CRACK-FREE CONCRETE FLOORS WITHOUT METALLIC WIRE-MESH AND WET-CURING

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Abstract

A research work, based on laboratory and field tests, was made to manufacture crack-free industrial concrete floors without wet curing and metallic wire-mesh. To do this, a shrinkage-reducing admixture (*SRA*) was used with and without high-range water reducer in form of polycarboxylate superplasticizer (*PCS*), and with or without polypropylene fibres (*PPF*). Thanks to the use of *PPF* in combination with *PCS* and *SRA*, crack-free industrial reinforced-concrete floors were achieved in the absence of wet curing without any wire-mesh with advantages in the execution of the floor.

Keywords
Ready-mixed concrete. Industrial floor concrete. Polymer fibers. Superplasticizer. Shrinkage-reducing admixture. Cracked concrete.

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1. INTRODUCTION

Concrete industrial floors usually include a metallic wire-mesh which should be correctly placed at one-third of the floor thickness from the top. The role of the metallic mesh is to reduce the opening of the cracks on the concrete surface particularly because of the drying shrinkage. However, the metallic mesh can be moved from its correct position during concrete placement because of the workers walking on the floor and/or the passage of truck-mixers on it. Because of these un-proper movements, the metallic wire-mesh may become ineffective.

A special research work, based on laboratory and field tests, was made to produce crack-free industrial concrete floors without wet curing and metallic wire-mesh. To do this, a shrinkage-reducing admixture (*SRA*) was used with and without high-range water reducer in form of polycarboxylate superplasticizer (*PCS*), and with or without polypropylene fibres (*PPF*).

2. Experimental

Materials and results will be shown in the following paragraphs.

2.1 Materials

Blended Portland cement with 15% of fly ash (CEM II A-V 42.5 N, according to the European Standard EN 197-1) was used in combination with natural aggregates including sand (0-4 mm), gravel (4-16 mm) and coarse aggregate (16-32 mm). A polycarboxylate-based superplasticizer (*PCS*) in form of an aqueous solution containing 20% of active matter was used at a dosage of about 0.6% by mass of cement in order to reduce the amount of mixing water by 15%. A poly-ethylene glycol based *SRA* was used at a dosage of 4.5 kg/m^3 of concrete (1). Polypropylene macro-fibres (*PPF*) -30 mm long and 0.95 mm in diameter- were used at a dosage of 3.5 kg/m^3 (2).

Table 1 shows the composition of four concrete mixtures all at given *w/c* (0.60) and slump level (220-240 mm). With respect to the plain concrete (*Control-mix*), the amount of both the mixing water and cement in the superplasticized concrete (*PCS-mix*) was decreased by 15% in order to keep the same *w/c* and slump; the aggregate volume was increased to compensate the decrease of volume in mixing water

and cement; therefore, the aggregate-cement ratio (*a/c*) of the *PCS-mix* was higher than that of the *Control-mix* (6.5 against 5.1).
In other words, the superplasticizer was used as a water reducer at given *w/c* and slump level just to reduce the drying shrinkage by increasing the aggregate/cement ratio. Table1 also shows the composition of concrete mixtures containing *SRA* (*SRA-mix*) or *PPF* (*Fibre-mix*) with *w/c* (0.60) and *a/c* (5.3) very close to those of the *Control-mix*.

Table 1 Composition of concrete mixtures

INGREDIENT (kg/m^3)	CONTROL MIX	PCS MIX	SRA MIX	PPF MIX
CEM II A-V 42.5 N *	350	297	345	350
Sand 0-4 mm	915	982	927	910
Gravel 4-16 mm	395	424	400	393
Gravel 16-32 mm	483	519	490	482
Water	210	178	207	210
PCS: Polycarboxylate superplasticizer	—	1.8	—	—
SRA: Shrinkage-reducing admixture	—	—	4.5	—
PPF-polypropylene fibres	—	—	—	3.5
w/c	0.60	0.60	0.60	0.60
a/c**	5.1	6.5	5.3	5.1
Slump (mm)	230	240	235	220

