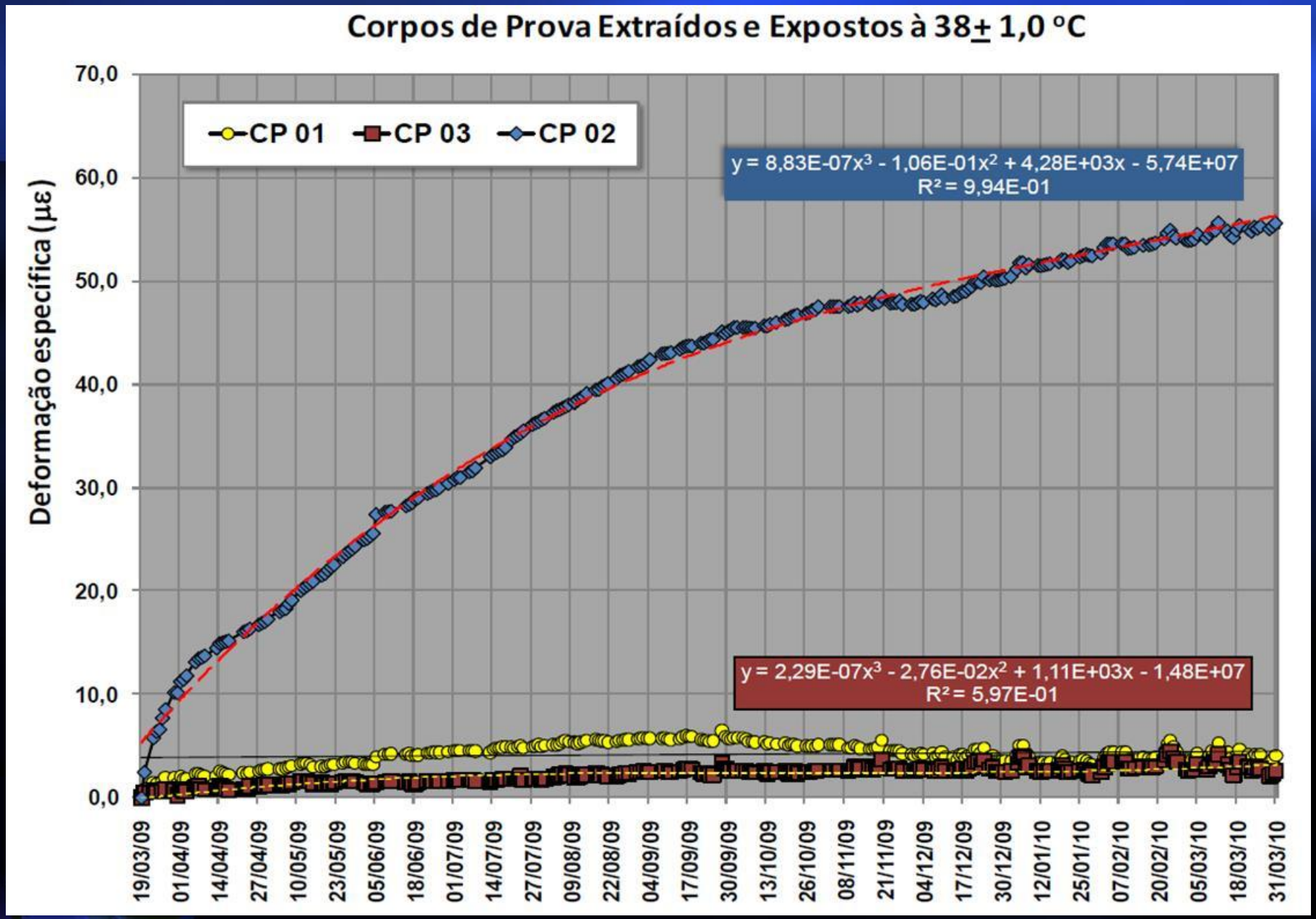
06/05/10
24/05/10
11/06/10
29/06/10

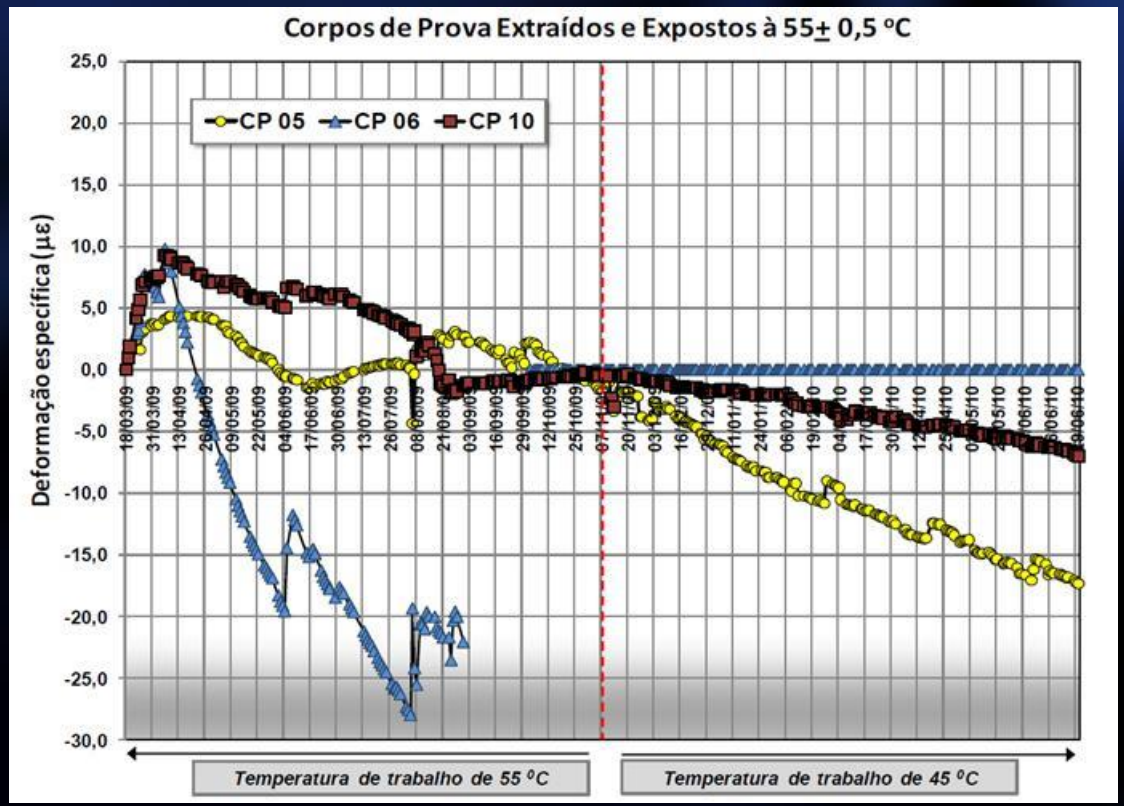

Corpos de Prova Extraídos e Expostos à 38± 1,0 °C
Deformação específica (με)
70,0
60,0
50,0
40,0
30,0
20,0
10,0
0,0
CP 01
CP 03
CP 02
y = 8,83E-07x³ - 1,06E-01x² + 4,28E+03x - 5,74E+07
R² = 9,94E-01
y = 2,29E-07x³ - 2,76E-02x² + 1,11E+03x - 1,48E+07
R² = 5,97E-01
19/03/09
01/04/09
14/04/09
27/04/09
10/05/09
23/05/09
05/06/09
18/06/09
01/07/09
14/07/09
27/07/09
09/08/09
22/08/09
04/09/09
17/09/09
30/09/09
13/10/09
26/10/09
08/11/09
21/11/09
04/12/09
17/12/09
30/12/09
12/01/10
25/01/10
07/02/10
20/02/10
05/03/10
18/03/10
31/03/10

- The samples at 55 °C were initially stored in a thermal chamber with the humidity and temperature conditions maitained using a water bath.

- Due to the problems presented for the test proposed at 55 °C, a different working temperature of 45 °C was adopted in the thermal chamber.

2nd Mistake:

