EFFECT OF HOT-DIP GALVANIZATION ON HC 260LA STEEL SCAFFOLDING PLATFORM LOAD CAPACITY

Wpływ technologii cynkowania ogniowego na nośność podestów ruzstowań ze stali HC260LA

Влияние технологии огненного цинкования на работоспособность строительных стелажей из стали HC260A

Maciej JASTRZĘBSKI ORCID: 0000-0003-2805-4740
Andrzej MISZTELA ORCID: 0000-0002-4706-5982
Krzysztof GOŁOŚ ORCID: 0000-0003-1534-575X

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Abstract: The goal of the present paper is to examine the influence of hot-dip galvanisation process on mechanical properties of HC260LA steel (yield stress, ultimate stress and elongation) and scaffolding platforms load capacity. The galvanized welded scaffolding platforms manufactured from sheet thickness 1.25 mm were used in the tests. The experiments have shown the increase in load capacity of galvanised scaffolding platforms by 4.76 % compared to the non-galvanised ones.
Keywords: hot-dip galvanisation, HC260LA steel, assembly of scaffolding platforms
Streszczenie: Celem niniejszej pracy są badania wpływu procesu cynkowania ogniowego na zmianę własności mechanicznych stali HC260LA (tj. granicy plastyczności Re, wytrzymałości na rozciąganie Rm i wydłużenia Agt) oraz nośności granicznej stalowych elementów konstrukcyjnych rusztowań. Przedmiotem badań były spawane stalowe podesty rusztowań wykonane z blachy o grubości 1,25 mm. Przeprowadzone badania nośności podestów wykonanych z blach ocynkowanych wykazały nośność wyższą o 4,76% w stosunku do podestów wykonanych z blach nieocynkowanych.
Słowa kluczowe: cynkowanie ogniowe, blacha ze stali HC260LA, montaż podestów rusztowań

Introduction

Hot-dip galvanization is one of the most effective methods for protection of the steel elements of scaffoldings from the corrosion [1]. Owing to galvanization, the durable zinc coatings, resistant to corrosion and to all types of mechanical damages are obtained. The latter property has a great meaning due to the fact that the scaffolding elements are assembled and disassembled many times during their use. The high requirements for the mentioned scaffolding elements in regard to mechanical resistance of the coatings have caused that the different methods of protecting the steel elements of scaffolding e.g. painting. are sporadically employed.

The research in respect of hot-dip galvanization is mainly focused on galvanization technology, quality of coatings and the studies on the impact of material, surface and thickness of galvanized elements on the quality of galvanized coating. In the studies, the problems of the effect of hot-dip galvanization on mechanical properties of materials, from which the galvanized elements are made, have been almost completely omitted. The existing papers are fragmentary and the obtained conclusions are non-univocal. For the examined steels, the authors of a part of the studies did not observe the effect of the hot-dip galvanization on the change in the mechanical properties of the examined steel samples [4]. In some papers, the mentioned effect was found [2, 3]. In paper [3], the results of the tests on the effect of hot-dip galvanization on the mechanical properties of two commonly used steels: St3S and 18G2A, were presented. In the mentioned publication, the performance of the tests with the samples of 8 mm and 10 mm thickness (steel St3S and 18G2A) was documented; in the result of the experiments it was found that the galvanized coatings caused the increase in yield stress and ultimate stress. In paper [2] the results of the effect of hot-dip galvanization on the mechanical properties of low-carbon steel with carbon content 0.045 were presented. In the examined steel, after galvanization, the ultimate stress was decreased and the toughness (fracture energy) – determining the material's resistance to cracking or fracture, corresponding to the energy absorbed during generation of material-destructing fracture.

