

Fig. 1 : Summary scheme of the different fields of use of cement grouts.

Table 1: Bogue composition of the Portland cement CEM I 52.5 PM ES CP2 from Teil (France).

Anhydrous components	Bogue composition of the anhydrous components (%)	Mass of water necessary to complete hydration per unit of mass of the component in %	Mass of water necessary to complete hydration per unit of mass of the anhydrous cement in %
$\text{C}_3\text{S}$	63.30	24	15.19
$\text{C}_2\text{S}$	17.90	21	3.76
$\text{C}_3\text{A}$	4.74	40	1.90
$\text{C}_4\text{AF}$	5.62	37	2.08

Table 2: Mixing procedure for tests.

Operations	Cement introduction	Cement mixing	Water progressive introduction	Mixing pan scraping	Paste mixing
Time (s)	0	60	120	30	90
Mixer position	Stop	Low speed	Low speed	Stop	Low speed

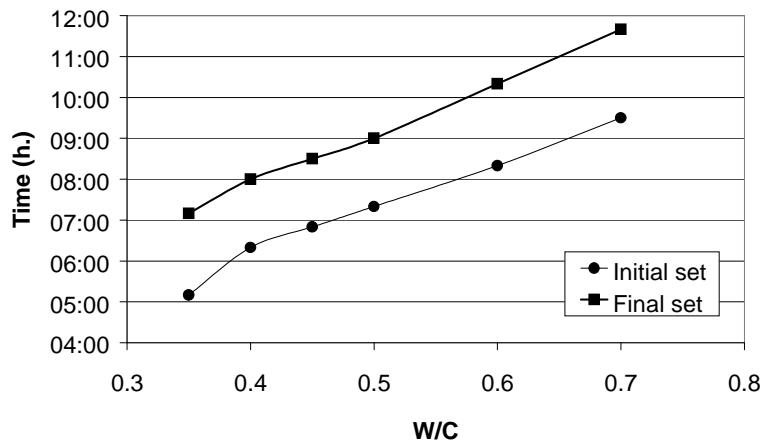


Fig. 2: Evolution of initial and final set times as determined by Vicat test for different W/C ratios.

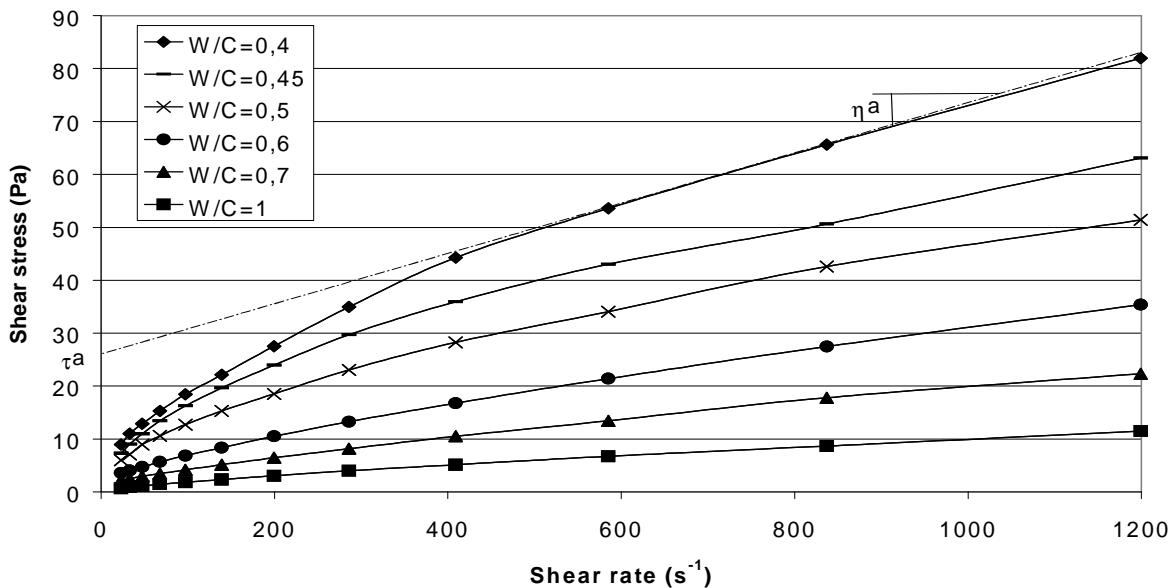


Fig. 3: Evolution of shear stress as a function of the shear rate for each W/C ratio.

