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INFLUENCE OF SEPARATION AGENTS ON QUALITY OF CONCRETE SURFACE

WPŁYW ŚRODKÓW SEPARUJĄCYCH NA JAKOŚĆ POWIERZCHNI BETONU

Abstract Application of new type of unique Confocal Laser Scanning Microscope system, that presents a new generation optical system for identification and description of esthetical imperfections of fair-face concrete are presented in contribution. System enables 3D observation and high-precision 3D measurement in real time. The influence of mixture composition, separation demoulding agents and technology procedures are observed..

Streszczenie W artykule przedstawiono możliwość zastosowania nowego rodzaju mikroskopu Confocal Laser Scanning Microscope do identyfikacji i opis jakościowego powierzchni betonu. System pozwala na 3D obserwację i dużą precyzję pomiaru w rzeczywistym czasie. Analizowano wpływ składu mieszanki betonowej oraz środków separacyjnych na jakość powierzchni betonu.

1. Introduction

The concrete is the most used building material at the moment and this trend is going to continue for a long time in future. The production of fair-face concrete components that are used more or less successfully as a final surface of not only transport constructions (bridges, retaining walls, piers, etc.) but also at public and house-building constructions is growing up and is applied more often.

Fair-face and architectonic concretes are extremely technologically difficult elements because of high requirements on final esthetic view and because of many factors that influence production and result. Very important role in building up of top surface layer of concrete plays application of separation agents on formwork surfaces [1],[2]. Methodology and some results of 3D microscopic observation and measurements of concrete surface treated by different separation agents are presented in this contribution.

2. Perspective methodology of measurements

Some opportunity of objective and quantifiable evaluation of concrete surface is offered by a confocal laser scanning microscope LEXT OLM 3000 we use for different types of observations and measurements. Confocal laser scannig microscopy is a representative of new generation of optical systems with the high accuracy, 3D projection and measuring. It offers new possibilities for development and control of various materials and components. It is especially useful for new applications in micro- and nano-technological branches that put heavy demands on nonstandard ways of nondestructive noncontact measurement and control of materials, miniature components, very fine connections and also on control of roughness of surfaces with submicron accuracy.

The basic principle of confocal laser scannig microscope is that it does not create a picture as the whole but point after point – by scanning. With the help of scanning optical sections are scanned in the plane X-Y and due to the accurate defined feed of the objective in axis Z also single optical sections.

It allows also 3D observation and highly accurate 3D measurement in a real time. Owing to an excellent resolution 0,12 μm and an range of magnification 120×–14 400× the LEXT is assigned directly to research workers that work between limits of common optical microscopes and scanning electron microscopes (SEM). Apart of a situation in SEM any sample can be put directly on the microscope table without pre-preparation. Confocal microskop is suitable ideally for ultra-detailed observation of surfaces and measurements that are necessary during production of micro-devices, such as MEMS (Micro Electro Mechanical System), during development of new materials and also at contemporary compact devices during a spatially more compacted surface installation.

In construction industry it is used for measuring of real distances, volumes, areas and projections, measuring of roughness of surfaces, measuring of profiles, analysis of particles, control of materials, coatings and many other functions directly in 3D projection. Abilities of such system can be utilized very well also during analysis of faults and defects (such as cracks, porosity, etc.) and it also exceeds a frame of conventional microscopy significantly by the fact it presents a very efficient 3D projection tool with high accuracy of measuring.

