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THE BEST SCC: STABLE, DURABLE, COLORABLE

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ABSTRACT: A special Self-Compacting Concrete is presented in this paper. It is a shrinkage-free concrete even in the absence of any wet curing due to the combined use of a CaO-based expansive agent and a particular superplasticizer containing a chemical group in its molecular structure acting as a shrinkage-free admixture.
Moreover, it is a special Self-Compacting Concrete for the low water-cement ratio (≤ 0.45) adopted for durability reason.
Finally, this Self-Compacting Concrete is a colored material specially devoted to architectural structures with ist surface protected by the growth of organic micro-organisms such as fungi and lichens.

Keywords: Durability, Espansive agent, SCC, Colored Concrete.

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INTRODUCTION

The purpose of the research described in the present paper was to optimize the available knowledge in the area of chemical admixtures (1-3) to manufacture the best SCC for architectural structures. In particular the following chemical products were taken into account:

- a special superplasticizer PC-SRA based on poly-carboxylate (PC) in which functional groups of polypropylen glycol, acting as shrinkage-reducing admixture (SRA), are attached to the molecular structure of the PC;
- the combination of this special polymer PC-SRA, acting as superplasticizer and a shrinkage-reducing admixture, with a CaO-based expansive agent;
- the use of inorganic pigments to manufacture colored SCC;
- the use of hydro-phobic admixture (HPh) to preserve the colored surface from humidity and then from the growth of organic micro-organisms such as fungi, lichens, etc.

Therefore a set of special compositions of SCC were studied and their performances were comparatively assessed.

The following compositions were examined:

A) a SCC with w/c ratio not higher than 0.45 where a "regular" PC-based superplasticizer was used;

B) the same SCC as that of **A**) but with a special PC-SRA superplasticizer capable of liberating the chemical group acting as SRA;

C) the same SCC as that of **B**) but with the addition of a CaO-based expansive agent;

D) the same SCC as that of **C**) but with the addition of an inorganic pigment;

E) the same SCC as that in **D**) but with the addition of a hydro-phobic admixture based on alkyl-silane.

The following compositional parameters for manufacturing SCC were adopted:

$$200 > V_c+V_f > 170 \text{ L/m}^3 \qquad [1]$$

where V_c and V_f are the volume of cement and filler respectively;

$$V_g < 340 \text{ L/m}^3 \qquad [2]$$

$$D_{max} \leq 25 \text{ mm} \qquad [3]$$

where V_g (in L/m^3) is the volume of gravel and D_{max} is the maximum size of the aggregate;

$$1.20 > V_w/(V_c + V_f) > 0.85 \qquad [4]$$

where V_w is the volume (in L/m^3) of the mixing water.

DURABLE SCC

The first column of Table 1 shows the composition of the **A**-type SCC characterized by a w/c not higher than 0.45 for durability purposes. Portland cement was used in combination with ground limestone filler for a total volume of fine materials of $305/3.15+275/2.7 = 199$ L/m^3 where 3.15 and 2.7 are the specific gravity (in kg/L) of the portland cement and ground filler respectively. About 274 L/m^3 of gravel, with maximum

size of 16 mm, were used which correspond to 740 kg/m^3. The $V_w/(V_c+V_f)$ was 195/199 = 0.98

The workability loss of this SCC was relatively small because the slump flow descreased from 750 mm to 680 mm in 2 hours.

The 28-day compressive stength of 45 MPa is related to the w/c as low as 0.45.

The PC-based superplasticizer was combined with a Viscosity Modifying Agent (VMA) to manufacture a segregation-resistant SCC.

The second column of Table 1 shows the **B**-type SCC, where a special superplasticizer (PC-SRA), including a SRA component in its molecular structure, was used. The performances, in terms of slump-flow, workability loss and compressive strength at early and later ages, are the same as those of the **A**-type SCC, the only difference being the drying shrinkage. This was measured on plain concrete beams kept at R.H. of 50% during the first 6 months after demolding the specimens at 2 days (Fig. 1). Due to the functional group acting as a SRA, the drying shrinkage of the **B**-type SCC is about 50% of that of the **A**-type SCC during the first 1-2 months and 40% at later ages.

