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BEHAVIOR'S EVOLUTION OF MICRO-CONCRETES IN COMBINED SULPHATE AND MAGNESIUM AGGRESSIVE ENVIRONMENTS, AT THREE-YEARS OLD

BY

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Abstract. In the present paper is analysed concrete behavior from strength structure elements, subjected to combined sulphatic and magnesian aggressive actions. In order to clearly relieve cement influence regarding corrosion behavior and to be as close as possible of concrete structural characteristics, tests are realized on standard mortars, which from compositional point of view are micro-concretes.

There were used different W/C ratios in order to obtain different structural characteristics, knowing that in the first period after casting, when concrete porosity is sensibly higher, corrosion process is more emphatic, with subsequent negative effects.

It was taken into account the fact that sulphatic corrosion effect appears after a long duration of aggressive agent action; in the present paper a three year duration for aggressive attack is proposed.

In the same time it was considered the fact that usual cement for structural elements is composite cement type CEM II/A-S 32,5, studying combined sulphatic and magnesian corrosion evolution on a large type of micro-concrete compositions with different compactness and aggressive agent concentrations.

Key words: micro-concrete; aggressive environment; cement; corrosion.

1. Introduction

This study takes into account the fact that aggressive factors action is combined, not independently, the combination proposed being frequently used in practice.

It is proposed the analysis of the concrete behavior in the resistance structure of buildings subjected to combined sulphate and magnesium aggressive actions. To point out better the quality of the used cement, and to get closer to structural characteristics of the concrete from work, the trials will be realized on micro-concretes.

The concrete obtained must have strong specific resistances to the aggressive action because at least in the first period after its application, when the porousness of the concrete is a bit higher, the soak of concrete structure with aggressive solution can lead to emphasize process of corrosion in the initial period with unfavourable effects, in perspective.

It was taked into account the effect of the sulphate corrosion which appears after a longer period of action of the aggressive agent, and in the present paper we suggest a three years period for the aggressive attack.

Having in view that the usual cement for the structure elements has the composition cement of CEM II/A-S 32,5 (Pa35) type, the evolution of sulphate and magnesium corrosion with several compositions of micro-concretes and with different densities and concentrations of the aggressive agent were studied.

2. General Theoretical Aspects of Sulphate and Magnesium Type Corrosion

This type of corrosion is constituted like superposition of effects from the two following recognized types of corrosion:

a) *The sulphate type corrosion* is characterized by the expansion of the cement rock due to the formation of crystallized products with a higher number of crystallized water molecules.

This type of corrosion is also produced by the sodium sulphate (Na_2SO_4) which is a soluble sulphate. They react with calcium hydroxide in the cement rock and form the calcium sulphate. The calcium sulphate combines with the calcium hydroaluminium forming a complex salt which crystallizes the etringit with 31 crystallized water molecules. This tendency to form crystals makes it possible in a first phase to observe an improvement of the structure characteristics and in time it produces internal tensions which at the end lead to the destruction of the cement rock structure.

The sulphate type corrosion supposes the formation of less soluble compounds with a high molecule volume which will be deposited in the pores, the capillaries and the micro fissures of the concrete leading to internal tensions and the destruction of the concrete later on.

In the case of this type of corrosion the concrete structure plays an important role by its porousness and permeability by its contact surface between the aggressive agent and the cement rock, the volume of open and closed pores and the uniformity of their distribution.

Taking into account the complex nature of the sulphate aggressive action on concretes, the problem of the sulphate compound, which is the main cause of the destructive effect, is under discussion.

