Buffer zones of the loessial massifs ecological framework as the necessary condition of its sustainable development

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Abstract. The design of buffer zones of buildings consisting of ecological skeleton biogeocenosis construction on loess arrays, is essential for the normal functioning of buildings throughout their life cycle. If the removal of such dangerous phenomena as pseudokarst, subsidence and erosion are involved at the stage of design and construction, the development and manifestation of these processes during the operation in the buffer zones can cause deformation and even complete destruction of buildings. Therefore, requires monitoring buffer zones, which delimit technogenic changed territory (TIT) and ecological framework for preventive action reduce the negative impact of dangerous geological processes of natural and anthropogenic genesis.

1. Introduction

Loess is the unique creation of Nature. Possessing special, ephemeral characteristics they are allocated from all the variety of the Quaternary Period formations. In fact, such properties as porosity, low humidity, existence of unstable structural bonds, calcareousness, ability to hold vertical slopes to 100 m and more, ability to create pseudokarst, drawdown, the trace amount of readily soluble connections, etc. are characteristic only of loessial breeds. Loessial soils, are the lithogenic basis on which the numerous buildings and constructions are built. The exclusive fertility of the soils is bound to the loess, as they make up the maternal breed of black soils) allowing to receive rich harvests of crops – (millet, gaolyan, wheat, fruits and berries, and in case of irrigation valuable cotton crops.

Loessial breeds cover about 10% of the surface of the ancient breeds of the mainland of our planet and create the singular loessial landscape (more than 13 million sq.km). Loessial landscapes are the heterogeneous territories consisting of groups of the interacting ecosystems (not less than several kilometers in the diameter) which are naturally repeated in space [1].

Construction on the loessial massifs leads to the transformation of natural landscapes to the technogenic one. It causes the necessity of carrying out the whole complex of actions for the elimination of development of such dangerous geological phenomena as pseudo-karst, drawdown, landslides development, formation of gullies, etc. In this regard, there are relevant matters of the general geo-ecological assessment of the general condition of the loessial massif.

During the predesign stage and during the consideration the massif of loessial breeds as the main environment for the construction it is necessary to consider all the variety of features of loessial breeds. Considering that construction and operation of any structure on the loessial massif leads to the
violation of its geoecological sustainability, there is the need of projection of so-called buffer zones, which differentiate the construction and the main loessial massif.

2. Methods
The concept of buffer zones appeared in Europe in the 15-16th centuries. In the 1930th the standard form of projection and application of buffer zones was fixed in the USA [1]. Recently, the concept of projection of buffer zones has been generally focused on the mitigation of negative impact technogenically disturbed territories, such as settlements, industrial enterprises, brick-works, hydraulic engineering constructions, etc. [2, 3]. That is, buffer zones act as the peculiar cross-border geoecological zones, reducing technogenic influence [4,5].

In this regard monitoring of territories is necessary, including systematic observation and prediction of structural changes of the landscapes as well as their preservation and rational environmental management. The concept of the ecological framework of the territory can become the main solution of the arising problem [6, 7, 8, 9, 10, etc.]. The created ecological framework of the loessial massif can be the database source for the monitoring of territories.

Ecological framework is the legibly structured system interconnected during zoning and development natural and anthropogenic modified areas with different appointment and legal status, capable to provide ecological balance, social-and-economic wholeness and sustainable development technogenically disturbed (urbanized) territory as the biosphere-compatible complex [10].

The ecological framework designed taking into account influence of major factors of the framework cores, buffer zones, ecological corridors, zones of stabilization and anthropogenic modified areas allows to balance geo-ecological and technogenic indicators of the definite territory that in turn can help to keep the territory viability.

3. Results
Special protected areas which cannot maintain the geo-ecological equilibrium owing to the general technogenic loading, act as a core of an ecological framework. The solution of such task requires the creation of the compensation systems consisting of sites with various modes of environmental management. We suggest to consider the following generalized methodical approach to the formation of the ecological framework for loessial landscapes in the special physiographic conditions [7, 10, etc.] (Fig. 1):

1. Selection of ecological kernels of the framework;
2. Selection of buffer zones;
3. Selection of stabilization zones of the territory (reservations);
4. Selection of the anthropogenic modified areas (the urbanized territories, the industrial zones, farmlands, zones of water intakes, warehousing of solid waste, treatment facilities, etc.);
5. Selection of ecological corridors (or exchange zones).
Let us briefly consider the allocated building blocks of the ecological framework of loessial territories.