* CEM II A-V 42.5 N: High strength blended cement with 15% by weight of fly ash
** a/c: aggregate/cement ratio by weight

Table 2 Composition of concrete mixtures containing 2 or 3 additions

INGREDIENT (kg/m^3)	**SRA-PCS MIX**	**SRA-PPF MIX**	**SRA-PCS-PPF MIX**	**PCS-PPF MIX**
CEM II A-V 42.5 N	290	345	294	300
Sand 0-4 mm	1010	964	990	989
Gravel 4-16 mm	434	416	427	427
Gravel 16-32 mm	534	510	524	524
Water	174	207	176	180
PCS	1.8	—	1.8	1.8
SRA	4.8	4.8	4.8	—
PPF	—	3.5	3.5	3.0
w/c	0.60	0.60	0.60	0.60
a/c	6.8	5.5	6.6	6.5
Slump (mm)	240	220	230	220

Table 2 shows the composition of the concrete mixtures containing two additions (*SRA+PCS* or *SRA+PPF* or *PCS+PPF*) or all the three additions (*SRA+PCS+PPF*). Again, with respect to the *Control-mix* (Table 1) the slump level (about 230 mm) and the *w/c* (0.60) were kept constant and the aggregate-cement ratio was increased at about 6.7 in the concrete mixtures containing the superplasticizer *PCS*.

2.2 Results of laboratory tests

Laboratory tests were carried out to determine compressive strength of cubic specimens (150 mm) at 1-28 days at 20°C and relative humidity (*RH*) >95%. The drying free shrinkage of prismatic specimens (100x100x500 mm) demoulded at 1 day was measured at 20°C in a room with *RH* of 55% for 6 months.
Figure 1 shows the compressive strength of the concrete mixtures shown in Table 1. The strength development is approximately the same independently of the concrete mixture because the *w/c* is the same (0.60): about 5 MPa at 1 day; 25 MPa at 7 days; 35 MPa at 28 days. Similar results were obtained in concrete mixtures shown in Table 2.

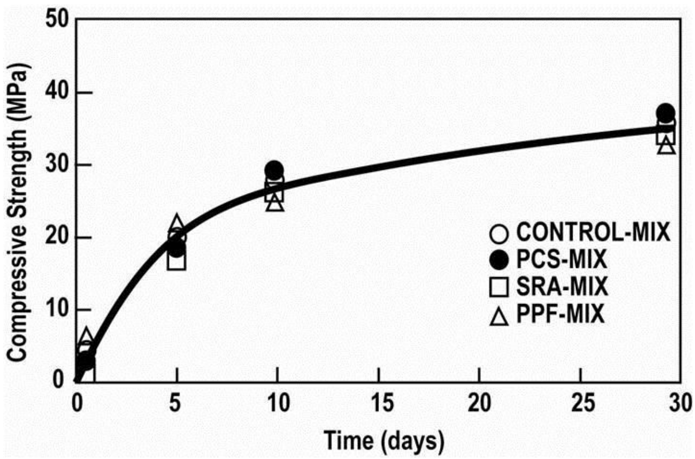

Figure 1 Cube compressive strength of different mixtures

Figure 2 shows the drying shrinkage of the concrete mixtures shown in Table 1. The shrinkage of the *SRA-mix* is strongly reduced with respect to that of the *Control-mix*, particularly at early ages: the reduction is about 50% at 1 month and 40% at 6 months. The shrinkage of the *PCS-mix* is decreased by about 35% at 1 month and at 6 months with respect to the *Control mix*. On the other hand, the shrinkage of the *PPF-mix* is substantially the same as that of the *Control-mix*.