If a synthesis were to be made as far as information in this field is concerned, the following conclusions could be drawn:

(i) the nature of the corrosive processes can be modified by increasing the concentration of sulphate ions under certain limits;

(ii) at low concentrations of sulphate ions the expansion is produced by the formation and crystallization of calcium sulphate and at high concentrations of the sulphate ions the expansion is mainly produced by the crystallization of the gypsum.

b) *The magnesium type corrosion* belongs to the II-nd type of corrosion. In this case the magnesium salts operate directly on $Ca(OH)_2$ and the basic reaction which takes place in the case of the corrosion produced by the magnesium sulphate, which is investigated in this experiment, is

$$MgSO_4 + Ca(OH) \rightarrow CaSO_4 + Mg(OH)_2 \,.$$

A characteristic of this interaction is the fact that one of the reaction products, $Mg(OH)_2$, is little soluble and it is deposited in the pores, the capillaries and the micro-fissures of the cement rock. For lower concentration solutions spongy deposits are formed which can be easily penetrated by aggressive waters while at high concentrations (5…6%) compact deposits can be formed and contribute to the improvement of the behavior at aggressive actions of the magnesium sulphate solution, a fact that was proved by a number of previous researches.

3. Experimental Organization

The combination of the two types of corrosion can’t be simply due to a number of effects because the mechanism of reaction products forming, in the imposed conditions, are much more complex and the concrete structure plays an important role from the point of view of his behavior in time.

For organizing the experiment, the present standards referring to the achievement of concretes in aggressive environments were taken into account and they also specify the limits for composition dosage (minimum cement dosage, maximum A/C ratio) and they also recommend the cement type according to the exposure class of the concrete. Taking into account the restrictions imposed by the standards, three recipes were obtained using poligranulate quartz sand as an aggregate and cement of CEM II/A-S 32,5 type for different values of the A/C ratio obtaining the structural characteristics indicated in Table 1.

Table 1
Compositional Characteristics

Recipe index	W/C ratio	C, [%]	P, [%]
R1	0.64	21.0	79.0
R2	0.53	17.5	82.5
R3	0.35	10.8	89.2

Prismatic test tubes of 40 × 40 × 160 mm, three prism for each recipe, were immersed in water and were kept there as witness tests until the testing time.

Three prisms of each recipe were immersed after a 28-day maturation in two parts calcium sulphate solution and one part magnesium sulphate with the following concentrations: 500; 1,000; 5,000 mg/dm^3 SO_4^{2-} and Mg^{2+} ions.

4. Experimental Results

According to the composition characteristics of the three recipes after subjecting the tests to the corrosion process, the obtained results were reproduced in Table 2.

Table 2
Structural and Mechanical Characteristics at 3 Years Old

Recipe index	Concentration mg/dm^3 $SO_4^{2-} + Mg^{2+}$	P_t, [%]	C, [%]	Resistance to compression N/mm^2
R1	$MgSO_4 + Na_2SO_4$, 500	21.0	79.0	40.2
R2		17.5	82.5	58.6
R3		10.8	89.2	85.6
R1	$MgSO_4 + Na_2SO_4$, 1,000	21.0	79.0	39.7
R2		17.5	82.5	59.4
R3		10.8	89.2	88.2
R1	$MgSO_4 + Na_2SO_4$, 5,000	21.0	79.0	43.4
R2		17.5	82.5	51.9
R3		10.8	89.2	72.5
R1	Drinking water	21.0	79.0	36.1
R2		17.5	82.5	50.3
R3		10.8	89.2	84.8

A graph would allow a clearer estimation of the micro-concrete behaviour subjected to the influence of sulphate and magnesium aggressively (Fig. 1).

