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Nikolai Dimitriadi, Construction Engineer, Institute BelNIIS RUE, Minsk (Belarus)

AUTOMATED EVALUATION OF THE CONCRETE PRODUCTS SURFACE POROSITY

ABSTRACT

Currently in the territory of the Republic of Belarus the normative document is used in order to evaluate the surface of concrete and reinforced concrete products and constructions [1]. According to this normative document concrete surfaces of the constructions are divided into 7 categories from A1 to A7.

The author suggests that the methods for evaluation of the surface quality, specified in [1], are not sufficient. Wherefore, the article reflects the works performed on development of the installation, methods and program to determine the surface porosity of concrete products. It describes the method to determine a particular and integral surface porosity through receipt and processing of the digital image with the developed program. It allows to automate the evaluation process of the surface and significantly speed up it (especially, in case of a great number of pores on the studied surface). The installation for receipt of the sample contrast images was developed, the modes for images photographic recording were selected. This installation for photographic recording used CANON EOS 1100D camera, on a special stand, used to maintain a constancy of focal length and distance to the registered object.

VBA based program was developed, it allows to determine the pores size and their distribution, calculate their number and evaluate the form, and also allows to determine particular porosity for concrete diameters

and integral porosity. The obtained value of the integral porosity can be used for a clarified calculation of the relative and absolute adhesion value when developing compositions of the release agents. Based on the obtained calculation results it is possible to plot a graph of the pores distribution that formalise and simplifies the aim of the surface quality evaluation.

Keywords: surface category, surface porosity, pores sizes, photographic recording, digital image processing.

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Димитриади Николай Павлович, инженер-конструктор, РУП «Институт БелНИИС», г. Минск (Беларусь)

АВТОМАТИЗИРОВАННАЯ ОЦЕНКА ПОВЕРХНОСТНОЙ ПОРИСТОСТИ БЕТОННЫХ ИЗДЕЛИЙ

АННОТАЦИЯ

В настоящее время на территории Республики Беларусь при оценке поверхности бетонных и железобетонных изделий и конструкций пользуются нормативным документом [1]. Согласно данному нормативному документу бетонные поверхности конструкций разделены на 7 категорий от А1 до А7.

Автором высказано мнение о недостаточности методов оценки качества поверхности, изложенных в [1], в связи с чем в статье отражены выполненные работы по разработке установки, методики и программы для определения поверхностной пористости бетонных изделий. Приведена методика определения частной и интегральной поверхностной пористости посредством получения и обработки цифрового изображения разработанной программой. Она позволяет автоматизировать процесс

оценки поверхности и значительно ускорить процесс оценки (особенно в случае большого количества пор на исследуемой поверхности). Разработана установка для получения контрастных изображений образцов, подобраны режимы фоторегистрации изображений. В данной установке для фоторегистрации использовался фотоаппарат CANON EOS 1100D, на специальной стойке, служащей для обеспечения постоянства фокусного расстояния и расстояния до регистрируемого объекта.

Разработана программа на основе VBA, позволяющая вычислять: размеры пор, их распределение, подсчитать их количество и оценить форму, также позволяет вычислить частную пористость для конкретных диаметров и интегральную пористость. Полученное значение интегральной пористости может быть использовано для уточненного вычисления величины относительной и абсолютной адгезии при разработке составов разделительных смазок. На основе получаемых результатов вычислений возможно построение графиков распределения пор, что формализует и упрощает задачу оценки качества поверхности.

Ключевые слова: категория поверхности, поверхностная пористость, размеры пор, фоторегистрация, цифровая обработка изображения.

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INTRODUCTION

The local and foreign normative documents [1, 2] specify the requirements for the quality of a concrete surface. GOST 13015.0-83, depending on the purpose of the construction, specifies the categories of concrete surfaces, the requirements for them and ways to form constructions. Besides the concrete composition and way of formation, the agent has a significant impact on the quality of a

concrete surface (change of the surface porosity nature, presence of grease stains etc.). Therefore, during development of the agents it is important to work out the evaluation methods for the concrete surface porosity and impact of different factors on its value.

