ANALYSYS OF COMPRESSION RESISTANCE RESULTS OF CONCRETES

P. J. CUNHA*, J. B. AGUIAR*, P. N. OLIVEIRA**

*** Department of Civil Engineering, Universidade do Minho**
Campus de Azurém, 4800-058 Guimarães
aguiar@civil.uminho.pt
**** Department of Production and Systems, Universidade do Minho**
Campus de Azurém, 4800-058 Guimarães
pno@dps.uminho.pt

Abstract. The non respect of the rules specified on the standardisation and the consequent no conformity of the concretes leads the appearance of pathologies, arriving to a precocious degradation of the constructions. The collection of several specimens in five sites had as an objective to accomplish an "enlarged" statistical study, not only with the minimum number of specimens demanded by standards. The results were analysed with several combinations among them, respecting the minimum number of specimens demanded by standard, to verify probabilities existed of this to be respected. In four sites the concrete class obtained is superior to the demanded, while in one site the concrete did not verify the criteria. In this site, the classification of the quality control was medium, while in the other ones varied between good and very good. The classification was made taking in account the standard deviation of the results of the compression resistance tests.

1. INTRODUCTION

The concrete is a material formed by cement, aggregates and water, resulting from the hydration of the cement, developing their properties. For besides these basic components, it can also contain adjuvants and additions.

It is still of considerable importance the choice of the concrete constituents (cement, aggregates, water and adjuvants), production and its application (transport, placement, compacting, cure and protection). The composition of the concrete, the cement dosages, aggregates and water (and of the additions and adjuvants when used) it should be selected satisfying the criteria of behaviour for the fresh concrete and for the hardened concrete, including consistence, density, resistance, durability and protection of the armatures against the corrosion. The composition of the concrete should permit the achieving of a compatible workability with the construction method used. The inert's maximum dimension has to be chosen so that the concrete can be put and compressed to the turn of the armatures without there is no segregation.

A durable concrete, should protect the armatures satisfactorily against the corrosion and should support the environmental conditions it is exposed during the foreseen time of useful life. Some factors should be taken in consideration: choice of the constituents, choice of the composition, mechanical attacks, placement, compacting and the cure of the concrete. The control of the quality of the several factors actually is regulated through standard NP ENV 206 [1]. This standard will be replaced at short term by standard NP EN 206-1 [2].

It was noted that the control of the conformity of the compressive resistance of the concretes, reveals some negligence of the quality of this material. As consequence of no quality and no conformity of the concrete, can occur pathologies at the level of the structure or in the coverings and masonries, arriving to a precocious degradation of the constructions and possible fractures. This non execution of standard appears, frequently, due to the ignorance or relaxation, but also for times with the intention of saving material to improve the final profit.

2. HYDRAULIC CONCRETE

The concrete is legitimately considered the material for more versatile construction. It uses average plenty materials, the technology of manufacture is simple and it requests low energy consumptions. This appeared in substitution of the great blocks of stones that formed the most passing constructions, allowing more executions moulded to the builders' interests. In a very generic way we can define the concrete as the result of the mixture of cement, water and aggregates, being obtained a material more or less homogeneous and plastic [3] [4].

The concrete with cement, water and aggregates presents certain general characteristics, but however, a lot of times it is convenient to valorise certain characteristics, as for instance, a larger impermeability, fluidity, speed of obtaining the mechanical resistances, possible with addition of small amounts of adjuvants that will be the responsible for the obtaining of these and other characteristics of the concrete.

A good concrete needs for one side a commitment between the resistance and the permeability, and the workability for other side. It is necessary to know some elements related with the nature and the work type, placement means and compacting of the concrete, armatures and moulds, wanted class and type of the concrete, as well as the foreseen environmental conditions [5] [6].

The concrete is an artificial stone resulting from the mixture with an union substance (cement) and a material inert (no reagent) achieving good characteristics of mechanical resistance. It is necessary the addition of water to promote the chemical reaction of hydration. With view to obtaining of improvements at the level of some of their properties, it is usual the inclusion of other chemical substances to the mixture, designated of adjuvants. Being their dependent properties of several factors, they assume special relief the properties of the involved aggregate (geometric, mechanics and chemistries), the type of cement adopted and the several proportions among the elements, water/cement ratio (W/C) and amount of water for m^3 [7] [8].

