CEM I 52,5R CIMENT DE ÎNALTĂ PERFORMANȚĂ▲
CEM I 52.5R HIGH-PERFORMANCE CEMENT

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The harmonization of Romanian regulations with the European ones has led to significant changes regarding the rules for concrete production, for design and execution of the elements and structures. The enforcement, in Romania staring with 2002 year of the European standards continuing to require significant changes regarding minimum strength classes and concrete works' execution conditions.

The national infrastructure development program has become a priority in Romania. This aspect together with the additional strength and durability requirements make it necessary to use specialized high-strength cements.

The article shows the main features of cement CEM I 52,5R as well as the results of some studies carried out on concrete prepared with this type of cement.

Armonizarea reglementărilor româneşti cu cele europene a condus la modificări importante în ceea ce priveşte regulile de producere ale betonului, de proiectare şi executare a elementelor şi structurilor. Intrarea în vigoare în România începând cu anul 2002, a normelor europene continuă să impună modificări importante în privința claselor minime de rezistență şi condițiilor de execuție a lucrărilor din beton.

Programul național de dezvoltare a infrastructurii a devenit o prioritate în România. Acest aspect, alături de cerințele suplimentare de rezistență şi durabilitate impuse, conduc spre necesitatea utilizării unor cimenturi specializate, de înaltă rezistență.

Articolul prezintă principalele caracteristici ale cimentului CEM I 52,5R precum şi rezultatele unor studii efectuate pe betoane preparate cu acest sortiment de ciment.

Keywords: *performance, specialized, resistance, durability, concrete.*

1. Introduction

The enforcement in Romania of the European norms starting with the year 2002, continue to imply significant changes regarding the minimum strength classes and the execution conditions for concrete works. The harmonization of Romanian regulations with European standards has led, starting with 2007, to major changes in the concrete production rules, design and execution of elements and structures, having as purpose the increase of concrete constructions' durability. The enforcement of the European standard SR EN 206-1 [1], the national application document SR 13510 [2] and the concrete production practice code CP 012/1 [3] is the most important change affecting the national regulations regarding this construction material.

The national infrastructure development program became a priority for Romania. This aspect together with the additional strength and durability requirements make it necessary to use specialized high-strength cements for specialized applications as beams for large openings, thin pylons, crossbars, different precast products, etc.

2. Generalities on CEM I 52.5R cement

The CEM I 52.5R cement is produced in accordance with the provisions of

SR EN 197-1 standard [4]. This comprises of Portland clinker between 95 and 100% and minor auxiliary addition between 0 and 5 %. Calcium sulfate is added to the other constituents of cement during its manufacture to control setting.

The physical-mechanical and chemical characteristics imposed by the standard of product [4] and including by the technical sheet [5] are:

- Initial setting time - minimum 45 minutes
- Stability (expansion) - maximum 10 mm
- Compression strength:
  - Initial 2 days strength - minimum 30 MPa
  - Standard 28 days strength
    - minimum 52.5 MPa
    - maximum - unlimited
- Sulfate content (as SO_3) - maximum 4.0%
- Chloride content - maximum 0.10%
- Loss on ignition - maximum 5.0 %
- Insoluble residue - maximum 5.0 %

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Through its characteristics, the CEM I Portland cement type strength class 52.5 R is destined to be used for precast elements, reinforced and precompressed, executed all year long. It is also used in the composition of autoclaved cellular concrete, adhesives for ceramic tiles and dry mortars pre-packaged etc.

Concrete types and classes of compression strength for which this type of cement is recommended are: simple concrete, reinforced concrete and disperse-reinforced concrete C40/50 ÷ C100/115, precompressed concrete C40/50 ÷ C100/115 and micro-concrete C40/50 ÷ C100/115.

Possibilities of using (thin high performance concrete elements):

- Artwork: slabs, beams, frames, arches, vaults, pilots, teach, caissons, etc..
- Precast: columns, beams, floors, roof elements, stranded pillars, columns and vibrant spin on overhead lines, autoclaved cellular concrete, tiles for tram, sewerage pipes, voussoirs for mines, room type space elements.
- Elements of precompressed concrete: beams for bridges, thin roof space elements, railway crossbars.
- Micro-concrete: for making small items and repair mortars picture, monolithizations, spraying, injection, repairs (in suspensions, pastes, mortars, etc.).