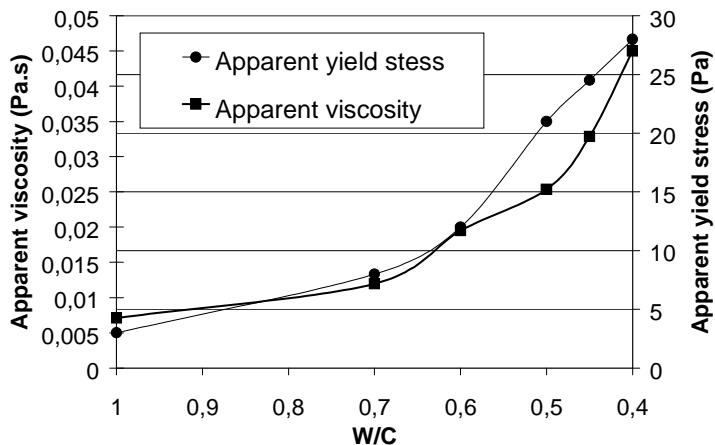


Fig. 4 : Evolution of apparent viscosity and apparent yield stress as a function of the W/C ratio.

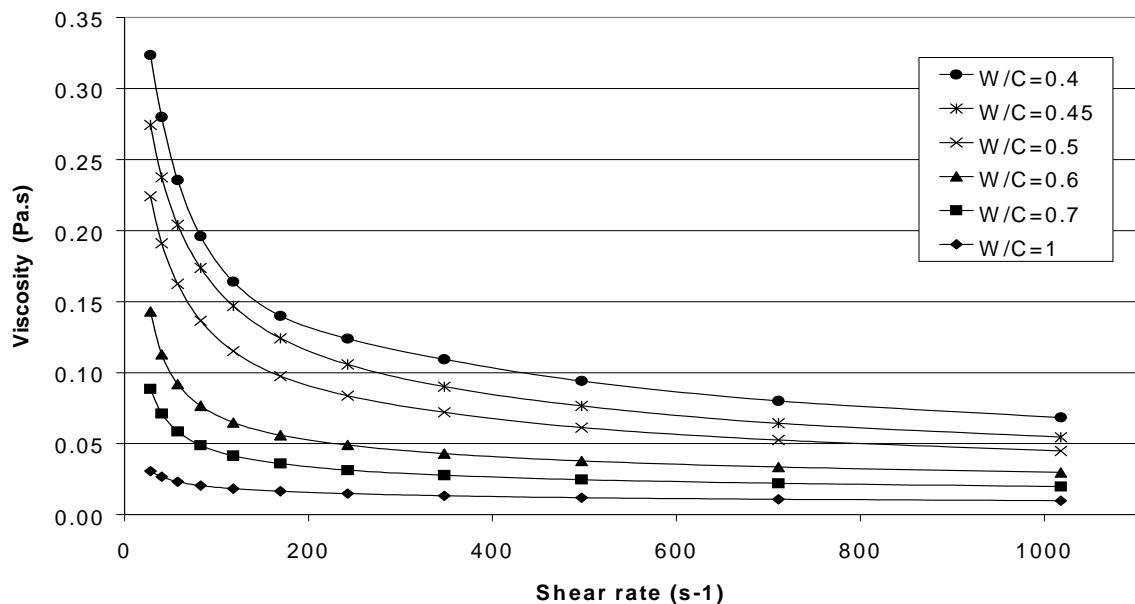


Fig. 5: Evolution of the viscosity as a function of the shear rate.

