Sustainable Architecture with use of soil

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ABSTRACT: Sustainability of architecture of buildings and engineering constructions with use of natural soil (ground) consists in increase of area of soil - vegetative layer and gardening in city, increase of heat-shielding properties of walls and roofs, improvement of visual perception of green area of buildings and engineering constructions, use of natural non-polluting material – ground, improvement of opportunity of recycling, increase of comfort in buildings. Biopositive (i.e. positive for animate nature including person) buildings and engineering structures with use of soil serve to sustainability of architecture of detached houses and of whole city.

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INTRODUCTION

All biopositive buildings and engineering structures in city are in a different degree ecologically favorable (friendly) for the person and for environment. Use of soil in biopositive buildings and engineering structures can be as: soil as soil-vegetable layer in which green plantings (for example, within the walls of buildings and on roof) are landed; soil as internal filling of walls with purpose of increase of their thermal resistance and planting of greenery on facades, in places of outlet of this soil on surface of walls); soil-vegetable layer as a filler of engineering constructions, for example, in fences, lampposts, bridges; soil as constructive element (for example, in underground buildings realized in a strong soil, in shore protected constructions, in underwater constructions for clearing of water, etc.); soil as a part of buildings and engineering structures (for example, in biopositive retaining walls when the soil serves for retention of wall), etc.

1. BASIC PRINCIPLES OF DESIGNING OF BUILDINGS AND ENGINEERING STRUCTURES WITH USE OF SOIL

Soil is one of the first natural ecological inexpensive local building materials given to the person by the nature. Soil is also the major part of soil-vegetable layer playing the important role in maintenance of life environment on the Earth. It is necessary to note special, completely exclusive, value of soil-vegetable layer: in it there is a number of major processes of ecological cycle connected with circulation of substances. Metabolism realizes thanks to soil, and all plants take roots in soil-vegetable layer. Therefore the role of soil-vegetable layer in city cannot be overestimated. Increasing the area of this layer in city, not occupying it at building and exempting it from building at reconstruction, builders "return" a part of the built up natural environment in more natural condition.

Ecological compatibility (biopositivity) of buildings and engineering constructions is their ability to be organically entered in the natural environment (in ecosystems) and to not be tear away by ecosystems, and at the same time to create healthy and beautiful architecturally–landscape environment of cities.

Biopositive buildings and engineering constructions should not pollute the natural environment; moreover, they should be capable to restore the nature. They should be adapted (bio-adaptive) for existence of wildlife on external surfaces of buildings and inside volumes of constructions, to save resources and to not demand for buildings nonrenewable resources, to not be barrier on ways of streams of substances and energy, to not allocate pollution not processed by the natural environment, to create high quality of life. Thus, ecological compatibility (biopositivity) of buildings and engineering constructions is the integrated concept including the basic requirements to environmentally safe objects.

Biopositive buildings and engineering constructions allow to return to the nature a part of territories with soil-vegetable layer and to create the new additional planting of greenery areas, and also to reduce pollution of environment. It can help to restore action of ecological rule of Le-Shatelye-Brown and to stop deviation of nature under anthropogenic pressure.

Five basic principles of ecologization may be used for creation of biopositive objects and technologies with use of soil [1-4]:

1. The most important principle is the principle of equivalent substitution. This principle has the following meaning: any artificial objects (city, house, street, etc.), which have replaced a part of
natural environment, act as substituted natural environment together with their main functions (for example, they produce biomass, oxygen, purify air and water, allow or no to interrupt natural circulation of matters and energy, let niches for biota, introduce only processed waste in the volume that in replaced environment, etc.).

2. The principle of eco-biosphere compatibility (eco-adaptation): all artificial objects or technologies must be adapted to environment. They don't destroy flora and fauna, must use natural renewing matters and energy, must save matters and energy, must self-decompose and self-destroy after realization of their functions with return of elements in natural circulation or works process; they don't interfere in landscape, etc.;

3. The principle of deep bio-analogy (all city techniques and technologies are similar to natural objects and technologies). There are eco- and biotechnology, they don't pollute nature and must give minimum of waste similar waste in biosphere cycle. The analogy must be deep; it must be founded on profound study of construction and function of natural objects. They don't bring harm to nature and don't use nonrenewable natural resources. Buildings and structures must be "soft" and "clever" objects and must self-react on various external influences, must create high quality of life.

4. The principle of ecological support, eco-restoration of nature (bio-restoration): all buildings and structures perform the additional duties of restoration of nature. They help to return formerly excepted matters and energy, to create new "anthropogenic" deposits of minerals, to save high quality energy.

5. The principle of eurhythmic (beauty, harmony, proportion with nature): all artificial objects are in harmony with landscape; they conform to sizes of landscape elements and to man sizes; their forms are founded on use of natural forms.

The healthy city must contain new buildings, structures, techniques and technologies with application of principles of biopositivity. All buildings and structures allow coexisting total of living organisms. Special constructive measures serve for guarantee of their life.

Biopositive buildings and engineering constructions have volumes and surfaces filled with natural ground. This ground can play the following roles:

1. It can be a constructive element of a building or a construction, perceiving various power influences.
2. It can serve as an element raising heat-shielding or noise-protected properties of a building or engineering construction, improving clearing of waves in seashore protection construction.
3. It is a soil - vegetative layer on walls and roofs of buildings or on engineering construction on which the grass and bushes grow.
4. It can be a substratum for fastening flora and create «underwater nesting boxes» for preservation of whitebait.
5. It can carry complex functions.