DURABLE AND SHRINKAGE-FREE SCC

The third column of Table 1 shows the composition of the **C**-type SCC characterized by the additional presence of a CaO-based expansive agent (35 kg/m^3) with respect to the **B**-type SCC. Due to the presence of the expansive agent, the amount of the limestone filler has been reduced by 35 kg/m^3. Because of the synergic effect of the SRA funcional group, liberated by the superplasticizer, and the CaO-based expansive agent (4), a restrained expansion occurs even in the absence of any wet curing (Fig. 2). The expansion-shrinkage behavior of the reinforced concrete beams of the three types of SCC (**A**, **B** and **C**) was measured according to the ASTM 878 test except for the absence of the initial wet curing in lime-saturated water. Indeed, during the first two days the specimens were only

protected from drying by using a polyethlene cling-film to simulate the hygrometric situation of real concrete structures inside the formworks before the demolding.

The results of Fig. 2 indicate that even at longer ages (6 month permanently at R.H. of 50%) there is still a significant self-stressing state of the reinforced specimens manufactured with the **C**-type SCC.

DURABLE, STABLE AND COLORABLE SCC

The fourth column shows the composition of the **D**-type SCC. This is a colored SCC which contains an inorganic pigment (cobalt-salt based) in addition to the other ingredients of the **C**-type SCC.

The amount of the limestone filler has been furtherly reduced by 20 kg/m^3 corresponding to the amount of the powder pigment used to manufacture the colored SCC.

The fifth column shows the composition of the **E**-type SCC where an hydro-phobic admixture has been used to protect the surface of the colored concrete from the growth of organic substances which can disfigure the aesthetical aspect of the structures in humid environments.

Figure 4 shows the aspect of the colored SCC treated by hydrophobic admixture to protect the surface from wetting and then keep the original aestetical aspect even at longer ages.

Both the **D**-type and the **E**-type perform as well as the **C**-type shrinkage-free SCC (Fig. 3) as far as the restrained expansion is concerned even in the absence of any wet curing.

The workability loss characteristics and the compressive strength of these colored SCC are substantially the same as those of the other SCC.

CONCLUSIONS

A stable, durable, and colorable SCC has been developed by the combination of the following ingredients:

- a special superplasticizer based on polycarboxylatye containing a SRA functional group in its molecular structure;
- CaO-based expansive agent which, in the presence of the SRA chemical group, is active even in the absence of any wet curing as usually required by expansive agents;
- inorganic pigment to color the concrete and a hydrophobic admixture to protect the surface of the colored concrete from the growth of organic micro-organisms capable of disfiguring the aestetical aspect.

REFERENCES

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Table 1 Compositions and performances of SCCs

MIX TYPE	A	B	C	D	E
Ingredients (kg/m^3)					
• Portlad Cement (II B/L 32.5R)	305	305	305	305	305
• Filler	275	275	240	220	220
• Sand (0-4 mm)	800	800	800	800	800
• Gravel (4-16 mm)	740	740	740	740	740
• CaO	----	----	35	35	35
• Pigment	----	----	----	20	20
• Water	190	190	195	195	195
• Superplasticizer*	7	7	8	8	8
• Viscosity Agent	1	1	1	1	1
• Hydrophobing adm.	----	----	----	----	1
Slump Flow (mm)					
• 5 min	750	755	745	740	740
• 30 min	750	750	740	730	740
• 60 min	740	745	735	730	735
• 90 min	720	710	705	725	730
• 120 min	680	680	690	685	680
• Bleeding	no	no	no	no	no
Compressive Strength (MPa)					
• 1 day	12	11	13	13	10
• 3 days	20	19	21	20	19
• 7 days	34	33	36	33	32
• 28 days	45	44	47	44	44

** Polycarboxylate-based superplasticizer only for mix **A**; for the other mixtures the PC-SRA type was used as superplasticizer*

