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CORROSION OF REINFORCE BARS IN RC CONSTRUCTIONS

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Abstract: In this article presented results of researching corrosion of steel bars in aggressive environment in time under loading. For researching were used special equipment. The experience and research works shown that steel bars in the crack cross-section area can be corrode. With increasing width of crack in re-bars and power of aggressive of environment increased the level of corrosion and decreased time of progress. The level of danger of corrosion in the crack in depend of specialty of steel bars. It is geometry parameters of steel bars and characteristic of corrosive behaviour. The general tendency of the influence of various defects on the strength of steels is widely studied experimentally and theoretically only for geometrically correct stress concentrators. For damages that are irregular in shape, such as corrosion ulcers, significantly less researching in each case must experiment to find their effect on the mechanical properties of steels. In this work the influence of simultaneous action of the aggressive environment and loading on strength of steel re-bars has been described.
Keywords: steel bars, corrosion, aggressive environment

1. INTRODUCTION

For today the reinforced concrete constructions is a one of the most popular material in the world. This material has found its application in production and in a constructional engineering (Brózda et al., 2017; Mazur, 2016).
In structural elements, subjected to compression with bending, compressive stresses are taken by concrete while tensile stresses are transmitted to the rebar (Bobalo et al., 2018; Krainskyi et al., 2018b). At the same time, concrete serves as protection of structures from corrosion and various damages. In particular the investigations of

special mineral additives like zeolite should be noted, which improve durability and corrosion resistance of cements for concrete (Sobol et al., 2014).

Many factors cause necessity for the repairing or strengthening (Blikharskyy et al., 2018; Khmil et al., 2018; Krainskyi et al., 2018a; Abu-Tair et al., 1996; Vegera at al., 2018) buildings and constructions. Often it is damages (Kos et al., 2017) or corrosion (Selejdak et al., 2018; Lipiński, 2017; Pliszka and Radek, 2017) of construction obtained during its lifetime from negative environment influence.

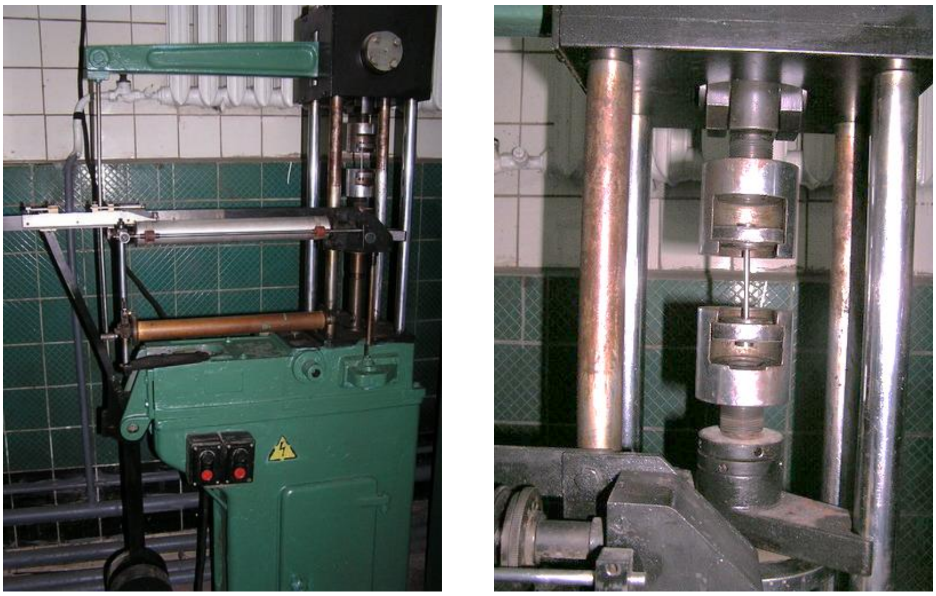
Around 20 to 70% of constructions in nonferrous metallurgy, chemical, wood-pulp and paper industry, and energy-generating factories is affected by various corrosive environments. A corrosion process can last longer when in an aggressive environment of small concentration whilst, when there is a high concentration corrosive environment, a construction can collapse very quickly. Durability and load-carrying capacity generally depends not only on loading but also on the influence of the environment (Kotsovou and Cotsovos, 2018; Selejdak et al., 2014; Dudek et al., 2017).

There are works in depend in corrosion of rebars (Pradhan and Bhattacharjee, 2011) and checking the apply the digital imagine correlation for investigate the mechanical characteristics (Zhang et al., 2015). Also, there are a lot of work for detection the corrosion by different sensors (Muchaidze et al., 2011; Cheng et al., 2018), magnetic memory technology (Yang et al., 2018). Not so much researching in depend the influence of static loading at in one time with corrosion of negative impact of environment. It simulate the corrosion in real constructions under loading and the goal of this work.

2. RESEARCH METHODOLOGY

The researching of corrosion of reinforce bars in aggressive environment under loading were made special prepared specimens with using the special equipment (Pietraszek and Goroshko, 2014).

The mechanical characteristics of steel bars determined in standard specimens with test diameter 5 mm in testing machine IM-4P (Fig. 1).



a) b)

Fig. 1.Test of specimens in testing machine IM 4P: a) general view, b) specimen it testing

Tendency to corrosion cracking determined in specimens with diameter 10 mm (Fig. 2). All specimens were made from reinforce bars with diameter 20 mm. After turning processing of rebars the allowance were 0.35 mm.
Grinding were carried out by alundum wheels EB25SM1K in next regime: the line speed of alundum wheels was 30 m/s, the speed of rounding specimens was 3 m/s and the deep of last pass of grinding was 0.005 mm/turn.
For detected the influence of welded joints in tendency to corrosion cracking of reinforce bars in central area of specimens welded the steel bar with diameter 5 mm. Welding was done by point method on a welded machine with automatic adjustment in factory conditions.