Table 3: Coefficients A and n for the different W/C ratios.

W/C	A (Pa)	n (.)
<b>1</b>	9.6	0.66
<b>0.7</b>	18.3	0.59
<b>0.6</b>	29.0	0.59
<b>0.5</b>	45.9	0.55
<b>0.45</b>	57.4	0.54
<b>0.4</b>	71.5	0.56

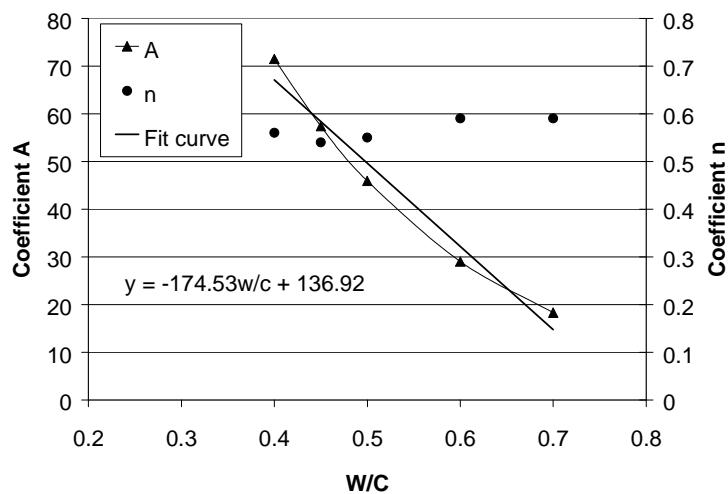


Fig. 6: Evolution of the coefficient A and n as a function of the W/C.

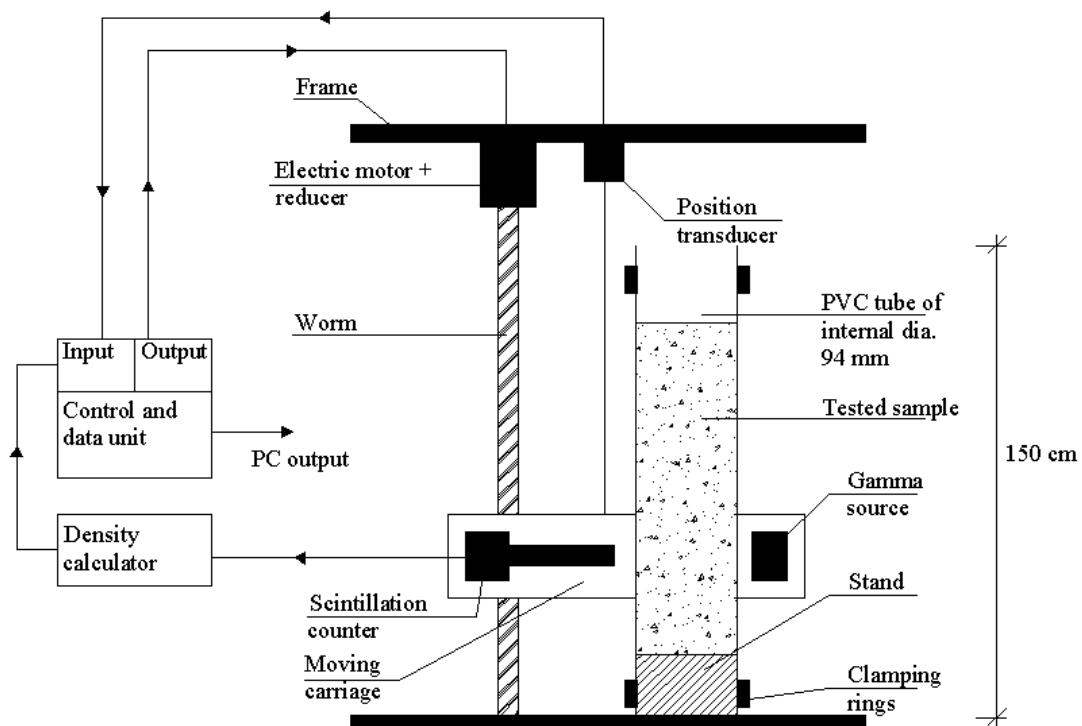


Fig. 7: Schematic diagram of the gamma-densitometer bench.