The changes in mechanical properties of steel after galvanization may have an influence on the resistance of constructional elements, made from the mentioned types of steel. The importance of the discussed problem may be indicated by the results of the resistance tests of the scaffoldings' frames, conducted at the Temporary Construction Research Laboratory of the Institute of Mechanical Construction and Rock Mining. A change in

Tab. 1. Chemical composition of HC260LA steel
Tab. 1. Skład chemiczny stali HC260LA

	C	Mn max	Si	P max	S max	Al min	Ti	N max
	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
HC260LA	≤ 0,10	≤ 0,60	≤ 0,50	≤ 0,025	≤ 0,025	0,015	≤ 0,15	-

the properties of material brings a change in resistance of frames at their loading with the axis forces and bending moment. The described effect of the changes in properties of material has not been practically presented in literature concerning material engineering and steel constructions.

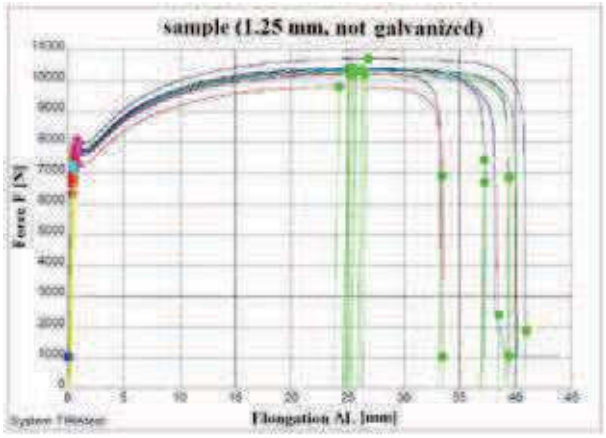
The aim of the paper is to examine the effect of hot-dip galvanization on the mechanical properties of HC260LA steel and on the load capacity of scaffolding platforms, made from the mentioned material. The obtained information may be useful in designing or in evaluation of loading capacity of scaffolding constructions on the grounds of empirical tests and static calculations.

The method of the studies and the results

The studies on the effect of hot-dip galvanization on the resistance properties were conducted firs for the flat samples of HC260LA steel and then, for the element of the scaffolding construction in a form of platform. In tab.1, chemical composition of the examined steel was presented.

In the first part, the tests of the samples cut out from the sheet were performed; then the studies of the produced scaffolding platforms were carried out. The dimensions of the test samples for examination of the resistance properties were selected in accordance with the recommendations of the standard [5]. For the tests, a series of 20 experimental samples was performed. The samples were cut out from the sheet with thickness of b=1.25 mm, using waterjet technology. Fig. 1 shows the tested sample.

Fig.2. Summary chart of tensile tests for non galvanized HC-260LA steel samples (thickness b = 1.25 mm)
Rys. 2. Wykres zbiorczy dla wyników badania wytrzymałościo-wego nieocynkowanych próbek ze stali HC260LA o grubości b = 1,25 mm.



Initially, the tests of the yield stress, ultimate stress and elongation were carried out. The mentioned values were determined in conformity with the standard [5], performing the static elongation trial. The studies were conducted at the Institute of Mechanical Construction and Rock Mining, in the Temporary Construction Research Laboratory, in strength testing machine TIRA. The results of the tensile tests of the HC260LA steel samples are given in Fig. 2 and the mean values are found in Tab. 2.

Fig. 1. Non galvanized sample – HC260LA steel (thickness 1.25 mm)
Rys. 1. Próbka badawcza nieocynkowana – stal HC260LA (gr. 1,25 mm).

Tab. 2. Experimental results of mechanical properties of HC260LA steel
Tab. 2. Wyniki badań doświadczalnych właściwości mechanicznych stali HC260LA

Type of sample	Yield stress	Ultimate stress	Elongation at yield stress	Total elongation at masimum strength	Total elongation at destruction
	R_e [MPa]	R_m [MPa]	A_e [%]	A_{gt} [%]	A_t [%]
Non galvanized	301,06	402,86	1,09	51,18	74,79
Galvanized	374,80	394,52	-	40,96	61,65
Change of value by	19,67%	-2,11%	-	-24,95%	-21,31%

The second half of the samples was subjected to hot-dip galvanization.