Ecological cores.

These are the basic elements of the ecological framework, providing the conditions of steady functioning of biogeocenoses. Natural landscapes of the high nature protection significance especially protected natural territories (reserves, wildlife areas, national parks, etc.) the representing characteristic natural ecosystems providing maintaining population background, the reference, infrequent and economically significant the significant types performing the environment-forming function, as a rule, are the part of ecological kernels. The assessment of the effectiveness of the core activity has to be organized on the basis of natural processes monitoring and the phenomena and their changes under the influence of technogenic activity on the uniform scientific and methodical basis. [7] (p. 14. Ecological framework of of the Republic of Tatarstan).

Now there is no consensus about what space the cores in the ecological framework have to occupy. According to some researchers, the method of expert evaluations, it was proved that the total area of the ecological framework has to be not less than 25% of the territory [5].

Figure 1. Schematic representation of structure of the ecological framework of the loessial massif, complicated with the anthropogenic modified areas.
The majority of experts consider that the necessary share of kernels of the ecological framework, for maintaining the ecological balance, is to be from is 20...60% of the total territory, and this share has to increase significantly from the South to the North and from flat territories to mountains. [7] (The same work, p. 714).

Protection of kernels of the ecological framework and anthropogenic modified areas from the adverse effects is carried out by "buffer territories" to which the sanitary protection zones of lakes, the rivers, reservoirs, the industrial enterprises, the forest land, etc. belong. There is the formation of the whole complex of the dangerous geological processes in this zone, causing the violation of conditions of the whole life cycle of the structure and the complex stability of the natural and technogenic ecosystem: structure - environment.

Figure 2. Fragment of the environment to Figure 1 on the example of the territory of the ecological framework of the left bank of the Huang He River (Province of Shanxi, to the northeast from the well-known thresholds of the Huang He River). Graphical symbols to Fig. 1.

Buffer zones. Buffer zones are intended for the mitigation of negative impact of technogenesis on the ecological kernels of frameworks, stabilization zones of territories (reservation) and zones of ecological corridors. The complex of architectural and planning, forest reclamation actions for the improvement and development of buffer zones is necessary. The development of dangerous geological processes in buffer zones can lead to deformations, destruction and failure of the bringing communications, and in case of actively developing geological processes it can lead to destruction of the construction itself.

Knowledge of the reasons and operating conditions of the buffer zone of structures on the loessial massifs will allow to prevent the development of dangerous geological processes, and in case of their development, that will allow to provide measures for their localization.

Thus, buffer zones on the loessial massifs represent ribbon-like or ring-shaped zones of different width which surround settlements, urban agglomerations or kernels of the ecological frameworks, with certain density of vegetation and it is frequent, already held complex of some hydromeliorative actions, isolating the fragile environment from zones of active technogenesis. On the other hand, in the buffer zones dangers of geological processes destroying settlements and urban agglomerations are to be minimized [11, 12].

We consider four main options of the buffer zones arrangement (Fig. 3):
1. The buffer zone is on ledge of upper part of a slope. It can be of different width and kind of separates construction from the abrupt ledge.
2. The buffer zone separates the structure from the slope, made up by the loessial breeds, that is the structure is at the slope foot.
3. The buffer zone is on the slope of the valley, made up by the loess. In this case we consider two options of buffer zones: on the gentle or steep slopes.

4. The buffer zone is on the horizontal surface, as a rule, at the bottom of valleys. In this case we also consider buffer zones of the river terraces and floodplains of the rivers (alluvial plains).

Each of the allocated options of the buffer zones has clear boundary and rather isolated ecosystem. Such a way of allocation of the ecological units (sites) gives us the chance of zoning of rural and forestry management. It also allows to investigate the sequence and the continuity of change of ecosystem of loessial arrays under the impacts of the technically armed human activity [11].

Figure 3. The main options of the arrangement of structures on the loessial massifs. The shooters specify the buffer zones locations [11].