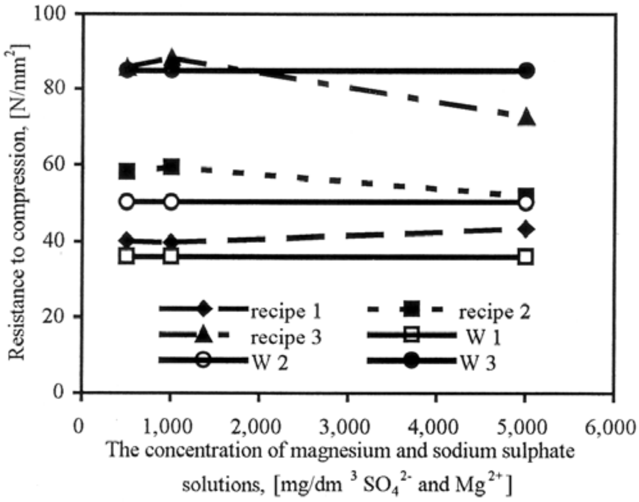

Fig. 1 – The variation of resistances at three years old in combined sulphate and magnesian corrosion.

4. Conclusions

The analysis of the obtained experimental values leads to the following conclusions:

1. Can be observed a slow decalcification to edges and corners of prisms, without a material exfoliation or tears.

2. Recipe 1 presents constantly resistance growths, lower than the others recipes, but for all concentrations in condition of a structural characteristics which shown a reduced compactness; it may consider to have the best behavior in the conditions of present experiment, because the resistances values, no matter concentrations, are presenting an approached growth and relative high values and this can be real basis for a better behavior in future;

3. Recipe 2 is giving the highest growths for concentration less than 1,000 mg/dm^3 SO_4^{2-} and Mg^{2+} ions, but the resistance growth at 5,000 mg/dm^3 is closed to the value of witness test, all those in conditions of structural characteristics which shown us a supreme compactness than recipe 1.

4. Recipe 3 has an unfavourable behavior, with less growth for reduced concentrations and a suggestive reduction of the resistance to compression for a 5,000 mg/dm^3 concentration.

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R E F E R E N C E S

1. Neville A.H., *Proprietățile betonului* (trad. din l. engl.). Edit. Tehnică, Bucureşti, 1980.
2. Moskvin V.M., *Korrozia betona v agressivnyh sredah*. Stroiizd., Moskva, 1971.
3. Dascălu V. ş.a., *Variația agresivității apelor subterane din municipiul Iaşi şi influența acestora asupra durabilității betonului.* A XII-a Conf. de betoane, vol. **II**, Iaşi, 1984.
4. Rujanu M., *Contribuții privind influența unor caracteristici structurale asupra comportării la coroziune a mortarelor şi betoanelor cu lianți minerali*. Teză de doctorat, Fac. de Constr. şi Arhit., Univ. Tehn. „Gh. Asachi", Iaşi, 1993.

EVOLUȚIA COMPORTĂRII MICROBETOANELOR ÎN MEDII AGRESIVE COMBINATE SULFATICE ŞI MEGNEZIENE, LA VÂRSTA DE 3 ANI

(Rezumat)

În lucrarea de față se pleacă de la analiza comportării betoanelor din elementele unor structuri de rezistență ale construcțiilor supuse acțiunilor agresive combinate sulfatice şi magneziene. Pentru a pune mai bine în evidență influența cimentului privind comportarea la coroziune şi a fi cât mai aproape de caracteristicile structurale ale betonului, încercările s-au realizat pe mortare standard, care din punct de vedere compozițional sunt de fapt microbetoane.

S-au utilizat rapoarte A/C diferite pentru obținerea unor caracteristici structurale diferite, ştiind că cel puțin în prima perioadă de după punerea în operă, când porozitatea betonului este uşor mai mare, procesul de coroziune este mai accentuat, cu efecte defavorabile ulterioare.

S-a avut în vedere faptul că efectul coroziunii sulfatice apare după o durată mai mare de acționare a agentului agresiv, iar în lucrarea de față se propune o durată de trei ani pentru atacul agresiv.

De asemenea s-a avut în vedere faptul că cimentul uzual pentru elemente structurale este cimentul compozit tip CEM II/A-S 32,5, studiind evoluția coroziunii combinate de tip sulfatic şi magnezian pe mai multe compoziții de microbeton cu compactități diferite şi cu concentrații diferite ale agentului agresiv.