Technology of hot-dip galvanization process during performance of the test samples and platforms:

- *Degreasing*: bath in degreaser with acid pH to be used in solutions of hydrochloric acid (Degrasan PS);
- *Digestion*: bath in hydrochloric acid solution:
  - HCl, concentration 40 g/l ÷ 160 g/l,
  - Fe+2, concentration 20g/l ÷ 160 g/l,
  - Temperature of 20oC ÷ 35oC
- *Washing*; bath in a tub filled with network water at ambient temperature and iron content Fe+2 < 15 g/l;
- *Flux treatment:* bath in zinc chloride and ammonium chloride solution:
  - Network water,
  - ZnCl2 ≥240 g/l,
  - NH4Cl ≥ 160 g/l.
  - Fe+2 < 15 g/l,
  - Temperature of 25oC ÷ 45oC
- *Drying*: temp. of 80oC ÷ 100oC, drying time: 15 min. ÷ 40 min.;

- *Galvanizing*: immersion in zinc bath
  Parameters of galvanization:
  - Composition of zinc bath: 99.8% Zn1, Pb, Al., Ni, Cd, Fe;
  - Temperature of zinc bath: 445OC (real 442oC ÷ 448oC);
  - Immersion time: 2.5 min
  - Method of cooling down: unhampered, at a free air;
  - Time of cooling down: 6 min ÷ 10 min.

The prepared galvanized samples were subjected to resistance tests. After galvanization, the mean thickness of galvanized layer was equal to 52 µm. The curves of elongation for the tested samples are given in Fig. 3. The mean values obtained in the tests on the mechanical properties are presented in Tab. 2.

Tab. 2. contains the comparison of the obtained results of yield stress Re, ultimate stress Rm and

Fig. 3. Summary chart of tensile tests for galvanized HC260LA steel samples.
Rys. 3. Wykres zbiorczy dla wyników badania wytrzymałościowego próbek ocynkowanych ze stali HC260LA

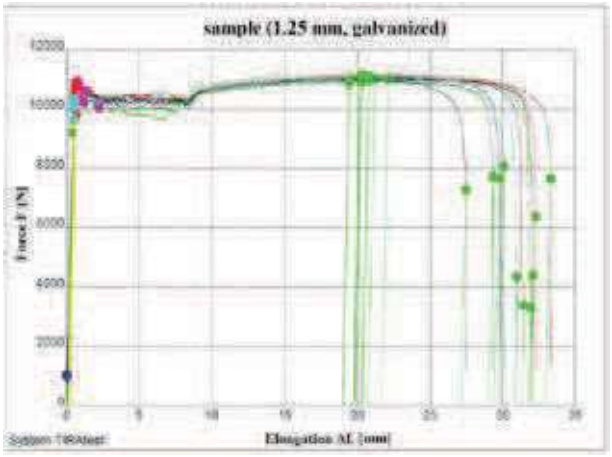


Fig. 4. Galvanize scaffolding platform made from HC260CL steel on the test stand
Rys.4. Ocynkowany podest z blachy stalowej HC260LA na stanowisku badawczym

