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DAMAGE OF CONCRETE BY EXPOSURE TO CALCIUM CHLORIDE

S. Moriconi, M. Pauri, I. Alverà* and M. Collepardi

Department of Science of Materials and Earth
University of Ancona, Ancona (Italy)

* MAC SpA - R&D Laboratories - Treviso (Italy)

SUMMARY

A strong solution of $CaCl_2$ (30%) causes quick damage of concretes after cooling to 5°C irrespectively of cement type (portland or pozzolanic) or water/cement ratio (0.67 to 0.56). The damage consists of deep cracks.

When the water/cement ratio is much lower (0.35), the damage rate is lower and crumbling at corners or edges rather than cracking is observed.

Aqueous solutions of 10% of $CaCl_2$ or 30-10% of NaCl do not cause damage within the period of the present investigation (60 days).

INTRODUCTION

It is well known that chlorides into a reinforced concrete promote corrosion of steel reinforcement (1-3). This occurs in concrete marine structures exposed to sea water or highway concrete structures subject to de-icing salts.

However, chlorides can damage concrete too besides steel reinforcement. Experimental data on the attack of concrete caused by chlorides are less numerous than those available in technical literature for corrosion of steel reinforcement. Chatterji and Damgaard Jensen (4) have shown a peculiar effect of quick damage of concrete caused by exposure to calcium chloride and subsequent cooling to 5°C, therefore without freezing. This can occur in practice when, for instance, concrete structures, already penetrated by calcium chloride utilized as de-icing agents in the previous winter, are weather cooled in the next winter even in the absence of freezing.

The purpose of the present work was to confirm this peculiar type of damage and to investigate how the quality of concrete could affect this behaviour.

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EXPERIMENTAL

Ordinary portland and pozzolanic cements (300 kg/m^3) have been used to manufacture four concrete mixes with or without superplasticizer based on naphthalene sulfonated polymer (Table 1). The superplasticizer has been used to reduce the w/c ratio at a given slump (110 ± 10 mm). However, all the above four concrete mixes have been manufactured with relatively high w/c ratio which was always higher than 0.56. A fifth concrete mix has been manufactured with a quality level definitely higher than the above mentioned four mixes (Table 1). The difference in the quality has been achieved by using a high strength portland cement, a higher cement content (450 kg/m^3), a significantly lower w/c ratio (0.35).

The specimens of the five concrete mixes have been cured at 20°C for 28 days and then transfered into NaCl or $CaCl_2$ aqueous solution baths at 30°C. The concentration of the two above chloride salts were 10 and 30%. After 14 days the temperature of the baths were lowered from 30 to 5°C. Every day the specimens were visually examined for any sign of crack formation or crumbling.

Table 1
Composition of concrete mixes

Mix No.	Cement type	Cement content (kg/m^3)	Superplasticizer (% by weight of of cement)	w/c	Slump (mm)
1	Ordinary Portland	300	—	0.67	120
2	Ordinary Portland	300	1	0.57	110
3	Ordinary Pozzolanic	300	—	0.65	120
4	Ordinary Pozzolanic	300	1	0.56	105
5	High strength portland	450	2	0.35	120

RESULTS AND DISCUSSION

All the concrete specimens were not damaged when kept at 30°C independently of the chloride salt and its concentration.

Cooling to 5°C was accompanied by cracking of the specimens (Fig. 1) within 3 days when the $CaCl_2$ concentration was 30% and the quality of the concrete was relatively poor (Mixes 1 to 4). For the concrete of higher quality (Mix No. 5) the length of storage required to cause the damage was longer (9 days) and the type of damage was less severe: only crumbling at the edges and corners was observed (Fig. 2).

Table 2 summarizes the type of damage and the length of storage at 5°C before damage appearance for the 30% $CaCl_2$ aqueous solution.

As far as the other aggressive agents are concerned (10% $CaCl_2$ and 10% or 30% NaCl aqueous solutions) no damage has been observed throught the period of this investigation, i.e. 60 days.

CONCLUSIONS

a) NaCl solutions (10 to 30%) do not cause any damage in all concrete specimens;

b) A strong solution of $CaCl_2$ (30%) causes quick damage after cooling to 5°C irrespectively of cement type (portland or pozzolanic);

c) in concrete specimens with water/cement ratio higher than 0.55, the damage generally consists in deep cracks formation;

d) when the water/cement ratio is very low, such as 0.35, the concrete is damaged more slowly and the breakdown consists in a surface crumbling rather than in deep cracks formation.

e) it is preferable not to use $CaCl_2$ as a de-icing agent on any cement concrete structure.

A

B

Fig. 1
An overall view of the nature of cracking (A) and a near view with details of cracks (B).

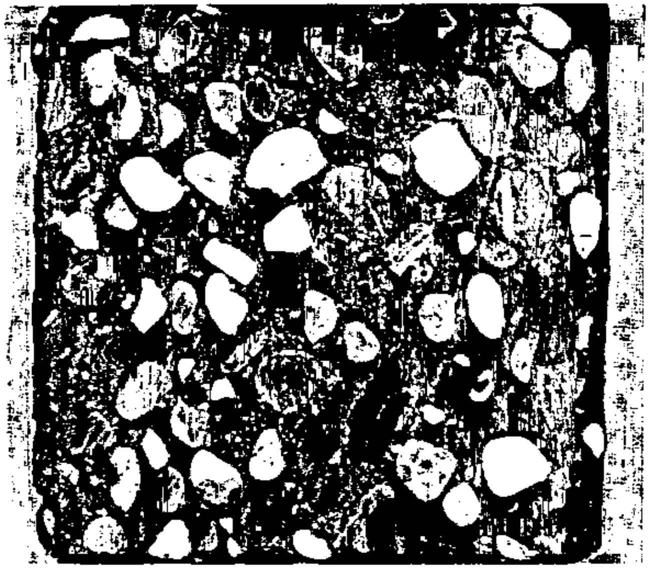

Fig. 2
An overall view of the Mix no. 5.

Table 2
Length of storage in 30% $CaCl_2$ aqueous solution at 5°C before damage appearance.

Mix No.	Type of damage appearance (days)	Tipe of damage
1	3	cracks
2	3	cracks
3	3	cracks
4	3	cracks
5	9	crumbling

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