3. DESCRIPTION OF THE EXPERIMENTAL WORK

3.1 - Collect of specimens

Collect of several concrete specimens in five sites of the District of Braga, along the year of 2005, had as objective to accomplish a "enlarged" statistical study, not only of the minimum number of results demanded by NP ENV 206 [1], but, with a vast number of results, and with several combinations among them, respecting the minimum number of results demanded by the standard, to verify wich possibilities exist of this to be respected or not.

Some companies were contacted, to collect in their sites concrete specimens, testing them in the Laboratory of Materials of Construction of the University of Minho. For the accomplishment of the tests existent equipments were used at the Laboratory (Fig. 1 and 2).

Fig. 1 - Vibrator and moulds.

In the site 1, the concrete used, it was done in site, with a compressive resistance class C16/20. In the site 2, it was used ready concrete of a resistance class C16/20. In the sites 3 and 4 concrete was used C20/25, done in site. In the site 5 the compressive resistance class intended was C25/30 and it was used ready concrete.

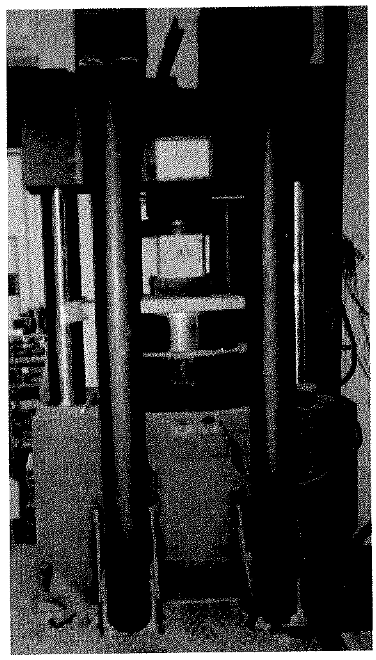

Fig. 2 – Equipment for compression tests.

Inside of each site, twenty specimens were accomplished. Individually for each combination, it was made the verification of the conformity criteria from the compressive resistance as well as the determination of the class of the concrete obtained. The procedure adopted in the control of the conformity was done initially in agreement with standard NP ENV 206 [1]. The control of the conformity was verified also with standard NP EN 206-1 [2], comparing the two obtained results.

First, and in agreement with standard NP ENV 206 [1], for the sites 1, 2, 3 and 4, 1140 combinations of 3 results exist and for the site 5, 38760 combinations of 6 results exist. Then and according to standard NP EN 206-1 [2], for the five sites 1140 combinations of 3 results exist, seen to treat of an initial production. For the sites 1, 3 and 4, the verification of the conformity criteria of the compressive resistance was made only using the criteria regarding the initial production, once it is treated of concrete without certification of the control of production. For the sites 2 and 5, although being treated of concrete with certification of the control of production, once we have a number of obtained results and inferior acquaintances to 35, we will have equally to use the conformity criteria of the compressive resistance to the compression regarding the initial production.

However and in relation to these two sites, the site 2 and the site 5, we put the hypothesis of the 35 previous results be known, treating them in each one of them, as if it was treated of a continuous production, using for such the standard deviation obtained for the twenty results. Besides the 1140 combinations of 3 results each, for the sites 2 and 5, we also made combinations of 15 results each, obtaining 15504 combinations in each one, leaving, of course, of the presupposition that we would be before two continuous productions. It was analysed also the 20 results at the same time, in only one combination to standard NP EN 206-1 [2], making the same according to standard NP ENV 206 [1] (with this standard, it was analysed in this way the five sites), comparing them to proceed.

In the end, it was compared the results obtained according to the standards NP ENV 206 [1] and NP EN 206-1 [2]. For the sites 2 and 5, it was compared also the combinations of 15 results and the combination of the 20 results in the global. For simplicity of understand a calculation leaf was used as tool to schematise the whole study described to the moment. For standard NP EN 206-1 [2], for the determination of the class of the concrete obtained and control of the conformity of the compressive resistance is necessary before everything to verify if each specimen tested to the 28 days accomplishes the criterion 2. The concrete in cause should be confirmed if accomplishes the criterion 3, in that case it belongs to the family, this in the case of the concretes with certification of the control of the production. Finally, it is necessary that the average of "n" transposed results accomplish to the criterion 1.