Table 4: Initial density.

W/C	Initial density
0.35	1.91
0.4	1.87
0.45	1.80
0.5	1.77
0.6	1.65
0.7	1.59
1	1.45

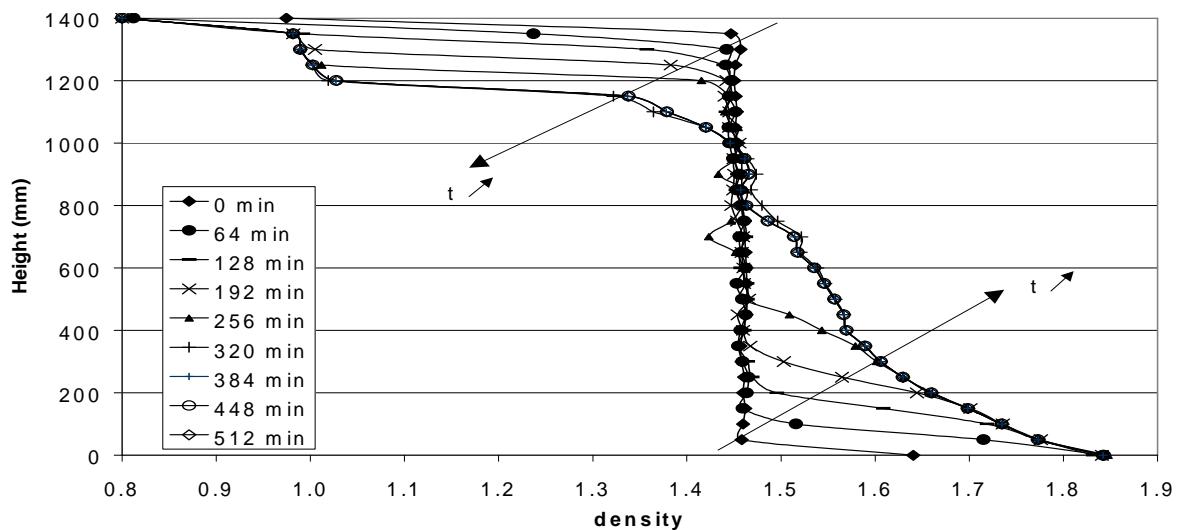


Fig. 8: Density profiles for a cement paste with a W/C ratio of 1 during 7hr12min.