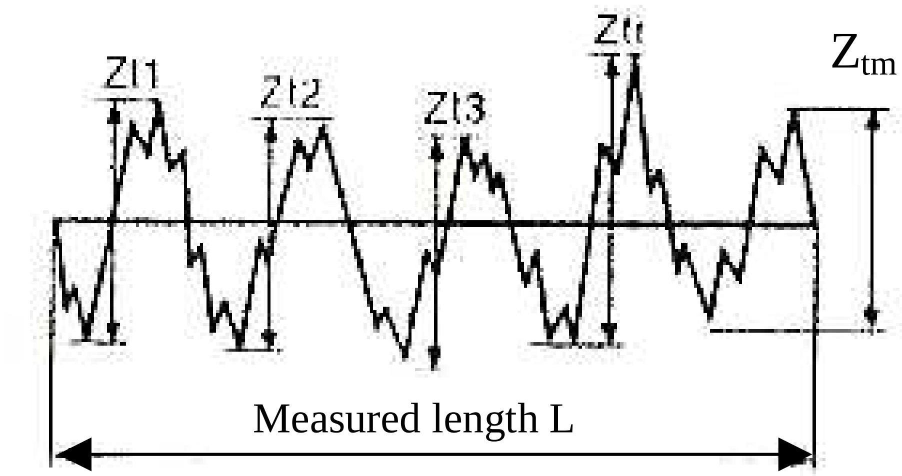

Fig. 1: Middle height Z_{tm} of elements of contour curve in measured length L

In the experimental program desribed below the scanned area of concrete surface was divided to partial rectangles size 1000x1024 μm by ten axes. The gained values characterize the structure of surface in sections along the single axes. For analysis of roughness of a microscopic area 15 characteristics are described altogether, but for evaluation of a surface just three were chosen because quality and structure of the surface is manifested the most at these chosen quantities. It is middle height Z_{tm} (fig. 1), maximal height of a profile R_t (fig. 2) and arithmetical middle height R_a (fig 3).

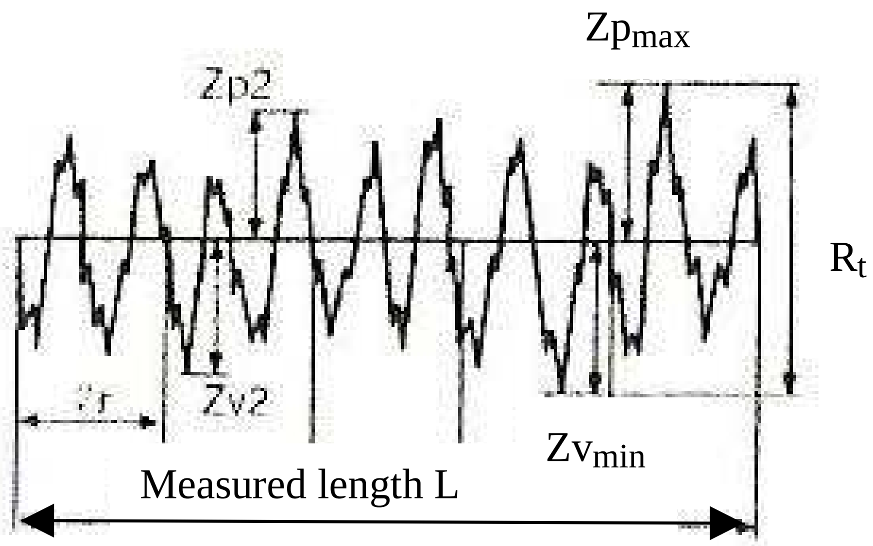

Fig. 2: Maximal height R_t of a profile of curve. It is sum of maximal height of apex Zp and minimal depth of a saddle Zv of contour curve in measured length L

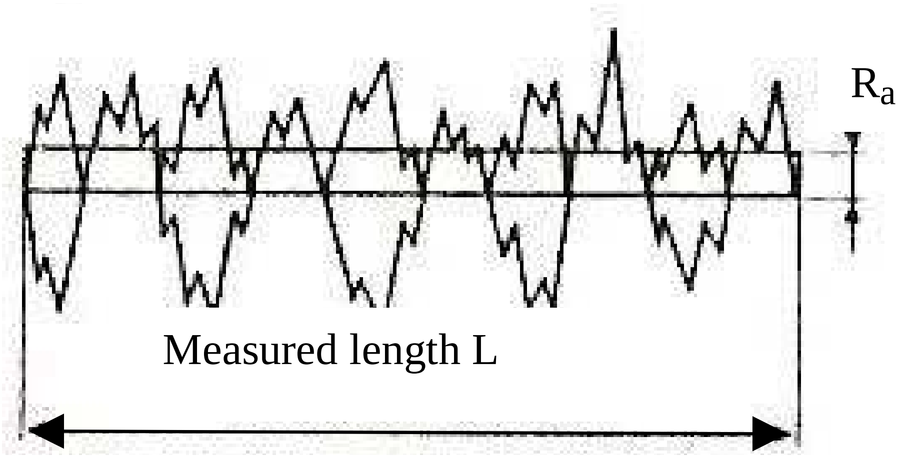

Fig. 3: Arithmetical middle height (roughness) R_a. Middle value from absolute value Z(x) in measured length L

3. Experimental program

Further important aspect in evaluation of concrete surface was examination of a possibility to evaluate not only roughness of the surface but also its variety of color. The microscope does not contain differentiating software that would carry out such a color evaluation. Consequently there was examined the way coloring of the surface is projected to its roughness. To examine this relationship a sample of concrete surface was chosen that showed regular marbling. Observation of surface was performed on the boundary of a light and a dark concrete surface. Screen of controlling PC is presented on Figure 4. Illustration of numerical outlet of microscope in the area of the boundary of color is given in Table 1.