3.2 - Type of calculations effectuated by standard NP ENV 206 [1].

3.2.1 - 3 to 5 results

Site 1 in the year 2005

a) Calculation of the rupture's tensions average to the compression of 3 results:

$$X_n = \frac{29{,}65 + 28{,}93 + 29{,}08}{3} = 29{,}22MPa$$

b) The smallest value of the obtained tensions:

$$X_{min} = 28{,}93MPa$$

c) The specified characteristic value:

$$f_{ck} = 20MPa$$

d) To verify if it accomplishes the following conditions:

$$X_n \geq f_{ck} + 5 \quad \Leftrightarrow \quad 29{,}22 \geq 20 + 5 \quad \rightarrow \quad O.K.\,(verified)$$
$$X_{min} \geq f_{ck} - 1 \quad \Leftrightarrow \quad 28{,}93 \geq 20 - 1 \quad \rightarrow \quad O.K.\,(verified)$$

e) To determine the class of the concrete:

$$29{,}22 \geq f_{ck} + 5 \quad \Rightarrow \quad f_{ck} \leq 24{,}22\ MPa$$
$$28{,}93 \geq f_{ck} - 1 \quad \Rightarrow \quad f_{ck} \leq 29{,}93\ MPa$$

- Being 24,22 MPa the smallest value => Concrete's class obtained: C19/24

3.2.2 - 6 or more results

Site 5 in the year 2005

a) Calculation of the rupture's tensions average to the compression of 6 results:

$$X_n = \frac{33{,}99 + 35{,}72 + 36{,}41 + 23{,}47 + 20{,}49 + 28{,}44}{6} = 29{,}75MPa$$

b) The smallest value of the obtained tensions:

$$X_{min} = 20{,}49MPa$$

c) The specified characteristic value:

$$f_{ck} = 30MPa$$

d) Calculation of the standard deviation:

$$S_n = \sqrt{\frac{\sum_{i=1}^{n}(X_i - X_n)^2}{n-1}} =$$

$$= \sqrt{\frac{(33{,}99-29{,}75)^2+(35{,}72-29{,}75)^2+...+(20{,}49-29{,}75)^2+(28{,}44-29{,}75)^2}{6-1}} = 6{,}71$$

e) To remove the values and k of the picture, in function of the number of samples:

λ=1,48 e k=3

f) To verify if it accomplishes the following conditions:

$$X_n \geq f_{ck} + \lambda * S_n \quad \Leftrightarrow \quad 29{,}75 \geq 30 + 1{,}48 * 6{,}71 \quad \rightarrow \quad K.O.\ (not\ verified)$$
$$X_{min} \geq f_{ck} - k \quad \Leftrightarrow \quad 20{,}49 \geq 30 - 3 \quad \rightarrow \quad K.O.\ (not\ verified)$$

g) To determine the class of the concrete:

$$29{,}75 \geq f_{ck} + 1{,}48 * 6{,}71 \quad \Rightarrow \quad f_{ck} \leq 19{,}83\ MPa$$
$$20{,}49 \geq f_{ck} - 3 \quad \Rightarrow \quad f_{ck} \leq 23{,}49\ MPa$$

- Being 19,83 MPa the smallest value => Concrete's class obtained: C15/19

3.3 - Type of calculations effectuated for standard NP EN 206-1 [2]

3.3.1 - Initial production - 3 results

Site 1 in the year 2005

a) The value of the obtained tensions:

$$f_{c1} = 29{,}65 MPa$$
$$f_{c2} = 28{,}93 MPa$$
$$f_{c3} = 29{,}08 MPa$$

b) Calculation of the rupture's tensions average to the compression of 3 results:

$$f_{cm} = \frac{29{,}65 + 28{,}93 + 29{,}08}{3} = 29{,}22 MPa$$

c) The specified characteristic value:

$$f_{ck} = 20 MPa$$

d) To verify if it accomplishes the following criteria:

