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Modeling of Wind Regime in Disturbed Areas Restorable for Urban Development

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Abstract

Territory is one of the main values of any nation. Its value is even higher as it is not renewable; meanwhile the growth of productive power, population and construction of cities all over the world keep developing at quick paces.
Nowadays, the high level of scientific and technological progress, civil engineering and mineral production leads to the decreased balance of lands and recreation resources while there is a steady rise in demand for out-of-town vacations among big cities residents, and therefore the necessity to implement nature protection activities. These factors make the problems of ecodevelopment and utilization of disturbed areas more and more topical. Under the conditions of the Soviet development in 1961-1970, built-up areas of cities had increased by almost 30 %, principally as a result of alienation of farmlands. Under modern conditions, the expansion of urban areas solely by the account of farmlands becomes impossible.
Therefore, one of the principal ways to reduce the territories alienated for housing development is their rational use. As a result of the Soviet urban planning policy in the CIS, the proportion of out-of-use urban territories in the boundaries of modern urbanized areas amounts to about 50 %. The disturbed areas are also considered unsuitable, because they are useless for public economic activities (considering the condition they are in), and also they have a negative impact on human life and activities.
In this paper, the experimental results of the airflow process of technogenic relief forms in disturbed areas, in particular of a partially planned refuse heap and of a circular in plan terraced excavation, are given. The obtained results can be used while drawing maps of aeration mode, when the disturbed areas after field mining are used in urban development or for other purposes (housing construction, parks, leisure area etc.).

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Keywords: Modeling, disturbed areas, technogenic relief, dump, borrow excavation, wind, aerodynamic characteristics.

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1. Introduction

The main objective of urban planning both in theory and practice – is creating safe and favorable living environment for the residents of cities and localities. One of the main problems of urban planning is recovery and utilization of the territories disturbed while extracting or processing minerals. This problem is most topical in the cities which suffer from land shortage for the functional zoning, and therefore suffer from unfavorable environmental situation, because the major part of disturbed areas is usually situated within the city limits or comparatively close to the residential buildings [1-8].

The necessity in early recovery of disturbed areas is conditioned by their sufficiently negative impact on the environment. This impact is expressed by withdrawal of significant land areas for mining operations, formation of new technogenic reliefs (deep cuts, dumps, refuse heaps, etc.), considerable change in hydrogeological and hydrological regimes of the territory (draining, underflooding, waterlogging), emission of harmful gas and dust into the atmosphere (by the mines and quarries) and so on [9-12].

Technogenic relief significantly influences aeration mode of the recovered areas. Meanwhile, this fact is not considered when developing the land plot layout, because the influence that forms and geometric characteristics of a technogenic relief have on the territory's aeration mode is still understudied [13-15].

In order to study the aerodynamic characteristics of the technogenic relief of disturbed areas, the experimental research in a wind tunnel was carried out. The objective of the experimental research of aeration mode in the disturbed areas lays in revealing dependence of the airflow transformation ratio τ from geometric characteristics of the technogenic relief. Experimental research by the method of physical modeling in a wind tunnel is based on the modern theory of aerodynamic similarity. One of the main and most complex tasks in aerodynamic tests is to create a flow in the wind tunnel which would be similar to the wind in natural conditions. Experience of other researches shows, that when conducting experimental research in a wind tunnel, it is necessary to maintain geometric, kinematic and dynamic similarity (Gorlin S.M., Zrazhevskiy I.M., Retger E.I., Serebrovskiy F.L., Nemoto S. etc.) [16-24].

In our case, geometric similarity is provided by accurate model generation in the established scale. Kinematic similarity of incoming air is provided by a special grid set in the wind tunnel contraction; this grid recreates vertically alternating flow velocity profile. Dynamic similarity of the modeling airflow with the natural wind is provided by the similitude of the turbulent structure [19].

2. Experimental procedure

Experimental research was conducted in a wind tunnel of the structural physics laboratory of South Ural State University. Testing of technogenic relief models in the wind tunnel allowed determining qualitative and quantitative airflow pattern around the models, depending on:

- model planform;
- parameters of the model's cross-section, including the angle of slope and relative elevation (depth) of relief form;
- orientation of the model relative to the incoming flow (0, 45, 90, 135 and 180° to the main axis of the model).

Airflow measurement was taken at height H = 10 meters from the land surface (equivalent to 10 mm at the model), which corresponds to the level of a wind vane at a weather station. The measurements were also taken at height H=2 meters (equivalent to 2 mm at the model), i.e. at the human scale height. First, undisturbed airflow velocity at the height of a weather station in a set scale without the model U_0 was measured. Then the model was set at the laboratory bench, and the velocity measurements in certain points of the model at the same fixed altitude U_1 were taken. Airflow transformation ratios τ were determined by the correlation

$$\tau = U_1 / U_0 \tag{1}$$

For the convenience of research data reduction and visualization of the airflow pattern, graphic method for material execution had been selected. Airflow transformation ratios in each of the measurement system points were