The known methods to evaluate the concrete surface quality [3–6] have certain deficiencies. Foremost, it is caused by a significant expansion of the photo- and video recording application areas, emergence and solution of new applied problems, requiring automation of the image evaluation process and expansion of its tooling. In our case the known existing software products for the analysis of the materials structure and processing of the dispersion analysis data did not fit us. For example, in GALLERY program [7] it is necessary to manually outline each pore after receipt of the digital pores image, after that the program will perform their quantitative evaluation. In our case it is unacceptable, as on the sample surface of 5 x 5 cm size the number of the pores may reach 1000 pieces and measurement of their size in the manual mode will be a rather time consuming task.

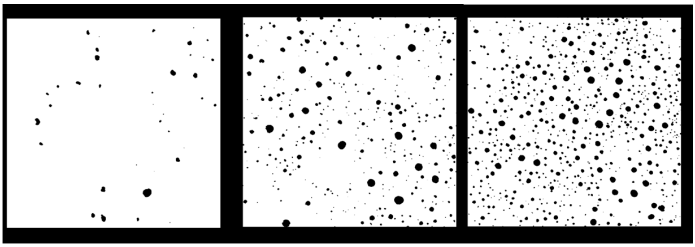
Accepted terms

Integral surface porosity – a total area of the pores on the analysed surface (measuring units: mm^2 or %).

Particular surface porosity – a total area of the pores of certain sizes (dimensions) on the analysed surface (measuring units: mm^2 or %).

The deficiencies of the normative document [1] and development of an automated method to evaluate the quality of the concrete products surface

During development of the release agent compositions [8] we found out that the evaluation methods of the surface quality, specified in the normative document [1] are not enough for research purposes: surface is evaluated only by the largest pore and blowholes diameter, without deriving their quantitative evaluation. Thus, it appears that the surface of the product with individual (rare) pores location and with dense in case of the equal diameter of the largest pore (blowhole) would be equated to the same category, despite even visually better quality of the surface in the first case. Based on the evaluation methods [1] of the surface quality only, we get that the same category of the surface can significantly differ visually (Fig. 1, Table 1).



a) b) c)

Figure 1. Concrete samples with various surface porosity. a) – the agent with the surface porosity reduction effect is used; b) – the agent based on the waste oils; c) - the agent, containing the air entraining admix

Table 1

Characteristics of the surfaces, shown in Fig. 1

Image	Largest pore diameter, mm	Surface category acc. to [1]	Integral surface porosity, %
Figure 1a	2.01	A3	0.73
Figure 1b	2.12	A3	4.07
Figure 1c	1.87	A3	8.39

As it is shown in Table 1 the samples with the same surface category (A3 acc. to [1]) have a significantly different integral surface porosity (0.73 % (Fig. 1a); 4.07 % (Fig. 1b); 8.39 % (Fig. 1c)). Thus, the characteristics of the surface by the largest diameter only is not sufficient (at least for the research purposes). It is also necessary to know their quantitative characteristics for a detailed evaluation.

Besides, the knowledge of the surface porosity value also allows to calculate an exact adhesion value for agents, as the calculation according to [9] does not consider the decrease of a real interaction area of a concrete sample with the mould or formwork surface (for example, by 8.39 % (Figure 1c)) that leads to the understated results when calculating the adhesion value.

Based on the foregoing, we set a goal to develop a program and evaluation method, allowing to calculate the size of the pores and their quantity (area).

This program allows to receive the values of both particular and integral surface porosity (Fig. 2).