Table 1. Illustration of numerical outlet of microscope (μm)

Axis (measured line)	**Light color**			**Dark color**		
	Z_{tm}	R_t	R_a	Z_{tm}	R_t	R_a
1	7,72	23,55	2,52	8,71	58,05	3,29
2	7,29	28,80	2,41	6,32	20,72	2,31
3	8,30	37,62	2,82	6,84	17,02	2,60
4	9,30	31,76	3,22	10,22	66,93	3,39
5	11,27	37,65	4,46	15,04	166,09	6,70
6	7,85	24,54	2,89	8,38	26,67	2,98
7	6,23	20,32	2,83	13,23	100,30	4,25
8	6,39	26,05	2,38	5,76	17,88	2,54
9	6,98	26,12	3,13	8,77	30,77	3,47
10	7,41	23,50	2,80	8,24	26,47	3,27
Mean	**7,87**	**27,99**	**2,95**	**9,15**	**53,09**	**3,48**

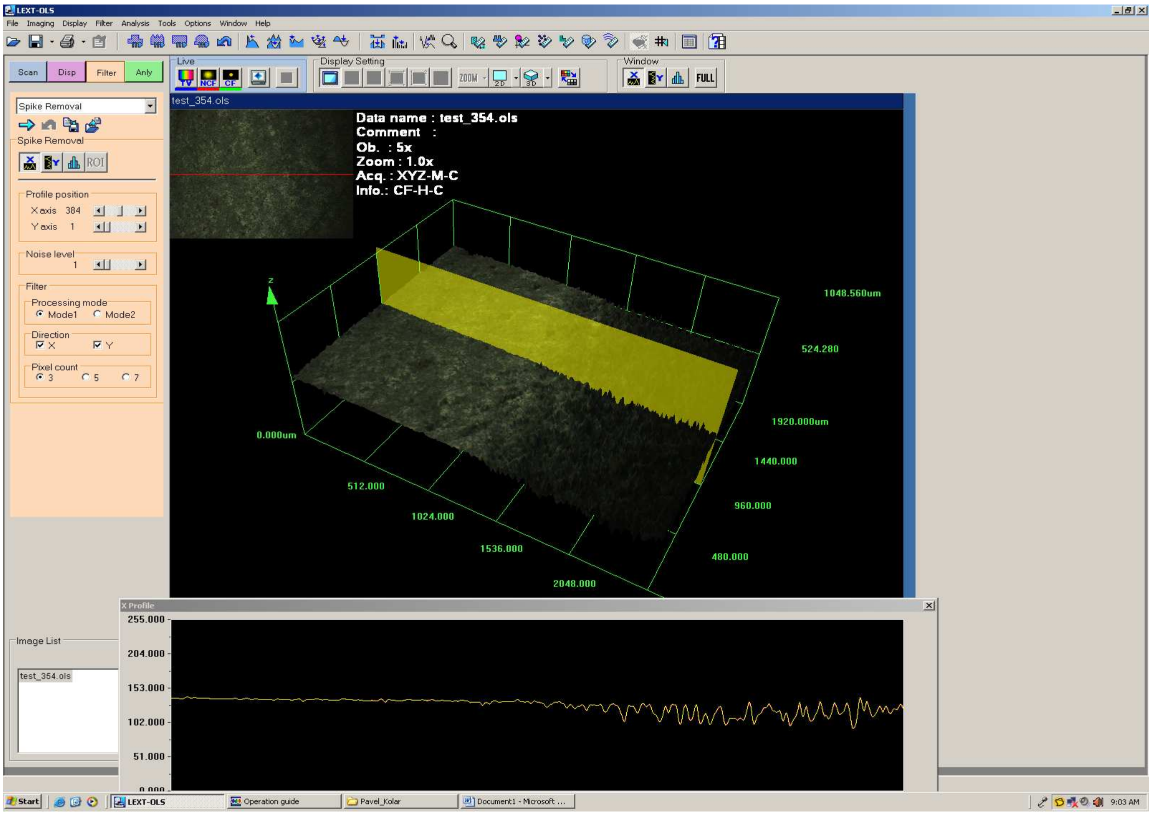

Fig. 4. Boundary of a light (left) and dark (right) color of concrete surface.