$$Criterion\ 2 \rightarrow f_{ci} \geq f_{ck} - 4 \quad \Leftrightarrow \quad f_{ci} \geq 20 - 4 \quad \rightarrow \quad O.K.\ (verified)$$
$$Criterion\ 1 \rightarrow f_{cm} \geq f_{ck} + 4 \quad \Leftrightarrow \quad 29{,}22 \geq 20 + 4 \rightarrow O.K.(verified)$$

e) To determine the class of the concrete:

$$28{,}93 \geq f_{ck} - 4 \quad \Rightarrow \quad f_{ck} \leq 32{,}93\ MPa$$
$$29{,}22 \geq f_{ck} + 4 \quad \Rightarrow \quad f_{ck} \leq 25{,}22 MPa$$

- Being 25,22 MPa the smallest value => Concrete's class obtained: C20/25

3.3.2 - Continuous production - 15 or more results

Site 2 in the year 2005

a) The value of the obtained tensions:

$$f_{c1} = 33{,}72MPa$$
$$f_{c2} = 33{,}58MPa$$
$$f_{c3} = 33{,}72MPa$$
$$f_{c4} = 33{,}28MPa$$
$$f_{c5} = 34{,}14MPa$$
$$f_{c6} = 31{,}64MPa$$
$$f_{c7} = 31{,}76MPa$$
$$f_{c8} = 32{,}21MPa$$
$$f_{c9} = 32{,}50MPa$$
$$f_{c10} = 32{,}19MPa$$
$$f_{c11} = 31{,}70MPa$$
$$f_{c12} = 31{,}52MPa$$
$$f_{c13} = 32{,}97MPa$$
$$f_{c14} = 32{,}82MPa$$
$$f_{c15} = 32{,}67MPa$$

b) Calculation of the rupture's tensions average to the compression of 15 results:

$$f_{cm} = \frac{33{,}72 + \ldots + 32{,}67}{15} = 32{,}69MPa$$

c) The specified characteristic value:

$$f_{ck} = 20MPa$$

d) Calculation of the standard deviation:

In this point, once it would be treated of a continuous production, we would have to calculate the standard deviation starting from at least 35 consecutive results. In our case, it was calculated with a base of our 20 results obtained in site:

$$S_n = \sqrt{\frac{\sum_{i=1}^{n}(X_i - X_n)^2}{n-1}} = \sqrt{\frac{(35{,}95-33{,}47)^2+\ldots+(32{,}67-33{,}47)^2}{20-1}} = 1{,}59$$

e) To verify if it accomplishes the following criteria:

$$Criterion\ 2 \rightarrow f_{ci} \geq f_{ck} - 4 \quad \Leftrightarrow \quad f_{ci} \geq 20 - 4 \quad \rightarrow \quad O.K.\ (verified)$$
$$Criterion\ 3 \rightarrow f_{cm} \geq f_{ck} + 3 \quad \Leftrightarrow \quad 32{,}69 \geq 20 + 3 \quad \rightarrow \quad O.K.\ (verified)$$
$$Criterion\ 1 \rightarrow f_{cm} \geq f_{ck} + 1{,}48 * \sigma \quad \Leftrightarrow \quad 32{,}69 \geq 20 + 1{,}48 * 1{,}59 \rightarrow O.K.(verified)$$

f) To determine the class of the concrete:

$$31{,}52 \geq f_{ck} - 4 \;\Rightarrow\; f_{ck} \leq 35{,}52\ MPa$$
$$32{,}69 \geq f_{ck} + 3 \;\Rightarrow\; f_{ck} \leq 29{,}69\ MPa$$
$$32{,}69 \geq f_{ck} + 1{,}48 * 1{,}59 \;\Rightarrow\; f_{ck} \leq 30{,}34 MPa$$

- Being 29,69 MPa the smallest value => Concrete's class obtained: C24/29

4. RESULTS

As we just said, the procedure adopted in control of the conformity for the compressive resistance, it was done initially in agreement with standard NP ENV 206 [1], using the same type of calculations effectuated in the number 3.2. It was verified later also with standard NP EN 206-1 [2] (see number 3.3), comparing the obtained results. They were used for such the several possible combinations with the 20 results of each site (table 1).