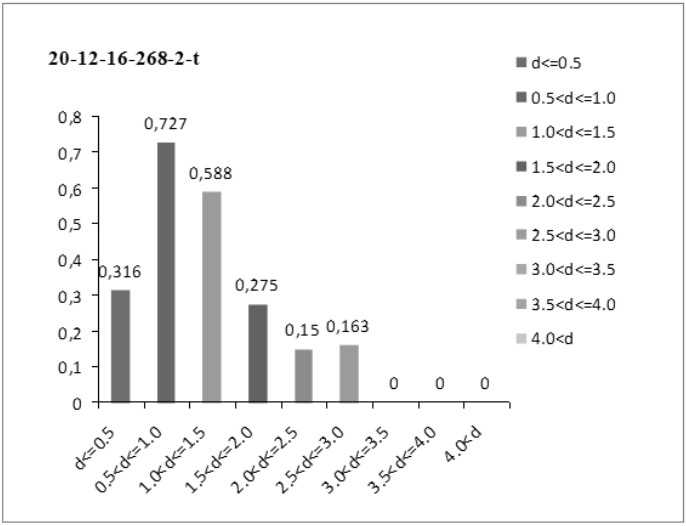


Figure 2. The result of the porosity calculation with the developed program

Figure 3 schematically shows the surface of the registered concrete sample (front view and section). Because the grains on the concrete surface have different colour, including dark, they can be mistakenly recognised as pores. In order to avoid such phenomenon, the surface is collared with a layer of a contrast paint before the photographic recording. When the sample is drying in the premises, it is necessary to avoid the dust sources not to get erroneous recognition results.

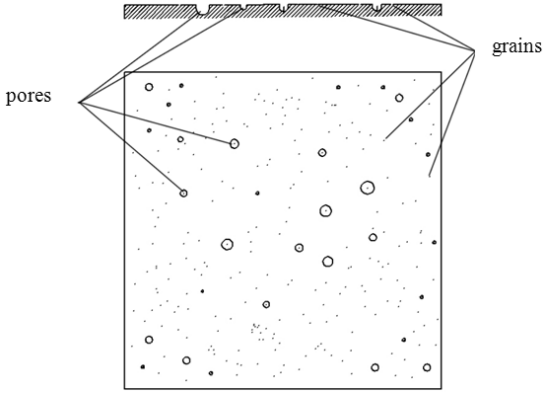


Figure 3. Layout view of the registered pores and grains

CANON EOS 1100D camera, installed on a specially prepared stand (Figure 4) was used for the photographic recording. The installation for photographic recording of the image was designed in such a way as to ensure the perpendicularity of the optical axis of the camera and the plane of the studied concrete sample, the constancy of the focal length and distance from the recorded object.

The sample shall be set in a tripod and photographed (while observing the optimal aperture, shutter speed and ISO settings of the camera).

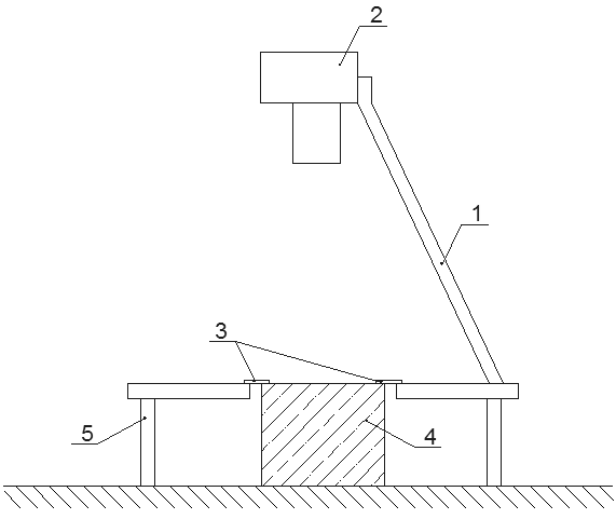
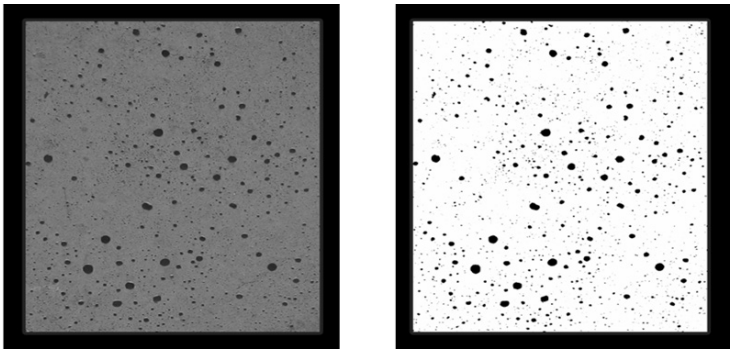


