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Examining the reinforcement of a reinforced concrete industrial chimney

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ABSTRACT:
The article exams the walls of a reinforced concrete chimney with a rectangular cross-section in Huta Częstochowa. A Ferroscan Hilti FS10 was used for the test. An example protocol of the results obtained from the device and several graphical images of the reinforcement signal are presented. Despite significant wall damage, the measurements were carried out with success. An orthogonal reinforcement solution was found. Bars in both directions differ significantly in diameter. Considerable density changes of the reinforcement in the corner zone were recorded in both the vertical and horizontal direction. As a result of the test, considerable carelessness in the reinforcement execution was observed, which manifested in a variety of cover and deviation of the reinforcement direction from the designed one. The conclusions state that a control forging the concrete up to the reinforcement and measuring the diameter of the reinforcement is necessary for the proper testing of the reinforcement using the electromagnetic method.

KEYWORDS:
reinforced concrete; diagnostic investigation, electromagnetic method; reinforcement

1. Introduction

The assessment of structural reinforcement is currently one of the most commonly performed tests, useful during facility operation, renovation, reconstruction, extension in order to supplement the technical documentation, or when, for example, there is a need to lead the installation through partitions. It is necessary for the quality control of reinforcement and concrete works during the erection of monolithic facilities and the production of prefabricated elements. It can be a preparation for performing other activities, such as for taking concrete samples, or it can be used to supplement technical documentation, and giving expert opinions [1].

Assessment of reinforcement can be carried out in an open pit in violation of concrete continuity or by a non-destructive method. Execution of an opening of the reinforcement usually allows - in the case of no significant corrosion of concrete and steel - to measure the diameter of the reinforcement and the cover and determine the type of reinforcement (or several possible types) based on the ribbing of the rod. The disadvantage of this method is, the larger the area of the structure to be examined, the more openings need to be made. Only then can a complete image of the element's reinforcement be created. In turn, the non-destructive method does not require any violation of the structure of the element and allows the exploration of a large area relatively quickly. However, most methods are subject to measurement inaccuracy resulting from specific test conditions and individual characteristics of the test item, such as

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damage, existence of finishing layers, surface structure. This means that the test result is, in principle, an estimate of the feature sought [2], and the obtained result should be verified by another method or it is best to make an open pit.

The currently most popular research methods use the phenomenon of magnetic field excitation and its changes in the presence of materials with ferromagnetic properties. The basis of methods generally called electromagnetic is the phenomenon of electromagnetic induction, and in addition the phenomenon of eddy currents. Eddy current methods are used to measure changes in the magnetic field and the method of scattering flux [3, 4]. Depending on the device and method used, the reinforcement diameter and cover thickness can be assessed at the same time or one of these features with the other known, bar spacing and number of layers. It is not possible to mark the grade. One of the most widespread device is HILTI Ferroscan. They generate pulses of the magnetic field, which in turn cause the formation of eddy currents on the surface of the rod within range of the probe, reducing the value of the original magnetic field [5]. They allow several types of measurements to be performed, facilitating the preparation of proper measurements and increasing their reliability.

2. Measuring device

Ferroscan FS10 (Fig. 1) is an older model of ferroscan [5, 6], enabling measurements in two modes. The first of these, the so-called Quickscan linear measurement, is recommended for determining the position of reinforcement at a selected depth and for determining the exact location of the measurement in the second mode, which is surface measurement. A single surface measurement of Imagescan covers a maximum surface area of 60x60 cm and consists of four equal width bands in a vertical and horizontal direction. To obtain information about a selected fragment of the surface being tested, it must be examined in both directions. The system takes into account the impact on the outcome of any reinforcement running across. The result is presented in the form of shades of gray, the intensity of which is related to the signal strength. During image analysis, it is possible to change the depth of signal strength observation, which allows the reinforcement layers to be recognized, vary the depth of the position of the bars and detect bars with variable depth of cover.

