Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
Make Harmony Between Technology and Nature, and Your Mind will Fly Free as a Bird
Annals of DAAAM International

HIGH PERFORMANCE CONCRETES FROM ROMANIA

BUCHMAN, I[osif] & IGNATON, E[lemer]

Abstract: *The theoretical studies and the experimental researches made by the authors regarding the obtaining and the research of high performance concretes are presented in this paper. There were researched the high performance concretes with medium compressive strength between 60-80 N/mm^2. There were elaborated the obtaining principles, the compound materials preparing, the physical, mechanical and chemical characteristics and the existing and the possible using domains.*
Key words: *superplasticizer, silica fume, aggressive, elasticity*

1. INTRODUCTION

The experimental researches regarding concrete development witnessed lately two significant stages.
The first stage consists in the perfecting of high performance concretes (Malier, 1990) characterized by a compression strength which exceeds 60 N/mm^2, as well as by other improved characteristics, such as the elasticity module, the contraction, the tranquil flow, the frost-thawing proof, the wear-proof, the impermeability, the resistance to aggressive chemical agents. They have been and are being studied in countries such as USA, Canada, France, Germany, Scotland, Norway, Japan, and are used at high buildings, large span bridges, marine structures, a.o.
The second stage included Western Europe, starting with the ninth decade of the last century. It refers to ultra high performance concretes, which, besides a very high compression strength of 200 N/mm^2 , or even more, also have other performance characteristics, such as water tightness and gas proofness, placement without passive reinforcement, resistance to aggressive chemical agents, a.o.
High performance concretes are considered the present time concretes, and the ultra high performance ones are considered the concretes of the future.
Following two specializations attended by one of the authors in France, there has been initiated the research of these concretes types in Romania, as well.
This paper presents the theoretical studies and the experimental researches carried out by the authors concerning high performance concretes obtaining and some of their characteristics. Thus, there have been obtained and there have been studied high performance concretes with the average compression strength ranging within 60-80 N/mm^2.

2. COMPOSITION AND PREPARING

The specific components of the high and very high performance concretes are the superplasticizer additives and the ultrafine granular materials.
The first superplasticizer additives belonged, mostly, to one of the following categories of chemical compounds: sulphonated melamine resins and sulphonated naphthalenic resins. At present, in Romania, there are marketed other efficient types of superplasticizer additives.
The granular materials, such as the ultrafine silica, adds to the cement granulometry, namely reacts with $Ca(OH)_2$ resulted at the cement hydration, there being obtained a very tight microstructure.
The establishing of the composition of a high or very high performance concrete is more complex than for the usual concrete, because there occur new parameters, namely: the superplasticizer additive and the ultrafine silica.
The authors' team has established that a very simplified way of establishing the composition of a high performance concrete supposes the following stages:
- there is established the composition of a usual concrete, whose class is 1.5 times smaller than the intended one for the high performance concrete, and this is completed with 10% silica fume (as compared to the cement mass) and 1-2% superplasticizer additive (as compared to the cement+silica mass);
- at preparing, the water quantity is reduced to make the high performance concrete have a consistency identical to that of the usual concrete, and after 28 days there is checked the compresion strength of the high performance concrete thus obtained, and, if needed there are applied corrections concerning the cement, ultrafine silica or superplasticizer ratios.

The preparing of high performance concretes can be carried out with the same equipment employed for the usual concrete. To obtain a good homogeneity and to shorten the mixing time, there shall be used wet mixers with forced mixing provided with paddles and pugmill. The sequence of the mixing operations is as follows:
- cement mixing with the silica fume;
- the introduction of the aggregates and the dry mixing of the granular components;
- the adding of water in which there has been disolved the superplasticizer, followed by the mixing going on.

The mixing time depends on the characteristics of the equipment employed. Compaction is obtained through vibration, as for the usual concrete.

3. COMPRESSION STRENGTH

Within the experimental researches that have been carried out (Buchman et al., 2001, 2003), there have been cast and compression tested 4 series of high performance concretes. The compositions have been established according to the presentation made at point 2.
There have been used the following materials:
- cement of CEM I 42.5 R type (series 1, 2), or of CEM I 42.5 type (series 3, 4);
- river aggregates with d_{max}=16 mm;
- silica fume from FEROM Tulcea;
- LOMAR D superplasticizer of foreign source (series 1, 2. 3), or FORTERA superplasticizer of indigenous source (series 4);

Series 4 have been obtained only with indigenous materials.
Table 1 showes that there have been obtained high performance concretes with on average compression strength, after 28 days, ranging within 63.5 and 84.9 N/mm^2.