At 55ºC the gages were damaged



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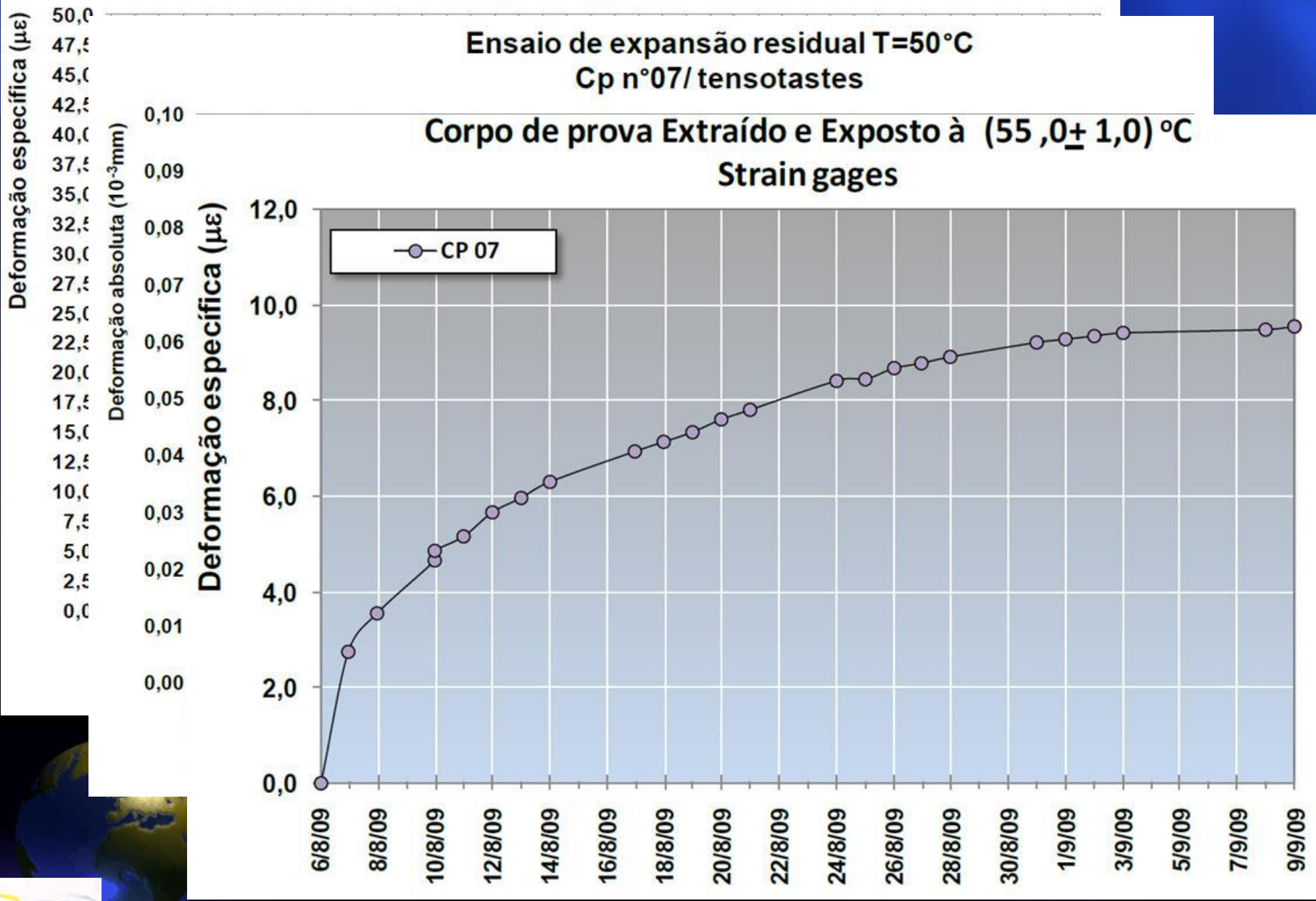