Zones of stabilization of the territory (reservations). They are can be intermediate, zones for the recovery of environmental setting and for the maintenance of ecological balance of the territory. Those are the biggest territories on the area, playing an important role in forming of the ecologically balanced structural organization of the territory of the area.

Zones of the anthropogenic modified areas (the urbanized territories, including zones of water intakes, warehousings of solid wastes, sewage treatment plants, agricultural grounds, etc.). Zones of active technogenesis which, are usually followed by the extensive adjacent territories, used as farmlands, industrial enterprises, places of mining, zones of warehousing of solid wastes, etc.

Zones of ecological corridors (or exchange zones). Those are the territories which are linearly extended in space and have small width. The main function of such zones is transport, they act as the main highways of biogeochemical exchange of substance and energy among elements of the ecological framework. Those are valleys of the rivers, ravine and frame network, hydromeliorative constructions (channels, water reservoirs, etc.), automobile, the railroads, bridges, etc. Such zones are to have the security mode, the planned activity and to be environmentally friendly as through them excessive pollution which can cause destabilization of condition of the whole ecosystem can come to kernels of the ecological frameworks soon.

In places where the ecological framework has gaps, such as zones of active development of loessial pseudo-karst, artificial elements have to be created (for example, landings of Robinia pseudoacacia L. belonging, to family Bean, sort Robiniya, or Chinese juniper (Juniperus chinensis L.) on the slopes where natural vegetation has been removed for the purpose of reconstruction of its uniform structure [13-14].

4. Conclusion
1. Because of the features of the geo-ecological environment of loessial massifs with special structure and properties, they collapse extremely quickly under the influence of technogenesis, with the development of such dangerous geological processes as loessial pseudokarst, drawdown, an erosion, etc. Restitution of the destroyed ecosystems long and not always efficient. These questions, in terms of
engineering geocology, limit the choice of the building site on loessial massifs and increase the construction cost. Therefore, the clarification of the major factors having influence on the geological environment, regularities and characteristics of formation of dangerous geological phenomena, creation of the system and methods of assessment of the building site on loessial massifs are prior tasks.

2. Projection of buffer zones on the loessial massifs is necessary for the regulation of biogeochemical exchange of substance and energy of the ecological framework of the loessial massif. Buffer zones reduce the imbalance of the ecosystem of loessial massifs destroyed by drawdown, raise its environment-forming function and the negative external impacts resistance.

References
[1] Qin Mingzau 2001 Protection of the soil and water 15(1) 119-120
[2] Danilevich D V, Bondareva E N 2014 the Cities, explicatings of the person 1(5) 75-83
[3] Pavlov E V, Makhrov M L, Yamsky G Yu 2015 Siberian Federal University of engineering and technology 8 706-714
[4] Voskova A V, Syomina M E, Shchekotova V A 2014 Geology, geocology, evolutionary geography: Collective monograph (SPb, RGPU publishing house of A.I. Herzen) pp 219 – 222
[5] Shchekotova V A, Minin A A, Voskova A V, Syomina M E Use of GIS-technologies when scheduling ecological network of the Moscow region pp 599-604
[6] Forman R T T, Gordon M 1986 Landscape Ecology (N.Y.USA: John Wiley and Sons)
[7] Ponomarev A A, Baybakov E I , Rubtsov V A 2010 Ecological consulting 3 (39) 12-17
[8] Lopatkin D A 2004 Cartographic display and the analysis of an ecological framework of the region (on the example of the basin of the Lake Baikal). thesis sciences (Irkutsk)
[9] Stoyashcheva N V 2005 An ecological framework of the territory and optimization of environmental management in the south of Western Siberia (on the example of the Altai region). thesis sciences (Barnaul)
[10] Pushkareva L, Pushkarev M 2020 E3S Web of Conferences 164 10027 doi:10.1051/e3sconf/202016410027
[11] Lu Shengping, Lavrusevich A A 2017 Industrial and civil engineering 10 18-21
[12] Evgrafova I M, Lavrusevich A A 2014 News of higher educational institutions. Construction 6 94-100
[13] Lavrusevich A A, Krashenninnikov V S, Lavrusevich I A 2012 Engineering geology 1 48-59
[14] Kozlov G, Pushkarev M 2019 E3S Web of Conferences 135 01053 doi:10.1051/e3sconf/201913501053