The CEM I 52.5 R cement can be used for concretes exposed to all exposure classes („X") to the environmental actions. For concretes located in moderated and intense chemical aggressive environments, there are limits regarding the sulfate attack. Therefore, in case of chemical sulfate attack over the exposure class „XA_1" is mandatory to use medium sulfate-strength cements (exposure class „XA_2") or high sulfate-strength cements (exposure class „XA_3").

Is mentioned the fact that this type of cement is not indicated for massive concrete elements (having thickness higher than 0,8m). Also, the high heat of hydration released by the CEM I 52.5R cement implies special protection measures for fresh prepared concrete. But this behaviour offers an advantage that makes from the CEM I 52.5R cement a resistant cement to cold conditions if the compliance conditions imposed by the norms in force are met on the site.

3. Case study on the use of cement CEM I 52.5 R in concrete

This case study presents the compositions realised and the characteristics obtained for fresh concrete, as well as the hardened concrete strength at 18 hours, 2, 7 and 28 days terms for the concretes manufactured with CEM I 52.5R.

Concretes were manufactured with cement dosages between 340 – 520 kg/m^3, aggregates sorts 0-4, 4-8 and 8-16 mm and superplasticizer additive based on a lignosulfonate substance [6].

The superplasticizer additive was used due to its "powerful water-reducer" action which enabled to realize low-water concrete and an increased initial fluidity at the same time with initial and final increased strengths. Having a large dosing domain from 0.2 to 2 % of the weight of cement, it can be used to perform both consistent concrete, fluid and self-compacting concrete [6].

In Table1 are presented the dosages for cement, superplasticizer additive and the quantity of aggregates used to manufacture concretes.

3.1. Characteristics of fresh concretes manufactured with CEM I 52.5R cement

In Table 2 are presented characteristics of

Table 1

Component materials of concretes manufactured with CEM I 52.5R / *Materialele componente ale betoanelor preparate cu CEM I 52,5R*

No. of recipe *Nr. rețetă*	Cement dosage *Dozaj ciment* (kg/m^3)	W/C ratio *Raport a/c*	Additive *Aditiv* (%)	Total aggregate *Total agregate* (kg/m^3) whom next on sorts *din care alăturat pe sorturi*	sort 0-4 (kg/m^3)	sort 4-8 (kg/m^3)	sort 8-16 (kg/m^3)
1	340	0.479	0.90	1886	792	377	717
2	360	0.46	0.90	1877	788	375	714
3	380	0.44	0.90	1863	782	373	708
4	400	0.43	0.90	1850	777	370	703
5	420	0.40	0.90	1841	773	368	700
6	440	0.38	0.90	1831	769	366	696
7	460	0.36	0.90	1827	713	365	749
8	480	0.34	0.90	1820	710	364	746
9	500	0.32	0.90	1818	709	364	745
10	520	0.31	0.90	1806	704	361	741

fresh concrete obtained for the above mentioned dosages in Table 1.

The resulted concrete were stiff for which it has been determining slump [7] and apparent density in fresh stage using specimens for fresh concrete prepared for the determination of compressive strength.

It is found that it has obtained slumps range between 185 and 205 mm for W/C ratios which decreased from 0.479 to 0.31; this allow to frame concrete in the slump class of S4 [1]; the slump values agreed to those of apparent density in fresh state.

3.2. Characteristics of hardened concrete prepared with CEM I 52.5R cement

In Table 3 are presented compressive strength obtained at terms of 18 hours, 48 hours (2 days), 7 and 28 days, for the cement dosages presented in Table 1. Determination was made according SR EN 12390-3 [8].

From Table 3 it is noticed that the values of the compressive strengths at 48 hours term (2 days) are high, being comprised between 61.6 N/mm^2 and 102.6 N/mm^2. In time, the strength increase, and at 28 days the values range between 75.2 N/mm^2 (the lowest cement dosage 340 kg/m^3, W/C=0.479) and 120.4 N/mm^2 (the highest cement dosage 520 kg/m^3, W/C=0.31). Thus, the corresponding characteristics of cement are hereby confirmed by performance levels reached of the concrete compressive strength, as supplementary is shown in Figure 1. The results show concrete compressive strength dependence on the cement dosage and respectively on the W/C ratio.