Fig. 1. Ferroscan FS10 (Photo B. Ordon-Beska)

Ferroscan allows the detection of rebar in the diameter range from 6 to 36 mm, lying at a depth of max. 13 and 18 cm, respectively (Fig. 2), with the maximum depth of position of these bars enabling the most accurate diameter estimation is 9 and 15 cm. The upper line concerns the measuring range, the middle depth of the reinforcement position, and the lower diameter. The diameter measurement error is at least one nominal diameter with a ratio of the distance between the bars and the cover of at least 3:1, but because the software does not take into account all the diameters used in Poland in the above-mentioned range, for some diameters this error may be even two diameters. The most accurate estimation of the cover thickness can be obtained up to a depth of 60 mm. The cover measurement error is up to 10%.

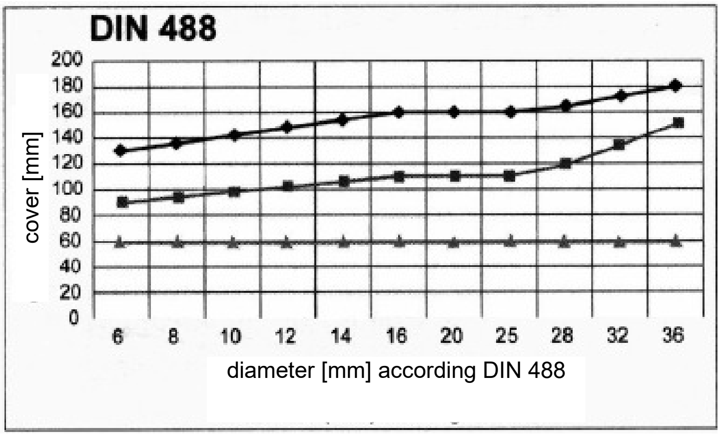

Fig. 2. The measuring range of Ferroscan FS10. Based on [5]

3. Industrial chimney examination

The tests presented below were performed on an industrial reinforced concrete chimney with a rectangular section, dimensions about 3.5x3.5 m, reinforced with horizontal and vertical bars. Reinforcement tests were part of the expertise, the subject of which was the technical condition of the object and assessment of the possibility of its repair. Many cracks were recorded on the surface of the chimney walls, some of which penetrated the walls throughout. In extreme cases, cracks and concrete defects were accompanied by the displacement of wall fragments into the interior of the chimney. Due to the damage mentioned above, the test was not carried out directly on the wall surface, but through a 3 mm fibreboard. The tests were carried out with Ferroskan, in Imagescan surface mode. Figures 3 and 4 present selected graphic images of the signal generated by the reinforcement at the reinforcement concentration and occurrence of the largest structural damage.

Figure 5 shows an example of the results analysis protocol for the first image in Figure 4. Measurements on the length of the rods were made at least twice to verify the results and detect anomalies or regularities. The symbol H indicates the horizontal course of the bar and the symbol V indicates the vertical course. The symbol Y means that according to the HILTI program for the analysis of measurements, the obtained result is reliable.