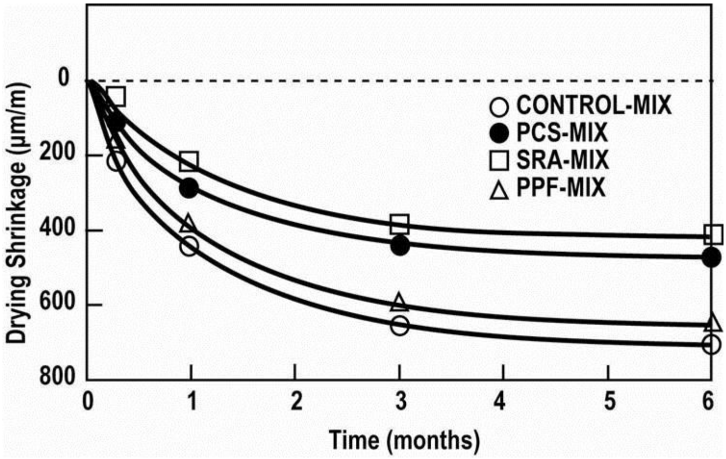

Figure 2 Free drying shrinkage (R.H. = 55%) of mixtures shown in Table 1

Figure 3 indicates that in *SRA-PPF-mix* or *PCS-PPF-mix* there is a decrease in the shrinkage at 1-6 months by about 45% with respect to that of the *Control-mix*. The combined addition of *SRA* and *PCS* in the *SRA-PCS-mix* is even more effective in reducing the drying shrinkage: the decrease is about 65% with respect to that of the *Control-mix*. The addition of fibres to the concrete with *SRA* and *PCS* does not produce any further reduction in the shrinkage, thus confirming that the polymeric fibres do not affect the drying shrinkage but only the post-cracking behaviour of the concrete.

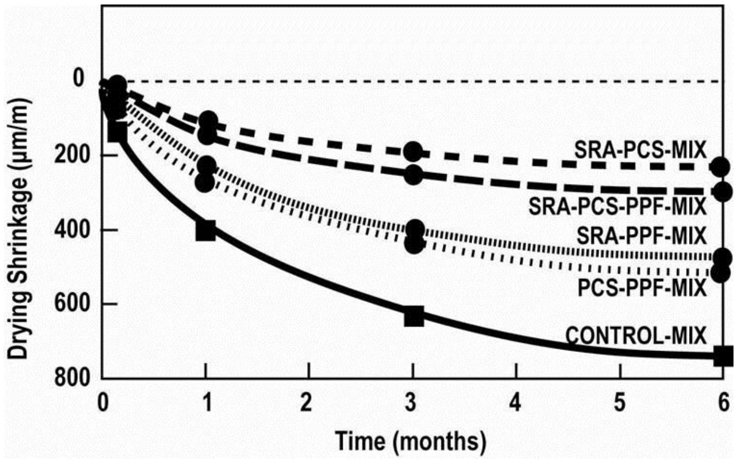

Figure 3 Free drying shrinkage (R.H.= 55%) of mixtures shown in Table 2

2.3 Results of field tests

Field tests were carried out to check the appearance of cracks in restrained concrete slabs (8 m long, 400 mm wide and 60 mm thick) kept in the open air in the same exposure conditions of temperature, *RH* and wind speed (Fig. 4). The slabs were fixed on the foundation at the two ends, so that the restrained shrinkage caused by drying in the open air produced cracks, if any, on the surface of concrete. The opening and the number of cracks were recorded to assess the behaviour of the concrete mixtures in the open air.

Figure 4 Field tests on restrained drying shrinkage of concrete slabs (8 m long, 400 mm wide and 60 mm thick)

The cracking behaviour was studied in the field tests shown in Fig. 4. The number and the width of cracks caused by the restrained shrinkage of slabs are shown in Table 3. These results indicate that both *SRA* and *PCS* reduce the number and the width of the cracks. This effect is increased when both these chemical admixtures are used together (*SRA-PCS-mix*). Only by using *SRA*, *PCS* and *PPF* a crack-free concrete slab was obtained. In Fig. 5 the visual observation of some cracks in the concrete slabs is shown.