Considering the specific use of cement CEM I 52.5R, mostly in pre-cast concrete elements with high strength (with or without pre-compression) a specific request of this sort of cement is the accomplishment of 60% from the strength class of concrete at the term of 18 hours.

Table 2

Characteristics of fresh concretes prepared with CEM I 52.5R
Caracteristici ale betoanelor proaspete preparate cu CEM I 52,5R

No. of recipe *Nr. rețetă*	Cement dosage *Dozaj ciment* (kg/m^3)	W/C ratio *Raport a/c*	Slump *Tasare* (mm)	Apparent density *Densitate aparentă* (kg/m^3)
1	340	0.479	185	2389
2	360	0.46	180	2403
3	380	0.44	210	2410
4	400	0.43	205	2422
5	420	0.4	215	2429
6	440	0.38	220	2438
7	460	0.36	205	2452
8	480	0.34	210	2463
9	500	0.32	200	2478
10	520	0.31	205	2487

Table 3

Characteristics of hardened concretes, prepared with CEM I 52,5R cement
Caracteristici ale betoanelor întărite preparate cu CEM I 52,5R

No. of recipe *Nr. rețetă*	Cement dosage *Dozaj ciment* (kg/m^3)	Compressive strength / *Rezistența la compresiune* (N/mm^2)			
		18h	48h (2 days)	7 days	28 days
1	340	44.7	61.6	68.7	75.2
2	360	46.1	62.6	72.4	78.8
3	380	52.5	67.3	77.9	84.9
4	400	55.3	69.1	78.8	85.9
5	420	58.3	75.9	88	95.2
6	440	62.8	78.1	89.2	96.9
7	460	78.2	90.0	100.5	104.6
8	480	79.7	92.5	101.1	110.2
9	500	89.8	98.8	104.8	115.0
10	520	91.3	102.6	108.2	120.4

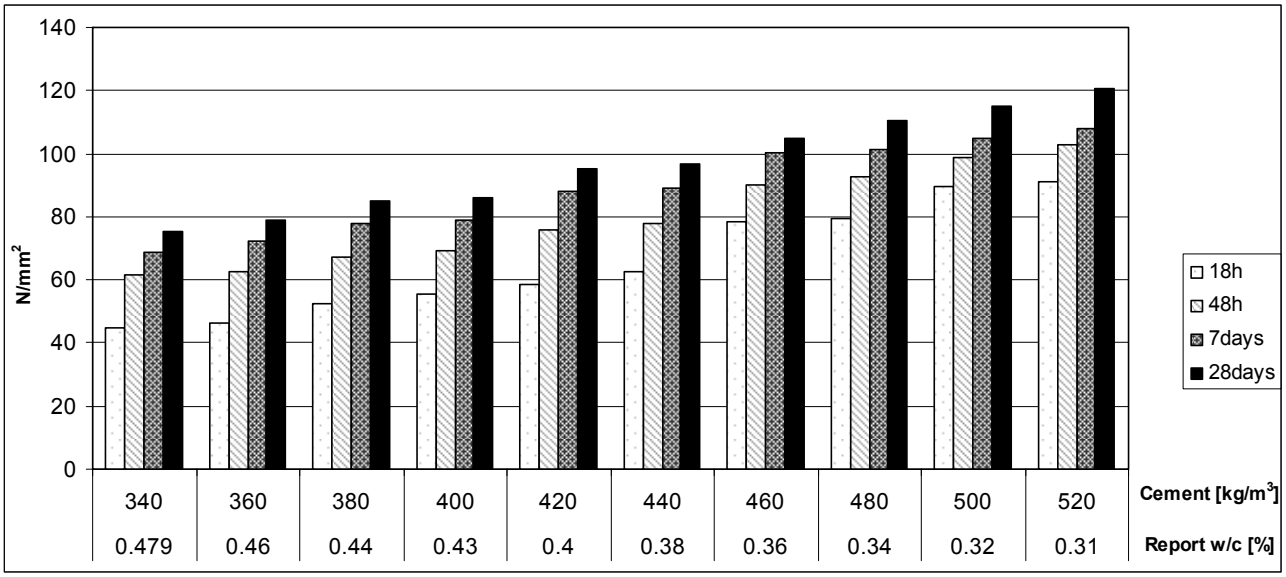

Fig. 1 – The variation of compressive strength as a function of the cement dosage and of W/C ratio / *Variația rezistenței la compresiune în funcție de dozajul de ciment şi de raportul a/c.*