The main goal of the experiment was the evaluation of an influence of various separation agents applied on surface of form work on a quality of final surface layer of a concrete. Separation agents of various bases were used for separation of the concrete (see Table 2). Besides these means comparative samples without using any agents were produced. Preparation of experimental samples simulated a production of prefabricated elements where bottom of a form creates a face side of fair-face element. For a production of experimental samples cylindrical forms with a diameter 150 mm and height 50 mm. As a covering a fiberboard with a laminated surface was used. To make a fabrication of a fresh concrete constant, each sample was vibrated on a vibration table with frequency 50 Hz. Vibration time was equal the double of consistency VeBe test result that was carried out, too.

Table 2. Used separation agents an no. of specimen

Agent No.	Name of separation agent	Material base
1	Dem Oleo 50	Synthetic oil
2	Dem Bio 4	vegetable oil
3	Dem Oleo 31	Mineral oil
4	Dem Ekla 12	water emulsion
5	Dem Graisse	wax paste
6	Alop	–
7	Without separator	–
8	Mould	–

Separation means mentioned above were tested on three concrete mixtures with a constant skeleton of aggregates. The first concrete mixture without using of plasticizing admixtures was suggested. At the second and third concrete mixture a plasticizer from Chryso company was used to avoid chemical reaction between a plasticizer and separation agents. Plasticizer based on carboxyl-ether was used. Dose of plasticizer was 0,75% cement mass. This way the cement-water ratio was reduced from 0,5 to 0,4.The third concrete mixture was designed to a consistency corresponding with VeBe test = 4s. Final composition of all concrete mixtures is in following table.

Table 3: Composition of concrete mixtures

Component	Mixture 1	Mixture 2	Mixture 3
	Dose [kg]	Dose [kg]	Dose [kg]
Sand 0 – 4	814	814	814
Crushed gravel 4 – 8	407	407	407
Crushed gravel 8 – 16	739	739	739
CEM I 42,5R	398	398	398
water	200	160	190
Plasticiser carboxyl-ether	0	2,94	2,94

Chemical composition and basic norm characteristics of a used cement CEM I 42,5 R are given in Tables 5 and 6.

Table 4: Results of VeBe consistency test and water – cement ratio

	Mix. 1	Mix.2	Mix.3
Consistency test VeBe, [s]	16	8	4
Water – cement ratio, [-]	0,5	0,4	0,48

Table 5: Chemical composition of a cement

Components	SiO_2	Al_2O_3	Fe_2O_3	CaO
Content [%]	23,9	5,2	2,9	58,8
Components	SO_3	MgO	Na_2O	K_2O
Content [%]	2,5	3,0	0,3	0,8

Table 6: Basic norm characteristics of a used cement

Blain surface [m²/kg]		426
Compression strength [MPa]	2 days	32,1
	28 days	60,5
Beginning of setting time [min.]		160
End of setting [min.]		240

The goal of experiment was to evaluate a quality of different agents on a constant concrete mixture. For this reason the same thickness of separating agent layer 5×10^{-5} m was spread on each form. This thickness of agent layer was achieved by spreading of the same volume (1 ml) to each form. After production of the first series of samples form mixture 1 the samples were taken out from moulds and left exposed to a laboratory environment for about 20 days, so that the carbonation of a surface layer could happen by the effect of air. Immediately after unmoulding the single samples had various tinges but their surfaces were uniformed by effect of air – but not absolutely. Under the influence of using various separation agents the different color of concrete surface was visible; the surface of some samples tended to pulverize. Paradoxically the visually best quality sample was produced without using any separation agent.