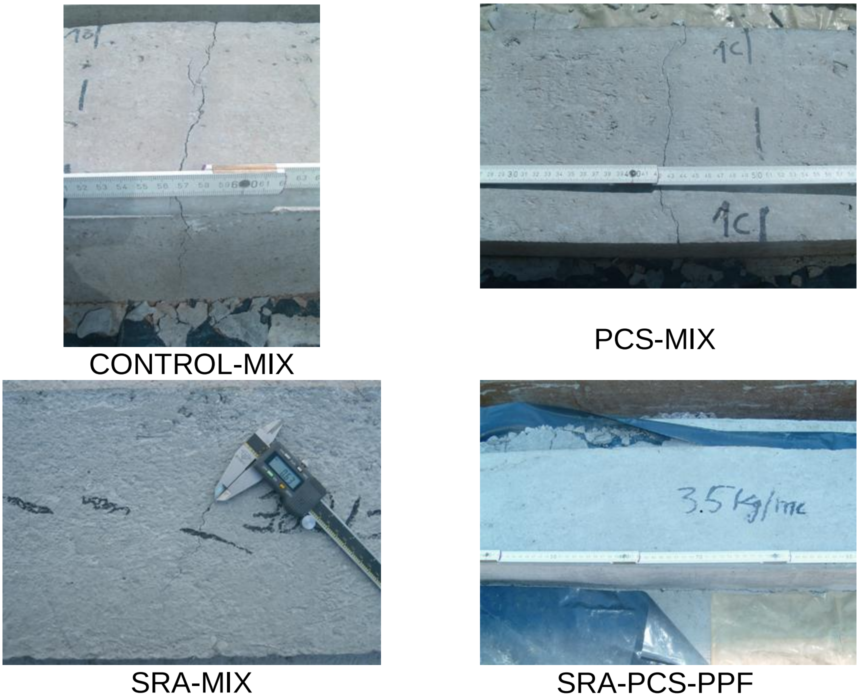

Figure 5 Cracking behaviour in the field tests of control-mix, SRA-mix, and SRA-PCS-PPF mix

These results indicated that *SRA-PCS mix* and *SRA-PCS-PPF-mix* are the best concrete in terms of crack-free characteristics. Therefore, these two concretes were selected for casting real industrial concrete floors that were protected for 1 day by plastic sheets without any further wet curing or application of curing compound: the industrial concrete floor with the *SRA-PCS-mix* was placed by using a steel wire-mesh (Fig. 6), whereas the *SRA-PCS-PFF-mix* was placed without the metallic wire-mesh (Fig. 7).

Figure 6 Placing of SRA-PCS-Mix in the concrete floor in the presence of the steel mesh

Figure 7 Placing of the SRA-PCS-PPF-Mix by chute from the truck mixer for the concrete floor without the steel mesh

The contraction joints were located at an interval of 5 m in the floor with the metallic wire-mesh embedded in the concrete with *SRA* and *PCS* admixtures; this interval was increased up to 8 m in the floor where the metallic wire-mesh was successfully replaced by the polypropylene fibre addition.

Table 3 Crack distribution in restrained concrete slabs shown in Figure 3

MIX	Number of cracks	Maximum crack opening (mm)
Control-Mix	5	2.13
PCS-Mix	4	1.05
SRA-Mix	2	0.63
SRA-PCS-Mix	1	0.20
SRA-PCS-PPF-Mix	0	----

Two industrial concrete floors (about 800 m^2 each) were cast outside with and without the wire-mesh by placing the concrete mixtures at a super-fluid consistence (slump = 240 mm).
The slabs were subsequently treated on the top by surface hardener and protected for one day from rain or wind by using plastic sheets. No crack was observed in these industrial floors cast without wet curing. Moreover, in the presence of macro-fibres the steel-mesh was removed without any consequence on the crack-free characteristic of the industrial floor. Significant advantages from the productivity point of view were recorded since concrete did not need to be pumped and was placed by chute from the truck mixer (Fig. 6): the placing time was less than 50 % with respect to the placement of the floor in the presence of wire-mesh (Fig. 5).

3. CONCLUSIONS

Thanks to the use of polymer macro-fibres, in combination with a polycaboxylate superplasticizer and a shrinkage-reducing admixture, crack-free industrial reinforced-concrete floors can be achieved in the absence of wet curing without any wire-mesh with advantages in the execution of the floor.

The role played by the macro-fibres is dual:

- to increase ductility and toughness;
- to intercept the small initial fibres by blocking them in length and opening so that, as matter of fact, they are un-visible.

REFERENCES

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