Series		Dosage, (kg/m³)						ρ_a Kg/m³	R_c N/mm²	R_c^{HPC} / R_c^{CC}
		C	W	Ag	SUF	SP	W/L			
1	CC	580	235	1585	-	-	0,40	2382	55,2	1,41
	HPC	587	181	1607	58,7	6,4	0,28	2419	77,6	
2	CC	588	223	1609	-	-	0,38	2335	56,3	1,51
	HPC	588	179	1608	58,8	6,4	0,28	2356	84,9	
3	CC	566	232	1602	-	-	0,41	2279	37,1	1,71
	HPC	586	188	1660	58,6	6,4	0,29	2370	63,5	
4	CC	639	227	1509	-	-	0,35	2326	48,5	1,57
	HPC	642	203	1517	64,2	7,2	0,29	2385	76	

Obs.: 1). HPC – high performance concretes; CC – conventional concretes (blank test);
2). C, W, Ag, SUF, SP, L – cement, water, aggregates, silica fume, superplascizer and binding agent (cement + silica fume).

Tab. 1. Concretes ratios and some of their characteristics

4. THE ELASTICITY MODULE

The elasticity module (E) has been determined on 3 types of concrete: a usual reference concrete (a mark one) and 2 high performance concretes (one with Lomar D superplasticizer of foreign source, and the other with FORTERA superplasticizer of Romanian source). The results are presented in table 2.
The researches concerning the elasticity module show larger values for the high performance concretes as compared to the usual concrete.

5. RESISTANCE TO AGGRESSIVE ENVIRONMENTS

The experimental researches carried out by the autors team (Buchman et al., 2003) studied the resistance in NH_4NO_3 environment and the penetration of chlorine ions.
The concretes resistances after the chemical attack are given in table 3.
For the chlorine ions penetration, the concretes samples (CC and HPC) have been kept 90 days in NaCl solution of 2.5 g/l concentration. The penetration depth of the chlorine ions determining has been carried out according to SR 13380(1997).

The concrete type	Age (days)	Compression strength (N/mm²)		The elasticity module	$\frac{E^{HPC}}{E^{CC}}$
		Cubic	Prismatic		
CC	28	55,2	36,6	30 690	–
HPC with LOMAR	28	77,6	67,6	33 230	1,09
HPC with FORTERA	28	73,2	66,5	32 430	1,06

Tab. 2. The elasticity module

The concrete type	The solution-concentration, (%)	The initial R_c (N/mm²)	The R_c after the attack (N/mm²)	Δ R_c (%)
BO	62.2	48.5	36.1	25.6
BIP		76.0	70.1	7.8

Tab. 3. Concretes resistance before and after the attack with NH_4NO_3

The results thus obtained are presented in table 4.

Concrete type	Penetration depth, mm
Usual concrete (mark)	3-5
High performance concrete	0-1

Tab. 4. Penetration depth of the CL ions

6. CONCLUSION

Following the experimental studies and researches that have been made so far, there can be drawn out the conclusions given below:

- The high performance concretes preparing and placement can be carried out by using the same equipment and procedures employed for the usual concrete.
- The high performance concretes have, besides the compression strength, other improved characteristics, as well, namely: the elasticity module, the contraction, the tranquil flow, the frost-thawing proof, the impermeability, the resistance to aggressive chemical agents.
- The own experimental researches have led to the obtaining of some high performance concretes with a compression strength ranging within 63.5 and 84.9 N/mm², one of the compositions having been obtained only from indigenous materials.
- The researches concerning the elasticity modules show larger values for these modules for the high performance concretes as compared to those for the usual concrete.
- The BIP resistance to the attack of NH_4NO_3 (the ammonium ions) is significantly increased. After 90 days of keeping in concentrated solution of NH_4NO_3 (62.2%), the BIP compression strength lowered with only 7.8%, while the compression strength of the usual concrete (mark) lowered with 25.6%.
- The penetration depth of the chlorine ions is much smaller at BIP: the penetration depth has been of 0 - 1 mm at BIP and 3-5 mm at BO.

7. REFERENCES

Buchman I., Bob C., Jebelean E., Badea C. (2001) *High performance concretes. Documentary study and experimental researches concerning high performance concretes obtaining.* Work synthesis. Grant A, UP Timişoara contract nr.34977/2001, theme 9 code CNCSIS 872, Timişoara, 8 pages

Buchman I., Bob C., Jebelean E., Badea C. (2003) High performance concretes. Determining of the wearing resistance, the frost-thawing proof, and of the resistance in an aggressive environment. The work synthesis. *Grant A, UP Timişoara contract nr.33501/2002, theme 7, code CNCSIS 504, Timişoara, 8 pages*

De Larrard F., Malier Y. (1990) *Propriétés constructives des bétons à trés hautes performances - de la micro à la macrostructure.* v.Malier (1990), 107-138