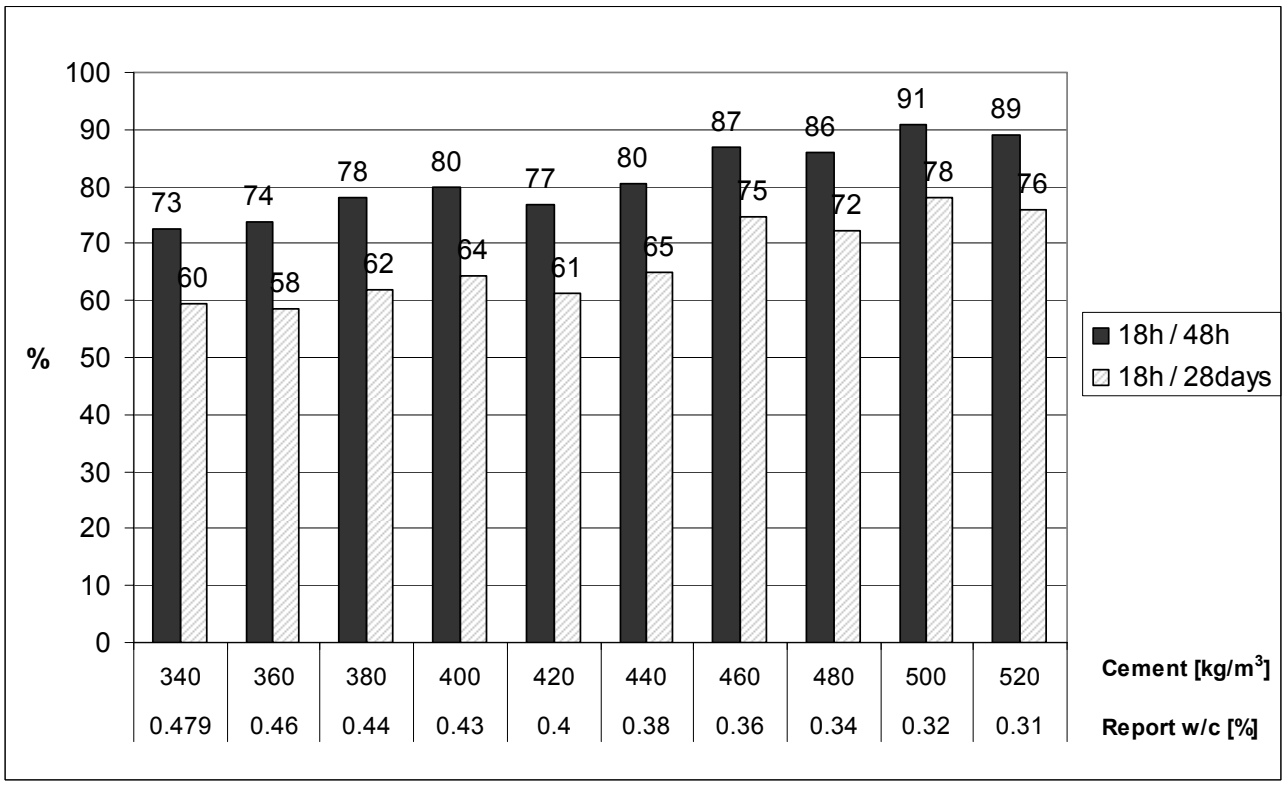

Fig. 2 – Ratio between the compressive strengths at 18 hours and 48 hours and respectively 18 hours and 28 days for concretes prepared with different cement dosages and various W/C ratios / *Raportul între rezistențele la compresiune la 18 ore şi 48 ore şi respectiv 18 ore şi 28 zile pentru betoanele preparate cu diferite dozaje de ciment şi rapoarte a/c variabile*

This condition is imposed due to the necessity to reach enough compressive strength of concrete in order to take over the efforts from the pre-laid reinforcing at the transfer moment (when the reinforcing braids are cut).

In order to evidence this characteristic, in Figure 2 is presented the report between the compressive strengths at 18 hours and 28 days (the moment of determining the strength class) for concretes prepared with different cement dosages and variable w/c ratios. The ratio between the strengths obtained on concrete at 18 hours and 48 hours has been supplementary calculated.