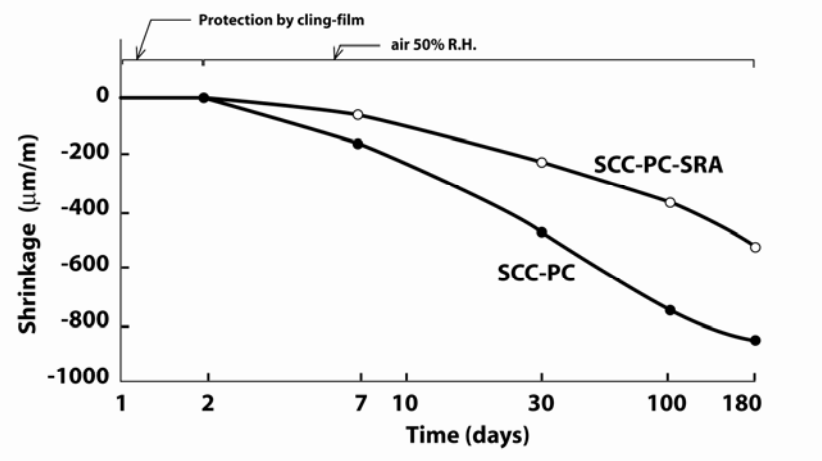

Figure 1 Influence of SRA on the shrinkage of plain concrete specimens.

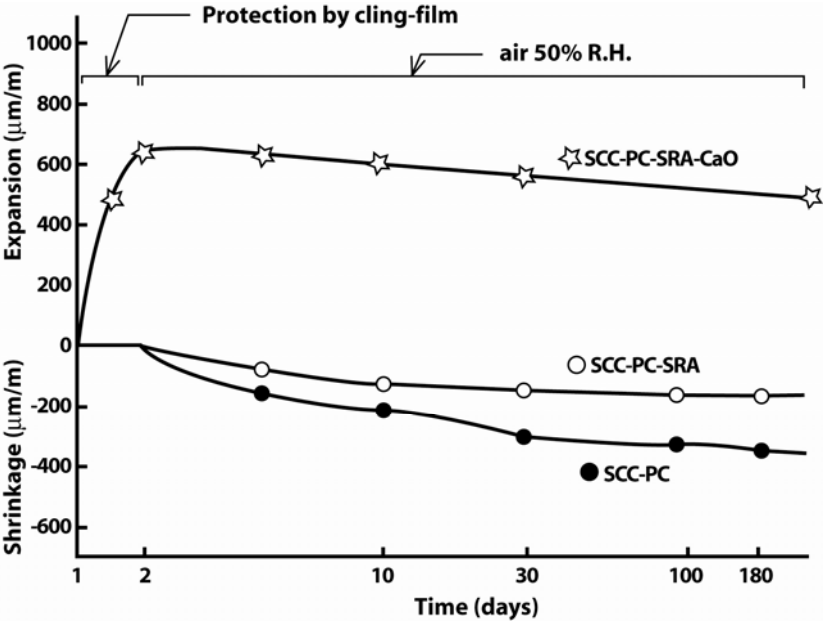

Figure 2 Length change of reinforced concrete specimens in the absence (SCC-PC and SCC-PC-SRA) or in the presence of CaO (SCC-PC-SRA-CaO).

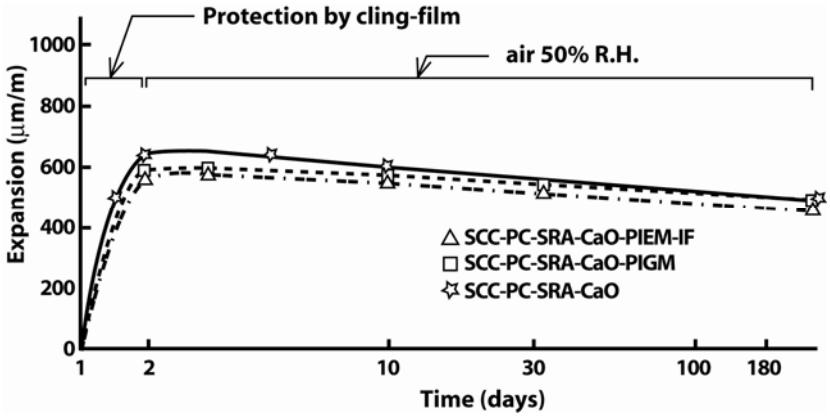

Figure 3 Influence of inorganic pigment (PIGM) and hydrophobic admixture (HPh) on the expansion of reinforced concrete speciments all with CaO (35 kg/m^3).

Figure 4 Colored SCC placed into a plastic bottle and then demoulded. Note on the right the drops of water not absorbed by the concrete skin.