Table 1 - Results of the five sites of 2005 (values in MPa)

Site Numb.	Site 1	Site 2	Site 3	Site 4	Site 5
Compressive Resistance	29,65	35,95	39,60	35,06	33,99
	29,70	35,63	38,02	34,15	37,83
	30,16	33,72	38,09	38,52	39,30
	29,99	33,58	38,92	37,36	35,72
	29,80	36,37	42,78	35,18	38,56
	28,93	33,72	44,13	36,15	39,55
	29,82	34,76	28,04	37,53	36,41
	30,33	33,28	29,11	37,45	38,96
	30,83	34,14	28,93	35,08	38,69
	29,08	36,24	29,56	37,00	38,41
	39,36	31,64	32,82	39,35	23,47
	39,51	31,76	31,77	38,46	36,93
	39,30	32,21	30,89	38,32	20,49
	39,08	32,50	33,81	36,86	28,44
	39,32	32,19	31,83	38,62	37,27
	39,65	31,70	32,50	38,47	37,18
	38,20	31,52	32,22	37,20	37,47
	37,37	32,97	32,86	38,59	39,03
	38,74	32,82	31,25	37,82	38,44
	39,67	32,67	32,74	38,21	37,53
Average	34,42	33,47	33,99	37,27	35,68
Stand.Dev.	4,76	1,59	4,64	1,45	5,31
Médium	34,10	33,13	32,62	37,49	37,50
Variat.Coef.	0,14	0,05	0,14	0,04	0,15
Site Class.	Good	V.Good	Good	V.Good	Medium

Just as we already referred previously, first, and in agreement with Standard NP ENV 206 [1], for the sites 1, 2, 3 and 4, 1140 combinations of 3 results exist and for the site 5 38760 combinations of 6 results exist. Then and according to standard NP EN 206-1 [2], for the five sites 1140 combinations of 3 results exist. However and in relation to two sites, the site 2 and the site 5, combinations of 15 results exist, obtaining 15504 combinations in each, leaving, of course, of the presupposition that we would be before two continuous productions. We analysed also, and as already referred, for the sites 2 and 5, the 20 results at the same time, in only one combination to standard NP EN 206-1 [2], making the same according to standard NP ENV 206 [1] (in this case for the five sites), comparing them to proceed.

In the site 1, concrete manufactured at the place, concrete without certification of the control of production, the class of resistance concrete to the intended compression was C16/20. Making combinations of 3 results, with the 20 tested specimens, 1140 combinations exist in the total. As we can verify at table 2, of those 1140 combinations, all of them, 100%, verified the conformity criteria of the compressive resistance, the same percentage occurred with standard NP ENV 206 [1] and with NP EN 206-1 [2]. With the combinations of 3 results, according to standard NP ENV 206 [1], the characteristic tension of resistance to the lowest obtained compression resistance was of 24 MPa and the highest was of 34 MPa. For standard NP EN 206-1 [2], the lowest value was of 25 MPa and the highest was of 35 MPa, increasing in 1 MPa in the lowest value as in the highest value. We can observe the following combinations: one with the lower and other three results with the three observed higher results of among the twenty. The site was classified of 'Good'. Its classification is given by the reason between the standard deviation and the medium. The average of the observed tensions was of 34,42 MPa. The characteristic tension of compressive resistance of the concrete obtained according to standard NP ENV 206 [1] it was 27 MPa.

Table 2 - Combinations of results for the site 1 of 2005

	Combinations of 3 Results				*Combinations of 15 results*				*20 results*
	OK %	KO %	$f_{ck,max}$ (MPa)	$f_{ck,min}$ (MPa)	OK %	KO %	$f_{ck,max}$ (MPa)	$f_{ck,min}$ (MPa)	$f_{ck,obtained}$ (MPa)
NP ENV 206	100	0	34	24	-	-	-	-	27
NP EN 206-1	100	0	35	25	-	-	-	-	-