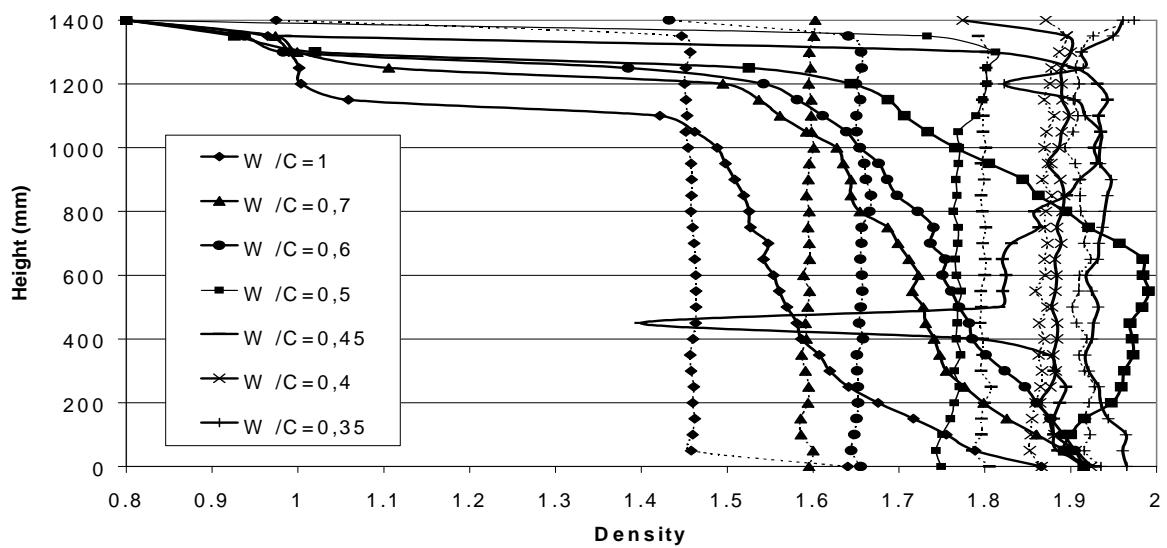


Fig. 9: 24-hour density history for W/C ratios from 1 to 0.35..----- t0 ; t = 24hr ——

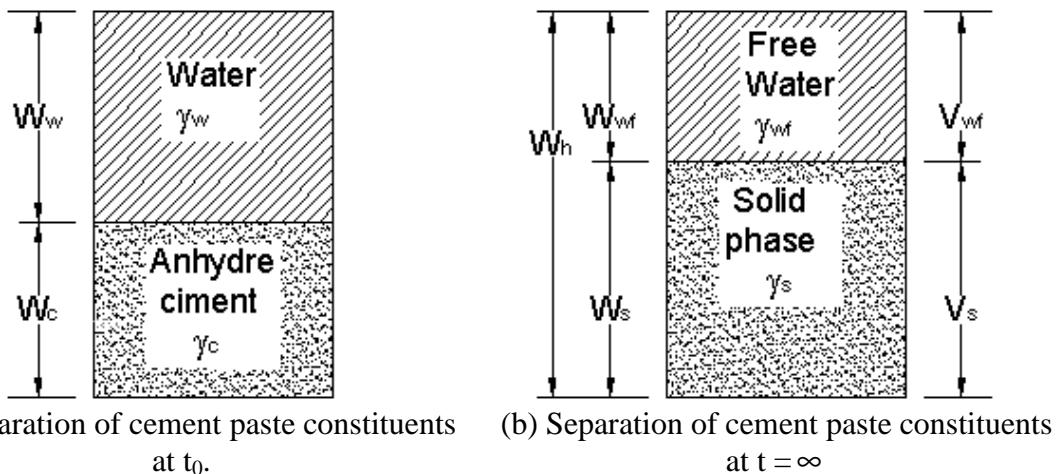


Fig. 10 : Simplified phase diagram.

Table 5: Degree of hydration.

W/C	Sampling level	Measured mass density $\gamma$ ( $\text{kg/m}^3$ )	Measured free water content $w_f$ (%)	Deduced bonded water content $w_b$ (%)	Calculated degree of hydration $\alpha$ (%)	Calculated Mean degree of hydration $\alpha_a$ (%)
<b>0.35</b>	Top	1988	19.2	15.2	66	63
	Middle	1967	21.9	13.9	61	
	Bottom	1998	19.5	14.3	63	
<b>0.4</b>	Top	1937	22.7	15.0	65	59
	Middle	1916	26.7	12.7	55	
	Bottom	1947	23.5	13.6	59	
<b>0.5</b>	Top	1671	49.6	13.5	59	64
	Middle	2018	18.6	14.1	61	
	Bottom	1927	21.2	17.1	75	
<b>0.6</b>	Top	1570	55.3	21.1	92	50
	Middle	1784	43.7	8.1	35	
	Bottom	1937	29.5	9.0	39	
<b>0.7</b>	Top	1518	51.5	31.9	139	61
	Middle	1753	46.6	8.4	37	
	Bottom	1927	32.3	7.3	32	
<b>1</b>	Top	1448	69.6	30.2	132	80
	Middle	1590	63.7	12.3	54	
	Bottom	1825	27.4	18.5	81	