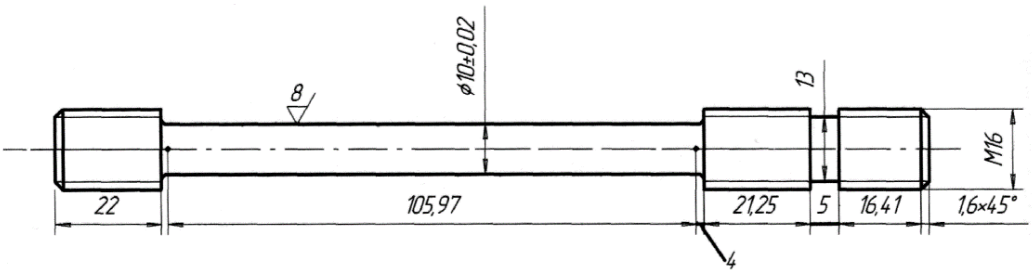


Fig. 2. Specimens for test of corrosion cracking

Corrosion damage on test specimens were obtained by their putted them in 3% aqueous sodium chloride solution (15 hours) and air (8 hours) for 15 or more days.
For research on corrosion cracking of reinforce bars, an testing machine was used, on which the stresses on the specimen were set to constant load. In Fig. 3 shown the general view of testing machine for test specimens in corrosion cracking.

a) b)

Fig. 3. The specimens in testing machine for test corrosion cracking: a) general view, b) specimen it testing

The bath for corrosive environment was fastened to the threaded part of the specimen. The corrosive environment was changing in every 24 hours.

3. RESULTS OF THE EXPERIMENTAL STUDY

Tests of the control specimens during uniaxial tension showed (Table 1) that the yield strength and the limit strength for the reinforcing bars correspond respectively to 318.8 and 510.3 MPa (the average of four measurements). Relative error was no more than 1.3%. Corrosive damages formed on the surface of the specimens during 15-30 days practically didn't change the of these value. Their values were within the error of the experiment (0.2 = 314,2…319,0 and u = 504,9…510,9 MPa).

Table 1.
Test results of steel rebars

Specimen	**σ_u, MPa**	**$\sigma_{0.2}$, MPa**	**Ψ, %**	**δ, %**
Control 1	509.5	319.7	63.5	26.7
Control 2	504.5	314.7	61.6	28.4
Control 3	514.5	318.7	62.5	27.2
Control 4	512.5	322.2	61.8	27.7
Average	510.3	318.8	62.3	27.5
SCD_1 (15 days)	508.3	315.6	54.6	27.1
SCD_2 (20 days)	510.9	315.9	53.3	26.8
SCD_3 (25 days)	509.5	319.0	53.3	26.4
SCD_4 (30 days)	504.5	314.2	51.0	22.2
SCD – specimen with corrosion damage				

However, the plasticity characteristics relative to elongation (δ) and narrowing (ψ) change more substantially. For control specimens this average value were δ=27.5% and ψ=62.3% (relative error not more than 3.3%). The values of δ for specimen with corrosion damage 1 and 2 (exposure time in the medium of 15 and 20 days) were somewhat less than average, but this data were in area of the error of the experiment. For specimen with corrosion damage 3 and 4 (exposure time in the medium of 25 and 30 days), the value δ decreases respectively in 1.04 and 1.22 times. In this case, can be talk about a clear tendency to decrease the values of relative elongation in the presence of corrosion damage in specimen.

The character of failure of specimens shown in Fig. 5, 6.

A change in the value of relative reduction were observed in all specimens with corrosion damage with a decrease in 1.14-1.22 times.

Fig. 4. Tested specimens by static loading in the air environment

Fig. 5. Tested specimens for corrosion cracking with a welded rod

A change in the value of relative reduction were observed in all specimens with corrosion damage with a decrease in 1.14-1.22 times. In this case, an increase in the aging time of specimens in a corrosive environment leads to a more significant change in the characteristics of plasticity. Consequently, the characteristics of plasticity are more sensitive to corrosion of the surface than the strength characteristics.

As a result of experimental research, new properties of reinforcing steel have been determined, in particular, deterioration of its plastic characteristics during work in structures, which can lead to undesirable consequences. Significantly reduces the time from the beginning of plastic fittings to fracture. Such a phenomenon cannot be allowed, for example, in seismic and other dynamic influences. In these cases, from the onset of plastic deformation to fracture, it takes some time necessary to evacuate people.

4. CONCLUSIONS

Experimental tests of steel bar specimens under the action of a statically applied tensile force and the simultaneous action of an aggressive environment had shown that corrosion damage slightly affects in the strength characteristics of reinforce bars.

The plasticity characteristics relative to elongation and narrowing changed substantially.

The values of elongation for specimen with corrosion damage in exposure time in the medium of 15 and 20 days were somewhat less than average, but this data were in area of the error of the experiment. For specimen with corrosion damage in exposure time in the medium of 25 and 30 days, this value decreases respectively in 1.04 and 1.22 times.

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As a result of experimental research, new properties of reinforcing steel have been determined, in particular, deterioration of its plastic characteristics during work in structures, which can lead to undesirable consequences. Significantly reduces the time from the beginning of plastic fittings to fracture.

These obtained features should be taken into account in exploitation, repairing and strengthening the real constructions.

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