For the Site 2, ready concrete, concrete with certification of the control of production, the concrete class intended was also C16/20. With the 20 results, making combinations of 3, 1140 combinations exists. According to table 3, all of them verified the conformity criteria of the resistance to the compression to the shelter of the two standards. For standard NP ENV 206 [1], the characteristic tension of resistance to the lowest obtained compression was of 28 MPa and the highest was of 33 MPa. For standard NP EN 206-1 [2], the lowest value was of 27 MPa and the highest was of 32 MPa, decreased in 1 MPa in the lowest value as in the highest value. They were also made combinations of 15 results, existing 15504 combinations. Equally all of them verified according to the two standards. For standard NP ENV 206 [1], the characteristic tension of resistance to the lowest compression and the highest obtained it was of 31 MPa. For standard NP EN 206-1 [2], the lowest value was of 29 MPa and the highest was of 31 MPa. It is verified that there is a decrease of 2 MPa for the lowest value, while the highest it maintains constant in 31 MPa. The average of the observed tensions was of 33,72 MPa. The classification of the site was 'Very Good'. The characteristic resistance obtained for the twenty results in Standard NP ENV 206 [1] it was 31 MPa and in Standard NP EN 206-1 [2] it was 30 MPa.

Table 3 - Combinations of results for the site 2 of 2005

	Combinations of 3 Results				*Combinations of 15 results*				*20 results*
	OK %	KO %	$f_{ck,max}$ (MPa)	$f_{ck,min}$ (MPa)	OK %	KO %	$f_{ck,Max}$ (MPa)	$f_{ck,min}$ (MPa)	$f_{ck,obtained}$ (MPa)
NP ENV 206	100	0	33	28	100	0	31	31	31
NP EN 206-1	100	0	32	27	100	0	31	29	30

In the Site 3, concrete manufactured at the place, concrete without certification of the control of production, the concrete class intended was C20/25 (table 4). They exist 1140 combinations equally with the 20 tested specimens, making combinations of 3 results. According to standard NP ENV 206 [2], 97,02% of the combinations, 1106 combinations verify the conformity criteria of the resistance to the compression and only 2,98% don't make it, corresponding to 34 combinations. To the shelter of NP EN 206-1 [1], 99,74%, 1137 combinations verify the criteria and 0,26% no, in other words, 3 combinations. For standard NP ENV 206 [1], the characteristic tension of resistance to the lowest obtained compression was of 23 MPa and the highest was of 37 MPa. For standard NP EN 206-1 [2], the lowest value was of 24 MPa and the highest was of 38 MPa, increasing in 1 MPa so much in the lowest value as in the highest value. The average of the observed tensions was of 33,99 MPa. The site was classified of 'Good'. The characteristic resistance obtained in Standard NP ENV 206 [1] it was 27 MPa.

Table 4 - Combinations of results for the site 3 of 2005

	Combinations of 3 results				*Combinations of 15 results*				*20 results*
	OK %	KO %	$f_{ck,max}$ (MPa)	$f_{ck,min}$ (MPa)	OK %	KO %	$f_{ck,max}$ (MPa)	$f_{ck,min}$ (MPa)	$f_{ck,obtained}$ (MPa)
NP ENV 206	97,02	2,98	37	23	-	-	-	-	27
NP EN 206-1	99,74	0,26	38	24	-	-	-	-	-

In the Site 4, concrete manufactured at the place, concrete without certification of the control of production, the intended class was equally C20/25. Once again 1140 combinations exist, with the 20 tested specimens, with combinations of 3. According to table 5, so much with a standard as with other, the verification of the conformity criteria of the compressive resistance was of 100%. For the Standard NP ENV 206 [1], the characteristic tension of resistance to the lowest obtained compression was of 29 MPa and the highest was of 33 MPa. For standard NP EN 206-1 [2], the lowest value was of 30 MPa and the highest was of 34 MPa, increasing in 1 MPa so much in the lowest value as in the highest value. The average of the observed tensions was of 37,27 MPa. The site was classified of 'Very Good'. The characteristic resistance obtained in Standard NP ENV 206 [1] it was 35 MPa.