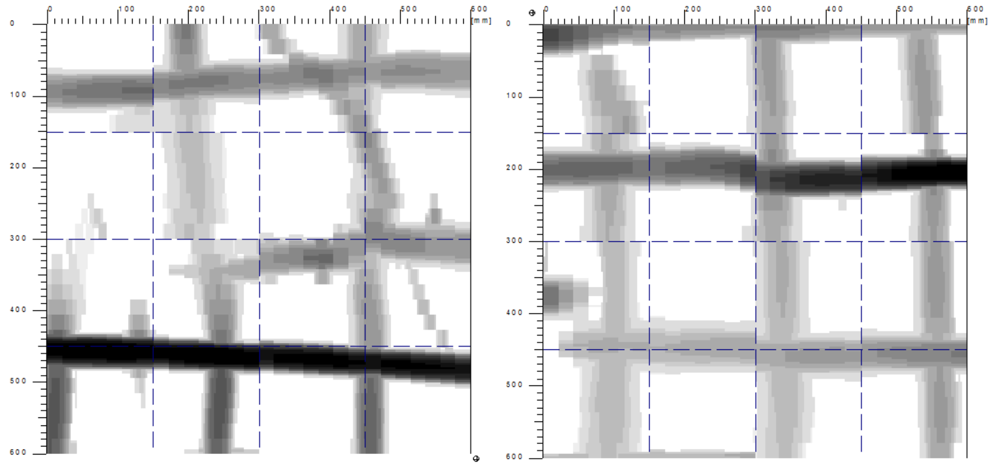

Fig. 3. Image of reinforcement signal in the central part of the walls

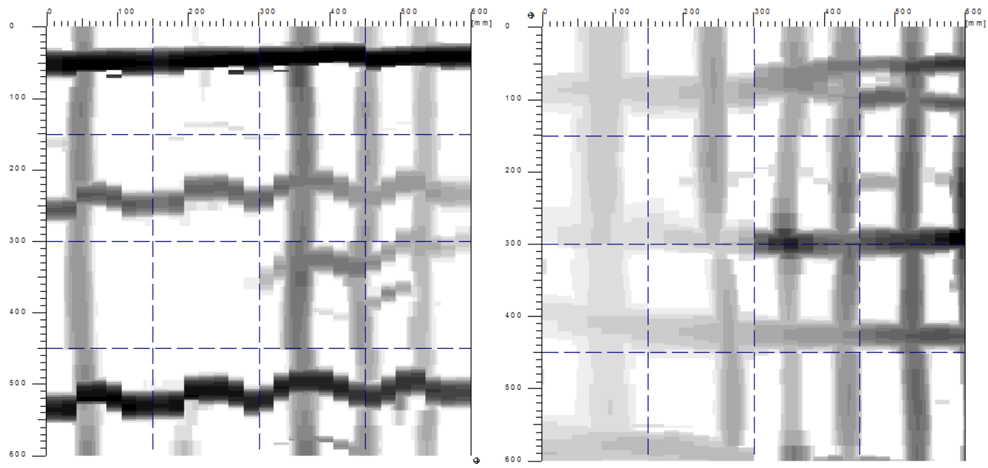

Fig. 4. Image of the reinforcement signal near the corner of the walls

Imagescan Image: Fs000007.bar

Point No	Coordinates X, mm	Coordinates Y, mm	Cover measured, mm	Cover mean, mm	Cover with correction min, mm	Cover with correction max, mm	Diameter measured, mm	Diameter mean, mm	Diameter with correction min, mm	Diameter with correction max, mm	Direction	Measurement validity	Angle degrees	Distance mm	Bar
1	121	249	10	11	8	14	6	7	5	9	H	Y	1,06	96	1H
2	229	244	12				8				H	Y			
3	386	342	13	13	10	16	6	6	4	8	H	Y			2H
4	48	134	15	19	16	22	6	6	4	8	V	Y	1,93	311	3V
5	46	312	21				6				V	Y	0,00		
6	48	432	21				6				V	Y			
7	359	130	16	20	17	23	12	13	11	15	V	Y	1,74		4V
8	360	262	20				12				V	Y	0,00		
9	352	431	20				14				V	Y	1,04	89	
10	363	541	22				14				V	Y			
11	450	124	22	23	20	26	6	6	4	8	V	Y	0,00		5V
12	450	282	22				6				V	Y	0,00		
13	442	419	22				6				V	Y	0,78		
14	449	565	24				6				V	Y			
15	528	120	30	30	26	34	6	6	4	8	V	Y	0,00	76	6V
16	520	416	30				6				V	Y			

