CORROSION RESISTANCE OF THE 11SMN37 STEEL IN THE POLYMER CONCRETE COVERING

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1. Introduction

In the alkaline environment of the concrete covering a thin layer of invisible ferric oxide (Fe_2O_3) is created at the steel surface, which protects the steel against corrosion [1]. A drop in the concrete pore fluid pH to the value of 11,8 results in destruction of the passive layer, which in turn increases the rate of corrosion [2].

Ammonium chloride (NH_4Cl) contained in industrial waste of the artificial nitrogenous fertiliser plant is reacting with all phases of the concrete covering [3]. Changes in the cement grout phase composition and migration of chloride ions inwards concrete deteriorate protective properties of the concrete covering and increase probability of the reinforcing steel corrosion [4]. Protection of the concrete material surface and structure is frequently related to introducing polymer additives to cement. Thanks to that, a significant improvement in the concrete mixture quality and concrete usefulness have been achieved.

2. Research methodology

Bars of the 11SMn37 grade steel of about 8 mm in diameter placed in the polymer concrete covering made of the acrylic resin based polymer-cement mixtures were used for the tests.

The test samples were marked as follows:

- Sample No 1: steel bar included in the polymer concrete covering from producer A.
- Sample No 2: steel bar included in the polymer concrete covering from producer B.

Chemical analysis of the steel bars used in the research has been presented in Table 1

Table 1. Chemical composition of the 11SMn37 steel according to the PN/H EN 10087 (09/1998) Standard.

%C	%Mn	%Si	%P	%S
≤ 0,14	1,00-1,50	≤ 0,05	≤ 0,110	0,340-0,400

3. Impedance spectroscopy method

Corrosion tests using the impedance spectroscopy method were performed in the ammonium chloride solution NH_4Cl with pH indicator of about 5.

Impedance measurements were performed using the IM6e equipment from Zahner, and the measuring and calculation programs.

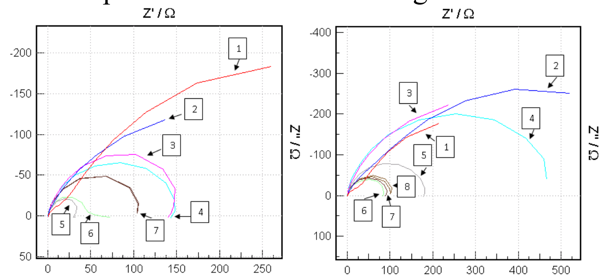
The tests were conducted within 1 mHz to 100 kHz frequency range and the amplitude value was 10 mV at stationary potential.

Wide range of the test frequency enabled interpretation of the electrochemical processes appearing at the steel surface in contact with the concrete.

4. Impedance spectroscopy test results

Measurement results from impedance spectroscopy, in the form of a series of impedance spectra for steel bars in the test corrosive environment, have been presented in Fig. 2 (a,b).

In the low frequency range, impedance spectra are visible in the shape of ever smaller semicircles. Diminishing of the impedance spectra semicircles for the steel in polymer concrete covering from producers A (Fig. 2, a) and B (Fig. 2, b) begins yet from the 6th week of exposure. That could suggest a loss of protective properties by the protective layer created at the steel surface. Beginning with the 6th week of exposure, resistance of the protective layer in sample No 1 decreased to 139 Ohm (Fig. 2, a), and in sample No 2 do 480 Ohm (Fig. 2, b). It is known from the subject literature that the bigger resistance of the protective layer the better it protects the steel surface against corrosion.



a) b)

Fig. 2. Nyquist impedance diagram:
a) Sample No 1
b) Sample No 2 (1 – 1st week, 2 – 3rd week, 3 – 6th week, 4 – 10th week, 5 -15th week, 6 – 21st week, 7 – 28 th week of exposure).

5. Tensile strength test results

Strength tests of the 11SMn37 steel grade were performed at the testing machine with the valid Calibration Certificate, according to the required procedure. Samples were subjected to axial force and loaded until rupture.

On performing the tensile strength tests, a brake in sample No 1 and sample No 2 happened in places weakened the most by the corrosion processes.

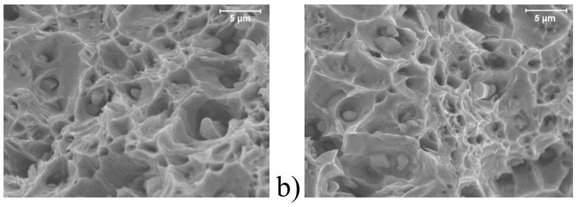
The tensile strength test results for samples No 1 and 2, after the 28-week exposure period to the corrosive environment, have been collected in Table 2.

Table 2. Tensile strength test results

Sample Number	F_m, [N]	$Rp_{0,2}$, [MPa]	R_m, [MPa]	A, %
1	27000	506	558	10,0
2	28500	---	574	10,0

Fig. 6 (a, b) presents fractures of samples No 1 and 2 observed at magnification of 4000x.

As a result of the fractographic tests the brittle-plastic fracture of the ferritic – pearlitic structure with non-metallic inclusions in the form of manganese sulfides was found.



a) b)

Fig. 6. Fracture zone in the samples after strength tests: a) sample No 1, b) sample No 2

6. Conclusion

1) The research performed with impedance spectroscopy method have shown that steel grade 11SMn37 in the polymer concrete covering from producer A (sample No 1) is less resistant to corrosion than the same steel in the polymer concrete covering from producer B (sample No 2), (Fig. 2 (a,b)).

2) The tensile strength tests have shown, that values obtained for both samples stay within the allowed range according to the PN/H EN 10087 Standard, i.e. from 510 MPa to 810 MPa. Comparing the Rm values for sample No 1 (Rm = 558 MPa) and sample No 2 (Rm = 574 MPa), a conclusion could be drawn that a bar made of the 11SMn37 grade steel in the polymer concrete covering from producer B is better protected against corrosion than the bar in covering from producer A (Table 2).

3) The fractographic test results for samples No 1 and 2 have shown the brittle-plastic fracture.

References

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