2. BIOPOSITIVE SUSTAINABLE BUILDINGS AND ENGINEERING STRUCTURES WITH USE OF SOIL

Constructions with use of soil can be used for erection of separate buildings and engineering constructions and of the whole city. The biopositive city with use of soil can have continuous roof - lawns connected by planting soil-filled foot-bridges, and soil in these soil-filled roofs must be connected with ground in the basis of buildings by help of hollow vertical walls and columns filled with soil (fig. 1).

Figure 1: Biopositive soil-filled city

All motorways in biopositive city should be located under ground, and on top of roofs of low buildings should be arranged the big park, suitable for walks, together with for migration of animals. This park incorporates in suburb to suburban woods. Continuous network of the "green" corridors filled with soil connecting all planted territories and natural landscapes should be created in such city.

Figure 2: Soil filled "green" corridor above and under motor road

Biopositive buildings filled with soil should be similar to trees (fig. 3). Planting of greeneries of all surfaces of buildings and engineering structures in cities must become a usual rule. The biopositive buildings must occupy a minimum area of surface of the land that this surface was planted greenery. Here must be executed stem of building in the manner of shells, filled by the vegetable soil and connecting with natural soil under the building. Vertical planting of greeneries of walls can realize by two ways. It is possible to do external walls of buildings with internal vertical cavities filled by soil (soil-vegetable ground filling). This soil must contact with the natural soil under building. In separate places on wall surfaces this soil leaves on the surface of walls in the manner of decorative cups, in which planted climbing plants with long
roots. In this case shells on surfaces of wall have the form of decorative cups. The shells filled by the soil can be fastening to existing walls outside. In this case the whole surface of wall with planting greenery will have the form of the multwave shell.

The combination of walls filled by the vegetable soil and coverings can create broad possibilities for the planting of greenery. Internal cavities filled by the soil must be filled with using of shells, well perceiving increased pressure of soil. Usual vertical planting of greenery of walls may be perfected by means of the decorative brackets - shells, which allow retaining climbing plants, to perfect a visual perception of facades and to create nestling boxes and condition for life of small birds. These decorative shells can be executed from ceramics.

In such buildings can be used the internal ceramic channels, which are coming to end on surface of wall by ceramic bowls, in whom land plants (in this case roots of plants on channels receive a moisture from natural ground). For rooting plants in blind area may be designed apertures with an open ground. At use of soil channels in walls they should contact to natural ground under building. For this purpose in the bases of buildings the apertures filled with vegetable ground should be executed.

The soil inside walls should not be compressed, condensed and decreased in volume. For this purpose it is expedient to arrange (with small step on height) the horizontal synthetic grids supporting small volumes of ground; it is expedient for loosening of ground and constant maintenance of its good properties to use worm culture.

All kinds of engineering constructions (retaining and noise-protected walls, seashore protection constructions, lampposts, fences and so forth) also can be executed as biopositive (ecological) structures with filling by soil (fig. 4, 5). Biopositive retaining walls may be designed with internal filling with vegetative ground and external continuous planting of greenery (fig. 4). The biopositive retaining wall filled with soil, which outside after assembling looks like honeycombs, has consisted of two modular elements - folded-plate structure and beams (fig. 5). Elements stacked against each other on a thin layer of cement mortar, simultaneously carrying out functions of maintenance of slope and filling of internal volume honeycombs with vegetative ground. The ground in such wall plays role of constructive element, which "is reinforced" with anchors and keeps them.

Biopositive noise-protected walls (screens) in view of the greatest efficiency of protection against noise may be realized as soil-filled walls, in which soil - vegetative ground fills the cavities, formed in reinforced-concrete walls. This ground in the bottom part contacts directly to a natural ground. It allows planting a grass, creepers and small bushes without necessity of constant watering, as roots of plants can settle down in a natural ground (it is recommended to select plants with the long roots penetrating into a natural ground). In these screens the ground participates in maintenance of good protection against noise.
freeway, sidewalks, bridges. Lampposts filled by the vegetable soil can be designed in form of shells of complex form (negative curvature, cone form etc.) allow enlarging an area of soil-vegetable stratum in city and to perfect visual perception of lampposts. The thickness of reinforced concrete shells must be not more than 10 cm, but concrete must have high density.

Designs of hard coverings of roads and sidewalks also can be biopositive. Small regular apertures that extend in the direction of soil should be realized for this purpose. Growing grass will be cut off over apertures by wheels of machines. Fences also can be reliable and at the same time biopositive. In designs of fences the hollow columns and plates filled with ground can be applied. The plants landed in open surfaces of vegetative ground, in process of growth achieve by roots of natural ground in the basis that cannot demand further watering.

![Figure 5: Biopositive retaining wall, noise-protected walls, sea shore-protecting constructions, lampposts with soil-filled internal rooms](image)

**CONCLUSION**

Constructions with use of soil were among the first constructions of mankind with use of natural material - ground. Now many people erect and use clay buildings successfully. Different types of ground were used in constructions in different parts of the world. Soil may be called for modern sustainable architecture as mean of increase of the area of soil - vegetative layer and gardening in city, increase of heat-shielding properties of walls and roof, improvement of visual perception of green area of buildings and engineering constructions, use of natural non-polluting material – ground, improvement of opportunity of recycling, increase of comfort in buildings. Modern sustainable architecture must use soil as natural element of constructions at new constructional level for support of nature in city and for increase of quality of environment inside and on the outside buildings.

**REFERENCES**