Fig. 5. Sample results analysis protocol

The reinforcement with the most probable diameters ϕ6÷ϕ8 and ϕ12÷ϕ16 was located in the examined object, while taking into account the measurement error it was found that it could even be up to ϕ10 and up to ϕ17, respectively (the diameters stored in the device's memory do not coincide with those used in Poland). In the extreme case, the diameter ϕ27 was measured. Locally recorded a clearly stronger signal indicates the probable occurrence of the bar plant zone. Unfortunately, the scope of commissioned works did not include the performance of the pit, therefore the result was not verified. The reinforcement creates a mesh, which the designer intends should have an orthogonal arrangement. In fact, a significant deviation of the graphic signal image from the horizontal and vertical direction has been observed, which in non-displaced areas indicates the carelessness of the structure. In the protocol quoted in Figure 5, the angle α of the reinforcement deviation from the vertical or horizontal direction does not take on significant values. The graphic signal arrangement in the first image in Figure 4. waving in the horizontal direction reflects the visible bar path in the area of significant displacements of fragments of the structure with concrete defects. The reinforcement cover, taking into account the measurement errors, for horizontal bars in the shallower layer from 8 to 16 mm, and in the deeper layer from 23 to 55 mm. The sheathing of vertical bars ranged from 13 to 36 mm. The reinforcement mesh was compacted according to the rules in the corner areas. The spacing of horizontal bars was set variable, 45 and 90 mm, and vertical bars 75, 90 and 100 mm. In the remaining area the spacing was from 130 to 370 mm in the horizontal direction and from 130 to 310 mm in the vertical direction. It should be emphasized that the conditions of conducting on a heavily damaged structure deteriorated the accuracy of the results.

4. Conclusions

1. Despite significant damage to the chimney structure, conducting the test turned out to be possible, but the results collected in places where displacements of concrete fragments occurred were burdened with a greater error.
2. The study showed that the reinforcement of the chimney walls was done carelessly. This is evidenced by both the reinforcement system and the cover measurement results.
3. Signal values converted to the diameter of the rods were often locally stronger than in the vicinity. This may indicate the presence of a plant zone or distance elements in the case of focused signals.
4. Reinforcement opencast is necessary when testing reinforcement with a non-destructive method, both to calibrate the device and to verify the interpretation of the results.

References

[1] Wójcicki A., Sokołowski K., Naprawa żelbetowych płyt balkonowych w budynkach wielorodzinnych, Zeszyty Naukowe Politechniki Częstochowskiej 2017, seria Budownictwo 23, 325-334.

[2] PN-EN 12504-4 Badania betonu w konstrukcjach. Część 4. Oznaczanie prędkości fali ultradźwiękowej.

[3] Chady T., Runkiewicz L., Sikora R., Wójtowicz S., Lokalizacja zbrojenia w budowlanych elementach żelbetowych, 31 Krajowa Konferencja Badań Nieniszczących, Szczyrk 2002, 233-236.

[4] Drobiec L., Jasiński R., Piekarczyk A., Sposoby lokalizacji stali zbrojeniowej w konstrukcjach żelbetowych. Metoda elektromagnetyczna (cz. II), Przegląd Budowlany 2007, 12, 31-37.

[5] Ferroscan FS 10. Operating Instructions, HILTI Corp., Liechtenstein (2000).

[6] Ferroscan FS 10. Software manual Version 4.0, HILTI Corp., Liechtenstein (2000).

Badanie zbrojenia żelbetowego komina przemysłowego

STRESZCZENIE:
W artykule przedstawiono badanie zbrojenia ścian komina żelbetowego o przekroju prostokątnym na terenie Huty Częstochowa. Do badania wykorzystane zostało urządzenie Ferroscan Hilti FS10. Zamieszczono przykładowy protokół analizy wyników uzyskanych z urządzenia i kilka obrazów graficznych sygnału

zbrojenia. Mimo znaczących uszkodzeń ścian pomiary udało się przeprowadzić. Stwierdzono ortogonalny układ zbrojenia. Pręty obu kierunków różnią się wyraźnie średnicą. Zarejestrowano również znaczne zagęszczenie zbrojenia w strefie narożnej zarówno w kierunku pionowym, jak i poziomym. W wyniku badania stwierdzono znaczną niestaranność wykonania zbrojenia, przejawiającą się zmiennością otuliny i nieprawidłowym przebiegiem prętów. We wnioskach stwierdzono, że kontrolna odkrywka zbrojenia jest niezbędna do prawidłowego przeprowadzenia badania zbrojenia metodą elektromagnetyczną.

SŁOWA KLUCZOWE:
żelbet; badania diagnostyczne; metoda elektromagnetyczna; zbrojenie