Table 5 - Combinations of results for the site 4 of 2005

	Combinations of 3 results				*Combinations of 15 results*				*20 results*
	OK %	KO %	$f_{ck,max}$ (MPa)	$f_{ck,min}$ (MPa)	OK %	KO %	$f_{ck,Max}$ (MPa)	$f_{ck,min}$ (MPa)	$f_{ck,obtained}$ (MPa)
NP ENV 206	100	0	33	29	-	-	-	-	35
NP EN 206-1	100	0	34	30	-	-	-	-	-

Finally, in the Site 5, ready concrete, concrete with certification of the control of production, the class of the concrete intended was C25/30 (table 6). In this site three specimens exist with very different and very low results in relation to the remaining ones. According to Standard NP ENV 206 [1], 38760 combinations exist with the 20 results, making combinations of 6 results. In 47,89%, 18564 combinations accomplish the verification criteria and 52,11%, 20196 combinations no. With standard NP EN 206-1 [2], they were made combinations of 3 results, obtaining in the total 1140 combinations. In 71,38% of the cases (816 combinations) the conformity criteria were verified from the compressive resistance in 37,19% (324 combinations) not. Surprisingly the same was verified at the site 3, increasing the number of combinations that it accomplish this new standard's criteria, and here, in this site, in a more significant way. For standard NP ENV 206 [1], the characteristic tension of resistance to the lowest obtained compression was of 19 MPa and the highest was of 38 MPa. For standard NP EN 206-1 [2], the lowest value was of 20 MPa, increasing in 1 MPa in relation to previous standard. The highest was of 35 MPa, decreasing in 3 MPa in relation to NP ENV 206 [1].

Table 6 - Combinations of results for the site 5 of 2005

	Combinations of 3 Results				*Combinations of 15 results*				*20 results*
	OK %	KO %	$f_{ck,max}$ (MPa)	$f_{ck,min}$ (MPa)	OK %	KO %	$f_{ck,max}$ (MPa)	$f_{ck,min}$ (MPa)	$f_{ck,obtained}$ (MPa)
NP ENV 206	47,89[a)]	52,11[a)]	38[a)]	19[a)]	5,26	94,74	36	24	24
NP EN 206-1	71,58[b)]	37,19[b)]	35[b)]	20[b)]	5,26	94,74	30	24	24

a) - Combinations of 6 results
b) - Combinations of 3 results

They were also made combinations of 15 results, existing 15504 combinations. Equally in the two standards, only in 5,26%, 816 combinations accomplish the verification criteria and 94,74%, 14688 combinations no. For the two Standards, the resistance tension to the lowest compression was of 24 MPa. For NP ENV 206 [1], the highest value was of 36 MPa and for standard NP EN 206-1 [2], the highest was of 30 MPa. It is verified that in the value of characteristic tension of resistance to the highest compression there is a decrease of 6 MPa in new standard. The average of the observed tensions was of 35,68 MPa. Even with a ready concrete, the site was classified of 'Medium'. For the twenty results verified at the same time, the characteristic resistance obtained in standard NP ENV 206 [1] it was 24 MPa and in standard NP EN 206-1 [2] it was 24 MPa equally.

In relation to the year 2005, so much with standard NP ENV 206 [1] as with NP EN 206-1 [2], in the universe of the five analysed sites, in which took place a week of tests, with twenty results each, was verified that the number of tests in that the class of the concrete obtained is superior to the demanded class is very high. Only in the Site 5 they were observed some problems with the verification of the criteria for compression resistance conformity.

5. CONCLUSION

Beginning for the Sites 1, 3 and 4, the concrete is manufactured at the place and without certification of the control of the production, we can observe that for combinations of three results, standard NP EN 206-1 [2] has a criterion with less exigency than NP ENV 206 [1], as one can see for the percentages of verification of the conformity criteria of the compressive resistance obtained in the Site 3, also providing a resistance tension to the highest compression in 1 MPa, in any one of the three sites in analyse.

For the Sites 2 and 5, cases in that it is treated of ready concrete and with certification of the control of the production, it is verified as one can see for the obtained percentages, that for combinations with a minimum number of results, for combinations of fifteen results and in the global analysis done to the twenty results, it also exists an execution much easier of the conformity criteria of the resistance to the compression. However, the resistance tension to the obtained compression is lower in this new standard NP EN 206-1 [2], starting to exist also the important contribute of a new criterion in the verification of the conformity criteria of the compressive resistance, the family criterion.

The analyse of the results for the five sites of 2005, in relation to the verification of the conformity criteria in the two standards, showed that the concrete class obtained is superior to demanded, the percentage is very high, having had only some problems of results with the site 5. In this site it was verified three very low results in relation to the remaining tested specimens.

6. REFERENCES

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