Figure 4. Installation diagram for photographic recording of the sample surface
1 – camera stand; 2 – camera; 3 – position limiters of the registered sample; 4 – registered sample; 5 – installation stand

After the photographic recording, the image passes a preliminary digital processing (scale change in accordance with the real sizes, conversion to monochrome (black and white) digital mode) (Figure 5).



Source Image Processed Image

Figure 5. Image before and after conversion into the monochrome colour mode

Further the raster image is converted into vector format using Corel Draw 13.0 software.

In order to receive the characteristics of the surface porosity, the VBA language program, representing a macros, is used (Fig. 6).

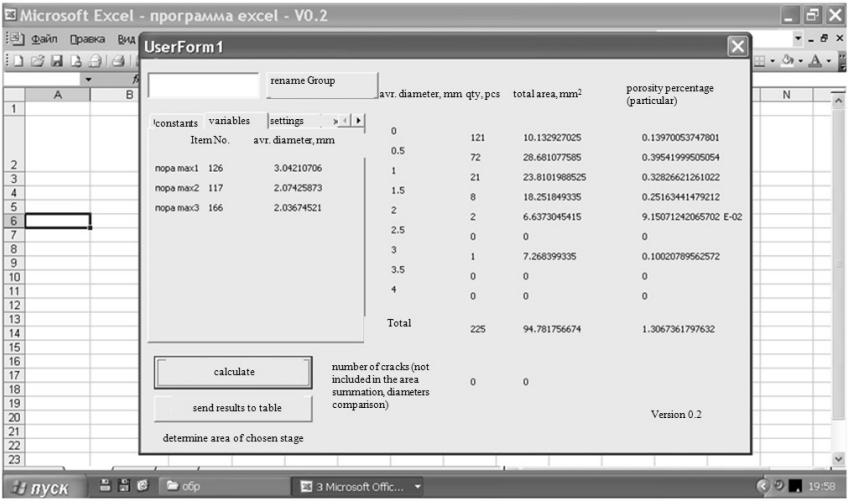


Figure 6. The window of the program for calculation of the surface porosity values

It performs search of the pore with the largest diameter, determination of the quantity of the pores, sorting out by diameters (d), summation of their areas at the stated intervals ($d \leq 0,5$; $0,5 < d \leq 1,0$; $1,0 < d \leq 1,5$; $1,5 < d \leq 2,0$; $2,0 < d \leq 2,5$; $2,5 < d \leq 3,0$; $3,0 < d \leq 3,5$; $3,5 < d \leq 4$; $d > 4$) in the prepared vectorised image (change of the intervals' boarders is allowed, but their quantity should not exceed 9). During processing of the bulk data, the defects of the concrete sample surface, which are cracks, are rejected (however, their area is taken into account when calculating the adhesion value). Based on the obtained data, the values of the particular and integral surface porosity are calculated, the value of the largest pore diameter is issued and a graph is plotted (Figure 2). The developed method allows to evaluate the surface (surface porosity) for both the laboratory samples and finished factory products and constructions. It can also be used to calculate the volume porosity values.

CONCLUSION

The installation for receipt of the sample contrast images was developed, the modes for images photographic recording were selected.

The VBA program was developed, allowing to calculate the size of the pores, their distribution, particular (for certain diameters) and integral porosity, which, besides, can be used for a clarified calculation of the adhesion value.

The program was used when studying the impact of the agent and additives, used in the concrete, on the concrete surface quality (pores diameter, their distribution and quantity) [8].

Considering the admission that the pores distribution on the surface corresponds to their distribution in the product volume, it is possible to determine a concrete volume porosity on the concrete products thin sections, using the program.

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