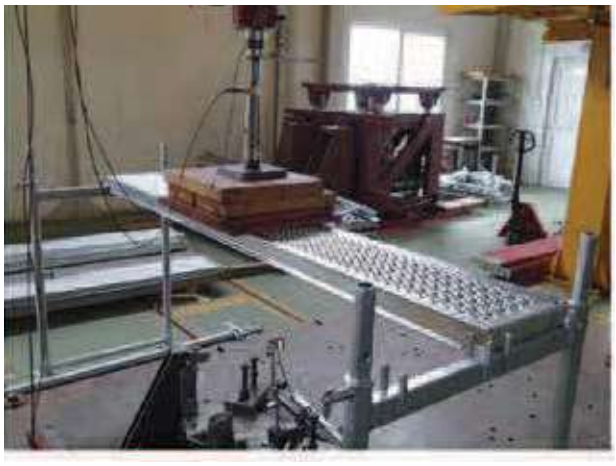
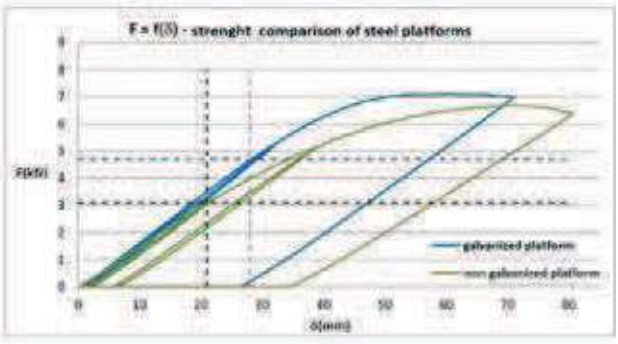


Fig. 5. Test results of galvanized and non galvanized scaffolding platforms strength
Rys.5 . Wyniki badań wytrzymałościowych ocynkowanych i nieocynkowanych podestów rusztowań



Tab.3. Comparison of the test results of scaffolding platforms loading capacity
Tab. 3. Porównanie wyników badań nośności dla podestów rusztowań

Type of platform	load capacity R_{dop} [kN]
non galvanized;	2,80
galvanized	2,94
increase by	4,76%

elongation Agt.

Then, the tests of load capacity of scaffolding platforms [6-8] of the length of 2.5 m, performed from HC260LA steel sheet of thickness b = 1.25, were carried out. Fig.4 presents the loaded scaffolding platform during tensile tests in order to determine its load capacity.

The tests included 5 non galvanized platforms and 5 platforms after hot-dip galvanization. The results of the tests are given in Fig. 5 and Tab. 3.

Conclusions

As a result of the conducted tests, it was found that the hot-dip galvanization process affected the change in the mechanical properties of HC260LA steel. In the case of the tested galvanized samples obtained from HC260LA steel of thickness b = 1.25, the following values were obtained:

– Increase in yield stress Re by 19.67%,
– Decline in value of ultimate stress Rm by 2.11%,
– Decrease in value of elongation Agt by 24.95%.

The studies on the load capacity of steel platforms, made from HC260LA steel sheet of thickness 1.22 mm demonstrated that the platforms after hot-dip galvanization had by ca. 5% higher load capacity as compared to non galvanized platforms. In the diagram illustrating the run of the tests of the load capacity of the platform, being presented in Fig. 5, there is given a very distinct increase in yield stress and decrease in elongation of the platforms after hot-dip galvanization. The demonstrated changes in the parameters of tensile tests of the examined HC260LA steel are most probably the result of the changes in the microstructure of the steel as a result of the temperature impact, occurring during the process of galvanization i.e. temperature of ca. 450oC. On the grounds of the conducted experiments, it is not possible however, to confirm or to exclude the presence of other factors such as time of zinc bath, chemical composition of steel, chemical composition of zinc bath etc. that may have an influence on the mechanical properties.

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mgr inż. Maciej Jastrzębski - Instytut Mechanizacji Budownictwa i Górnictwa Skalnego ul. Racjonalizacji 6/8, 02-673 Warsaw, Poland. e-mail: m.jastrzebski@imbigs.pl

dr inż. Andrzej Misztela - Instytut Mechanizacji Budownictwa i Górnictwa Skalnego ul. Racjonalizacji 6/8, 02-673 Warsaw, Poland. e-mail: a.misztela@imbigs.pl

prof. dr hab. inż. Krzysztof Gołoś - Instytut Mechanizacji Budownictwa i Górnictwa Skalnego ul. Racjonalizacji 6/8, 02-673 Warsaw, Poland. Politechnika Warszawska, ul. Narbutta 84, 02-524 Warsaw, Poland, e-mail: kgo@simr.pw.edu.pl