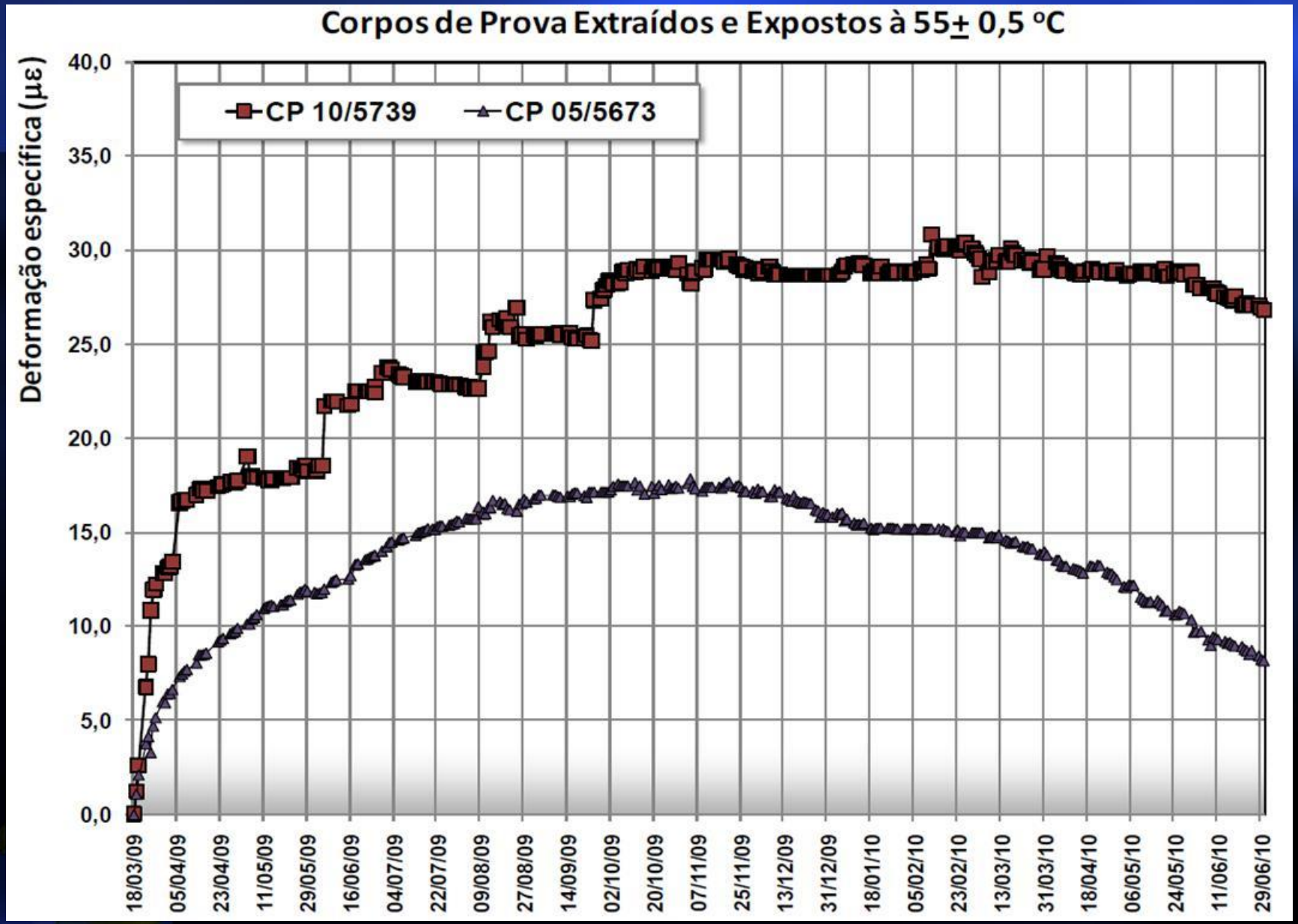
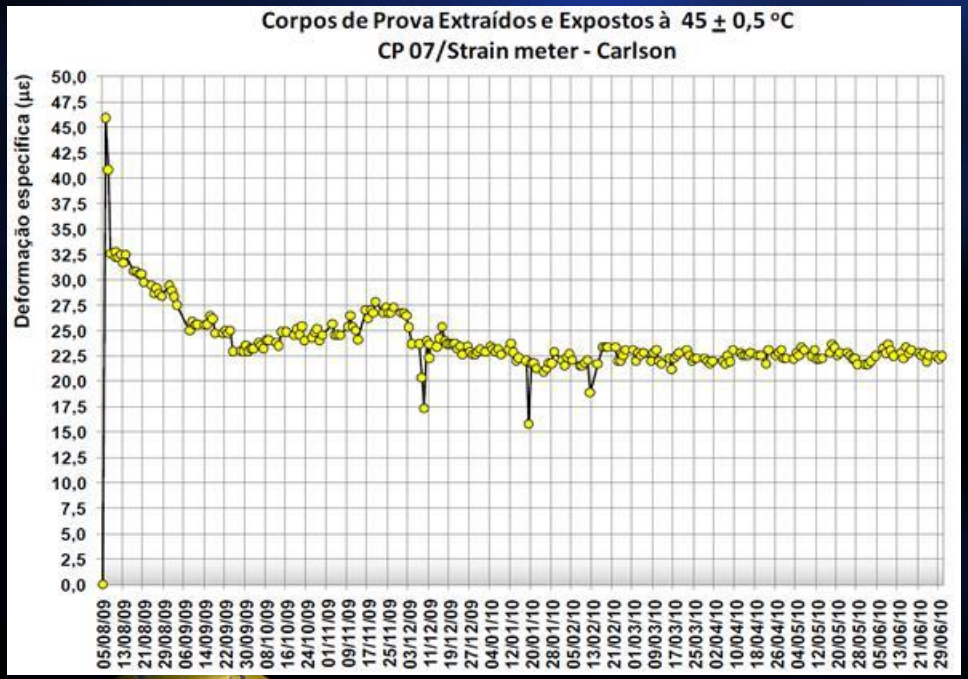
Corpos de Prova Extraídos e Expostos à 45 ± 0,5 °C
CP 07/Strain meter - Carlson