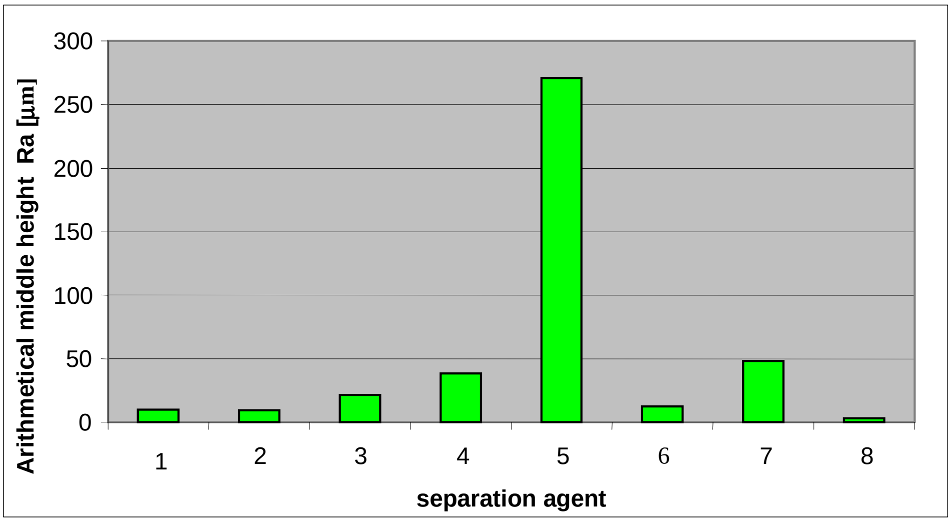

Fig. 5: Concrete mixture 1. Evaluation of roughness R_a

The second concrete mixture differed from the first one by using the plasticizer that was added to increase a workability. Separation agents were dosed also in the amount corresponding with a thickness 5×10^{-5} m. This series with mixture No.2 also showed clearly that after using separation agent the concrete surface had a significantly lighter tinge. This was probable caused by using a separator coloring the surface yellow or brown. This effect gives a certain chance to cover defects on surface that are not that visible on a lighter surface. From a numerical output it is obvious that gained values are much more equable (see fig. 5). This reality was influenced significantly by using a plasticizer that caused better workability and consequently also a possibility to create smoother surface.

Fig. 6: Concrete mixture 2. Evaluation of roughness R_a

Third and also the last concrete mixture differed from the second one only by a dosage of water. There was added 30 l of water on m^3 to increase a workability corresponding VeBe – 4s. For separation of forms the same separation agents were used as in former mixtures. This time agents were not spread in the same thickness. Agent was spread over by a cotton piece of rag so that just a fine film stayed on the surface of the form.

From a graphical output described by an arithmetical middle height R_a [µm] the quality of samples is obviously different. It is important to notice various scale of axis *y* in fig. 5–7. It is a consequence of concrete mixtures with various forming properties. At a last production of mixture 3 the series of samples makes almost the accurate copy of the form. Differences in arithmetical middle height R_a are in microns, but at previous concrete mixtures (1,2) they are in tens or hundreds microns.

Fig. 7: Concrete mixture 3. Evaluation of roughness R_a

4. Conclusion

Experimental work performed until now shoved that using of a 3D confocal laser scanning microscope to evaluate concrete surface quality give new opportunity of objective and quantifiable study and evaluation of concrete surface. During first phase of project the methodology of measuring process was studied. Few series of samples were produced and they were evaluated with microscopic output and also visually. During this phase it was found that color tinge of concrete surface corresponds with roughness of surface. Darker surfaces showed higher roughness and in the frame of one element this transition was visible very well.

The main goal of the measurement was an evaluation of an influence of various separation agents on microstructure (roughness) of surface. Three series of samples were produced for this purpose. In each series a sample without separation agent as a reference surface was prepared. Each series differed in consistency of concrete that was regulated by volume of batching water and plasticiser. After evaluation of the microscope measurement of roughness R_a it was obvious that samples produced without separation agent had the smoothest surface. Their roughnes with increasing workability of applied concrete approached closely to a roughness of used mould. But this result does not distance separation agent at all because samples prepared with using separation agents were much more color balanced and it can be stated that this samples had the same color all over the whole surface. On the other side the samples without using separation agent tended to make stains and maps. Higher roughness of surface at samples prepared with using separation agents is caused probably by not absolutely inert behavior of separators against a fresh concrete. This statement supports the fact that many samples prepared with agents had yellowish or brownish tinge after removing moulds. Intensity of such color weakened by virtue of air but has did not vanish. Rougher and more open surface makes a certain advantage for facades composed from more segments because open surface structure will carbonate faster and will unite in color a bit. Production of big amount of concrete segments with the same tinge is almost impossible. Measurement of tested concrete mixtures proved expected result, that not only agents but the workability influence roughness of surface very much. From that can be stated that mixtures with high workability as self compacting concrete (SSC) or similar mixtures are more suitable for production of fair-face concrete [3],[4].

Experimental work has not ended yet. Other concrete mixtures of various compositions and an influence of single components and other incoming agents on surface will be tested in the future.

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