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The usage of smart materials for skin-diagnostics of building structures while their monitoring

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Abstract

This study investigates the usage of smart materials for skin-diagnostics with the view of monitoring of building structures parameters characterizing their mode of deformation. The method is based on changes in electrical resistance of the smart coat owing to external influences. Conductivity achieving was performed by introducing of carbon nanotubes (CNTs) into the initial material. Composites on the basis of sodium silicate, epoxy resin, acrylic and cement have been worked out. Resistivity-number of CNTs dependence was obtained for sodium silicate and epoxy resin. The evaluation of the uniformity of the CNTs distribution in the bulk of samples by simple mechanical mixing was executed. The influence of the measurement of the electrical resistance by direct and alternating current was checked.

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Keywords: skin-diagnostic, carbon nanotubes, monitoring, smart materials, electrical resistance.

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1. Introduction

Monitoring of building structures is one of the most time-consuming and long-term operations in the operation during maintenance of buildings and constructions. According to [1] under the monitoring of building structures the constant monitoring of their condition is implied, which can be achieved only with the usage of automated systems of technical diagnostics.

I.e. the main task of the system of technical diagnostics and, consequently, monitoring of building structures is to monitor the parameters that allow controlling their technical condition.

The main parameters of building structures, which can be permanently monitored, are [1]: geometric, force, dynamic, temperature, longevity parameters.

Monitoring of force, dynamic and longevity parameters is a time-consuming process in terms of its organization, i.e. the system of installation. These observations are used in solitary cases after justifying the necessity, when it is impossible to obtain the desired results by measuring geometric parameters. Monitoring of the temperature change is obligatory practically in all cases of the organization of diagnostics system to assess the effect of this parameter on the others and their subsequent correlations. Monitoring of geometric parameters of building structures is the most common kind of observation in the organization of diagnostic systems and nomenclature of monitoring means over the given parameters is rather diverse [1,2]: fiber optic sensors, piezo resistive sensors (strain gauges), hydrostatic leveling system, geodetic systems and others.

The above mentioned monitoring means have both advantages and disadvantages. The main disadvantages of these systems are:

- the difficulty of installation and adjustment;
- the impossibility to install in the places with limited access;
- the instability to mechanical damage;
- the impact of external influences on the readings;
- the difficulty in localizing of structure deformation;
- the lack of sensitivity;
- the instability of the readings and others.

Therefore, the development of effective monitoring systems with a minimum of drawbacks is rather urgent task.

One solution to this problem is the development of smart materials that have the ability to react to the changes of geometric size, the distribution of local stresses, the formation and development of cracks, the moisture content and even the presence of chlorides. The successful implementation of this material is possible with the help of the usage of carbon nanostructures (graphite, graphene, nanotubes and nanofibers) according to two schemes: uniform distribution in the bulk of the structure material or in the composition of the coverage material applied to the surface (part of the surface) of the diagnosed structure (skin diagnostics).

Despite the considerable amount of researches in this area it may be noted with confidence that the issue is still urgent. The evidence of this can be the inconsistent results of studies by various authors, in which the mechanical and conductive properties of concretes reinforced by carbon nanotubes can vary significantly. In [3] the grafting of functional groups was performed by boiling in a solution of sulfuric and nitric acids. The formation on the surface of oxygenated groups has led to the increase of the strengthening properties of the concrete while compression and bending to 19 and 25%, respectively.

However, in [4] there was a decrease in durability while implementation of composite cement into the composition. According to the authors, the observed reduction of durability (7 times) is due to the absorption of water by carbon nanotubes and as a consequence of incomplete hydration of clinker.

The double improvement of the durability of concrete has been found in [5]. According to the authors in the course of the acid treatment, concurrently with the process of grafting of functional groups onto the surface of the carbon nanotubes, there is the formation of carboxylated carbon fragments whose presence helps to reduce the reinforcing effect from the usage of carbon nanotubes. The removal of the mixing of mentioned fragments from the water has increased the strength of the cement composite from 36 MPa to 71 MPa, at the concentration of carbon nanotubes of 0.03% by the weight of the composite.