In accordance with CP 012/1 [3], in order to determine the concrete class depending on the compressive strengths obtained at 28 days, conformity criteria must be applied.

In the case of initial test to determine the concrete composition in order to reach a certain concrete class, the compressive strength obtained

at 28 days, after storing the samples under standard conditions, must be higher than f_{ck} + 6...12, as follows:

$$f_{cm} \geq f_{ck} + 6\ldots12 \quad (1)$$

where f_{ck} is the characteristic strength (concrete class) and the margin of at least 6 N/mm^2 up to 12 N/mm^2 depends on the production facilities, the materials components and the available information concerning the possible variations.

In case of applying the f_{ck} + 8 N/mm^2 relation, the classes obtained are presented in Table 4.

When the concrete is produced in a plant where the production control certification exists, the following conformity criteria applies, for a defined concrete volume:

$$f_{cm} \geq f_{ck} + 1 \quad (2)$$

(for 2 – 4 results of compressive strength for defined concrete volume)

$$f_{ci} \geq f_{ck} - 4. \quad (3)$$

In current cases (current production/continuous or defined volume of concrete produced by a plant without production control certification) the following criteria apply:

$$f_{cm} \geq f_{ck} + 4 \quad (4)$$

$$f_{ci} \geq f_{ck} - 4 \quad (5)$$

The results obtained in the experimental conditions of this work shows, also in accordance with those given in [9], the importance of choosing the type of cement to ensure durability of concrete constructions and for the establishment of performance levels for concrete preparations with cements (including cement type CEM I 52.5 R) manufactured in accordance with SR EN 197-1 [4].

4. Conclusions

(a) Cement type CEM I 52.5R produced in accordance with the standard SR EN 197-1 is intended for use in a wide range of products for construction: prefabricated (pre-cast) components, reinforced concrete and precompressed concrete, autoclaved cellular concrete, adhesives for ceramic tiles and dry mortars pre-packaged etc.

(b) This case study on concrete realized with CEM I 52.5R type cement has shown that there is dependency between cement dosage, water/cement ratio and quality parameters of concrete taken into consideration in this work: slump, apparent density of fresh concrete and compressive strength at variable terms. Results of this study confirms classification of CEM I 52.5R cement in the category of high-performance cements; this framing makes them possible to use in the applications of the toughest.

(c) Applying the conformity criteria under experimental conditions in this work, has highlighted the possibility to obtain concrete strength classes range from C55/67 up to C100/115 by using a CEM I 52.5 R type of cement.

Table 4

Concrete classes obtained from CEM I 52.5R cement according to CP 012-1* provisions
*Clase de beton obținute din ciment CEM I 52,5 R în conformitate cu prevederile CP 012-1**

Cement dosage *Dozaj ciment* (kg/m^3)	W/C ratio *Raport a/c*	Compressive strength *Rezistența la compresiune* (N/mm^2)	Initial tests *Încercări inițiale*	Continuous production *Producție continuă*	Defined concrete volume *Volum de beton definit*
		28days	f_{ck} + 8 N/mm^2	f_{ck} + 4 N/mm^2	f_{ck} + 1 N/mm^2
340	0.479	75.2	C55/67	C55/67	C55/67
360	0.46	78.8	C55/67	C55/67	C60/75
380	0.44	84.9	C60/75	C60/75	C60/75
400	0.43	85.9	C60/75	C60/75	C60/75
420	0.4	95.2	C70/85	C70/85	C70/85
440	0.38	96.9	C70/85	C70/85	C80/95
460	0.36	104.6	C80/95	C80/95	C80/95
480	0.34	110.2	C80/95	C90/105	C90/105
500	0.32	115.0	C90/105	C90/105	C90/105
520	0.31	120.4	C90/105	C100/115	C100/115

* The results of this laboratory study have informative/ provisional character. Based on these results the consumptions of materials can be improved in order to obtain concrete classes within normal technological conditions to manufacture concretes on wide range.

* *Rezultatele acestui studiu de laborator au caracter informativ - orientativ. Pe baza acestora se pot optimiza consumurile de materiale pentru obținerea claselor de betoane în condiții tehnologice normale pentru fabricarea la scară largă a betoanelor.*

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