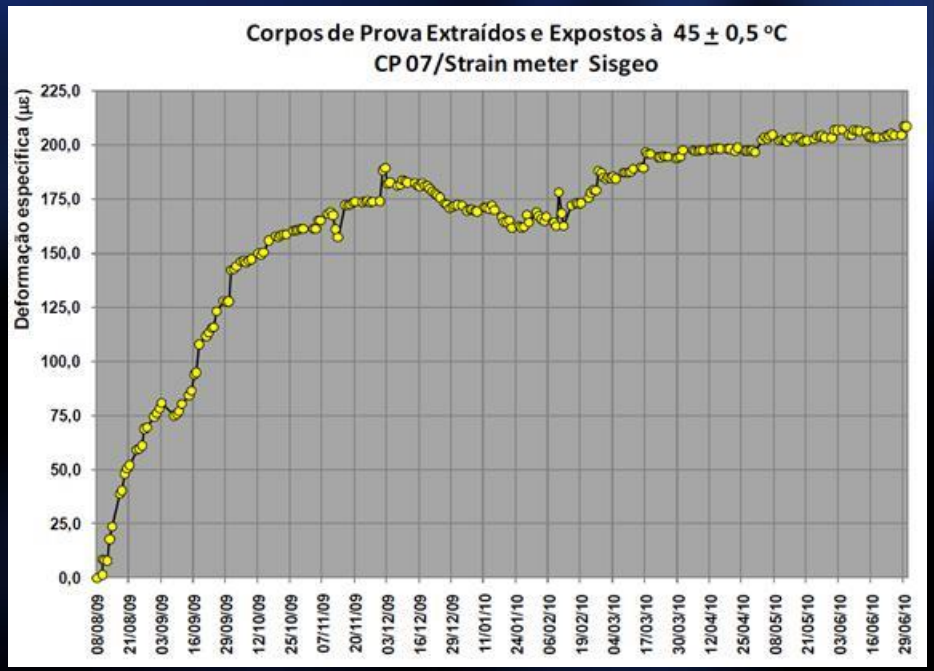


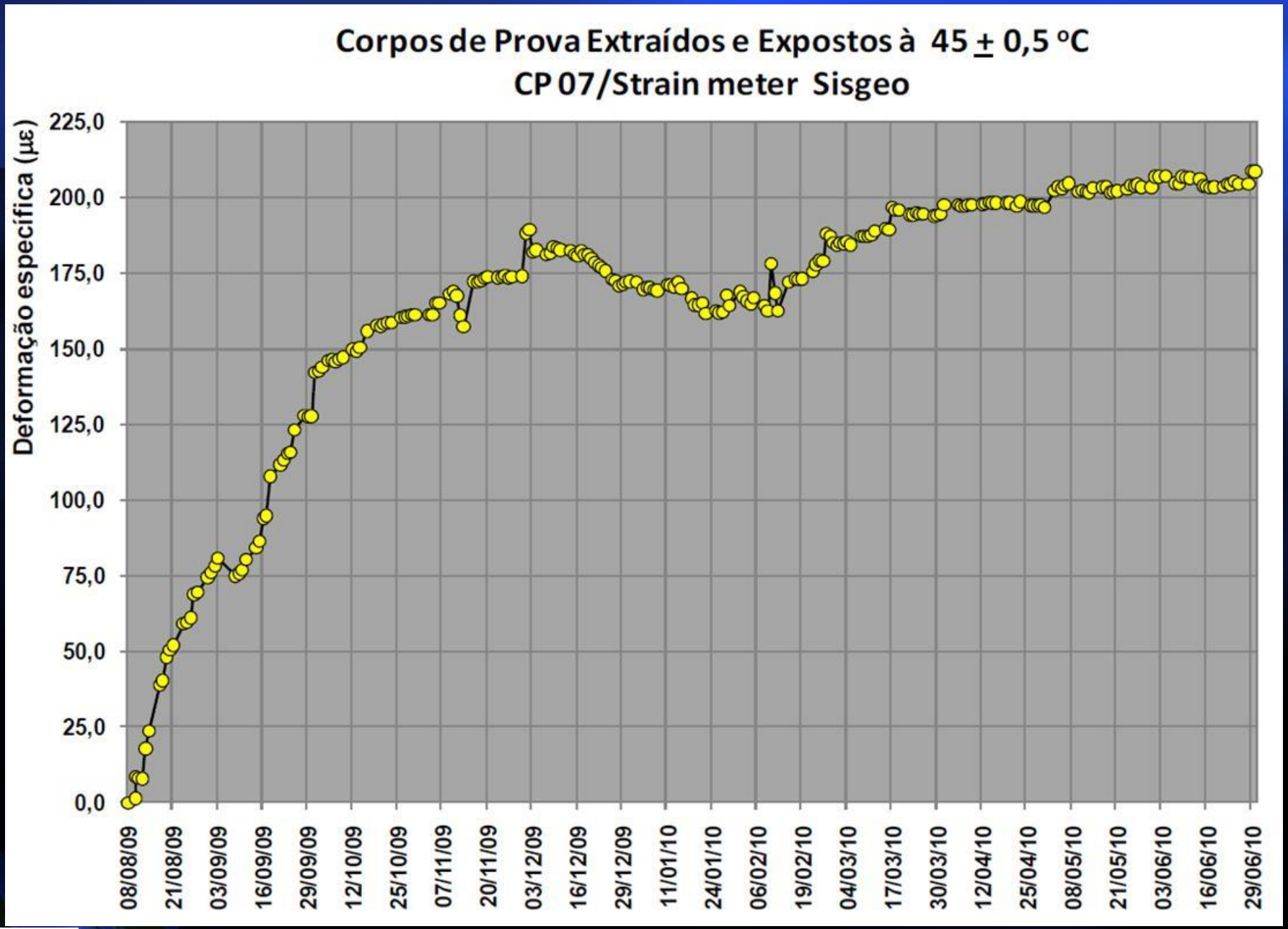

Corpos de Prova Extraídos e Expostos à 55± 0,5 ºC
Deformação específica (με)
CP 10/5739
CP 05/5673
40,0
35,0
30,0
25,0
20,0
15,0
10,0
5,0
0,0
18/03/09
05/04/09
23/04/09
11/05/09
29/05/09
16/06/09
04/07/09
22/07/09
09/08/09
27/08/09
14/09/09
02/10/09
20/10/09
07/11/09
25/11/09
13/12/09
31/12/09
18/01/10
05/02/10
23/02/10
13/03/10
31/03/10
18/04/10
06/05/10
24/05/10
11/06/10
29/06/10

ACTUAL RESULTS

- For test conducted at 45 °C, a decrease in the mean strain was noted






Corpos de Prova Extraídos e Expostos à 45 ± 0,5 °C
CP 07/Strain meter Sisgeo
Deformação específica (με)
225,0
200,0
175,0
150,0
125,0
100,0
75,0
50,0
25,0
0,0
08/08/09
21/08/09
03/09/09
16/09/09
29/09/09
12/10/09
25/10/09
07/11/09
20/11/09
03/12/09
16/12/09
29/12/09
11/01/10
24/01/10
06/02/10
19/02/10
04/03/10
17/03/10
30/03/10
12/04/10
25/04/10
08/05/10
21/05/10
03/06/10
16/06/10
29/06/10

ACTUAL RESULTS

The initial results enable us to comment the following:

☺ In general, the measurements obtained and the observation of gels all confirm continuous expansion;

☺ The rates of expansion at 23 ºC (close to the working environment temperature) were found to be approximately 20 με, which is much lower than those initially adopted in mathematical models (50 με) thus confirming the minimization of future expansions;

ACTUAL RESULTS

- The fact that a random sampling criterion was applied to choose the regions and specimens tested right at the beginning, without bothering to characterize any region and/or a specific structure with known characteristics was responsible for the lower observed expansions for higher temperature exposures;

- This probably will result in an interpolation curve of peak values, thus leading uniquely to a better statistical and mathematical performance.

ACTUAL RESULTS

☞ A level of maximum expansion was identified only in those specimens exposed to a temperature of 55 ºC while for those exposed to temperatures of 23 ºC and 38 ºC, it was not possible to characterize, up to now, the level of stabilization of the expansions.

☞ As a result, it was recommended that the tests be continued for another period of one year in order to estimate the maximum possible expansion, and from thence, conclude the mathematical regression models and subsequently determine the expected ceasing time of expansion.

Estamos abiertos a sugerencias

y

Gracias a todos !!