Assessment of Construction Materials Trends Salt Content from Scanned Images

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Abstract. Composite building materials subjected to such operational influences as high humidity and temperature have been investigated. As a result of the experiments carried out within 45 days of the samples, their scanned images were obtained, which were represented by RGB color models and processed in order to identify changes in their color properties. Samples of materials are ranked by revealing a tendency to salt formation on their surface. Depending on the change in the brightness of the samples during their exposure, the images of the samples are divided into two groups, one of which contains images that at the last exposure area have a higher level of brightness relative to the control sample, approaching white. The second group is characterized by lower brightness values also relative to the control sample. As a result, samples are identified, the images of which have a noticeable tendency to salt formation, which is controlled by the level of white brightness.

1. Introduction
A significant number of scientific papers and publications are devoted to the study of building materials and cement composites, some of which are reflected in [1-19]. There are also studies in the field of building materials based on digital image processing – scanned images of samples sustained in various operating conditions [20-26].

This paper continues research and software experiments with images of building materials. The research is based on both the General theory of digital image processing and some modern approaches to evaluating the quality of raster images [27-35]. In particular, we use the histogram method to determine the dominant colors of the image represented by the RGB color model (Red, Green, Blue – red, green, blue). It is noted that the RGB color model is the most appropriate for computer image research [28-30].
The task of research is to track changes in the brightness of the image of samples of building materials, sustained in conditions of high humidity and positive temperatures. However, the approach described below can be used for other testing conditions for certain building materials. A necessary condition for applying the considered approach to evaluating the quality of materials is a series of tests over a certain period of time. The control sample is scanned under normal operating conditions. And then the scan is repeated after 15 and 45 days in conditions of high humidity and variable positive temperatures. This mode of exposure was considered in [5, 7, 9].

2. Materials and methods
Compositions based on Ulyanovsk cement of the PC500D0 type were used as test materials. Table 1 shows the components of the tested building materials.

| Composition | Cement Ulyanovsk PC500D0 | Water | GP Melflux 5581 | Biocidal additive |
|-------------|--------------------------|-------|-----------------|-------------------|
|             |                          | Close | MultiDEZ Disinfectant | Teflex Universal | UltraDEZ -Bio Teflex-Antiplese |
| T1          | 1                        | 0.267 | –                | –                 | –                     |
| T2          | 1                        | 0.267 | –                | 0.03              | –                     |
| T3          | 1                        | 0.267 | –                | –                 | 0.03                  |
| T5          | 1                        | 0.350 | –                | –                 | –                     |
| T6          | 1                        | 0.350 | –                | 0.03              | –                     |
| T8          | 1                        | 0.350 | –                | –                 | 0.03                  |
| T9          | 1                        | 0.195 | 0.009           | –                 | –                     |
| T17         | 1                        | 0.267 | –                | –                 | 0.03                  |

In General, for computer software processing of a set of studied compositions of building materials, their images (graphic formats) should be located in files and corresponding directories (file system), as shown in figure 1.

The marked catalogues in figure 1 may correspond to brands, for example, of cement composites such as T (T1, T2,...), M (M0, M1,...), which are widely used in the construction industry. In General, the diagram of Fig. 1 was used in the development of a program that performs automated image processing (in this case, scanned images of test materials). In accordance with the notation in figure 1, the files in each directory are files of graphic formats, scanned images at exposure time points, of which there are only m. Accordingly, the catalog number 1, it can be the composition of T1, catalog number 2-the composition of T2, and so on. There will be eight catalogs in accordance with the notation in table 1.

Initial digital processing of the studied images of scanned samples is performed using the following algorithm.

Step 1. Converting a full-color image of an RGB model to a grayscale image.
Step 2. Calculating the histogram of a halftone image.
Step 3. Determine the value from the interval [0; 255] of the brightness level corresponding to the maximum value of the histogram of the halftone image.
Step 4. Repeat steps 1-3 for a group of images.
Step 5. Use an associative container (for example, multimap C++) with a key for the brightness value and the image name value.
Step 6. Compare the brightness levels of the control sample image (1st) and at the last point «End» of exposure. If the «End» is greater than «1st», the first group of such images is formed, sorting the brightness levels by the difference value \((255 - (\text{«End»} - \text{«1st»}))\). Otherwise, a second group of images is formed, also sorted by the difference value \((\text{«End»} - \text{«1st»})\).

Step 7. Ranking the first group of images. Determination of the composition of the test sample that is least resistant to the tests performed during the exposure time.

Step 8. Ranking the second group of images. Determination of the composition of the test sample that is most resistant to the tests performed during the exposure time.

\[\text{Figure 1. The file system structure.}\]

According to the above algorithm, the "worst" samples are more prone to salt formation, in which the image surface of the sample has a greater tendency to transition to a white surface color. Select the composition that has the smallest difference between the brightness level 255 and (End-1st).

Accordingly, the composition that is more resistant to operational effects, which has less noticeable salinity on the surface of the sample, and which has the smallest difference between the values of brightness levels at the initial test point and at the final time point of exposure.

3. Experimental results

In accordance with the described algorithm were investigated cement composites are presented in table 1. The following ranking results were obtained and the determination of more resistant and less resistant to salt formation on the surface of samples.

Results of ranking the 1st group of images (worst) samples:
the composition of the T17. Brightness level: 210
composition of T2. Brightness level: 226
composition of T1. Brightness level: 230
composition of T8. brightness Level: 242
composition of T6. Brightness level: 244
composition of T3. Brightness level: 248

Results of ranking the 2nd group of sample images:
composition of T5. Brightness level: 7.
the composition of the T9. Brightness level: 13.

The sample is more resistant to the tests performed: the composition of T5.

The sample is less resistant to the tests performed: the composition of the T17.

For a visual assessment of the calculations performed, see figure 2 and figure 3 shows images of compositions 5 and 17.

Figure 2. Composition of T5: a) control sample, b) after 15 days of testing, c) after 45 days of testing.

Figure 3. Composition of T17: a) control sample, b) after 15 days of testing, c) after 45 days of testing.
4. Conclusion
As a result of the research, an algorithm was developed for writing a program in C++ using the OpenCV computer vision library [17, 18]. In accordance with the described algorithm, construction composites were studied, the compositions of which are shown in table 1. A ranking of compositions that have been tested in conditions of high humidity and variable positive temperatures has been performed. This ranking can be considered an optimal sorting of materials based on the criterion of minimizing the deviation from the brightness level of the control sample and minimizing the "worst" compositions in relation to the brightness level 255.

5. References
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