

**SHEE “Prydniprovskaya State Academy of Civil Engineering and Architecture”  
(Ukraine)**

**Slovak University of Technology in Bratislava  
(Slovakia)**

**INNOVATIVE LIFECYCLE TECHNOLOGIES OF HOUSING,  
INDUSTRIAL AND TRANSPORTATION OBJECTS**

**MONOGRAPH**

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The monograph includes papers dedicated to the issues of energy-efficiency in construction and design of residential housing based on lifecycle, comfort parameters, sustainability, cost-effectiveness, as well as structural inspection and assessment, durability and reliability forecast, maintenance and renovation of buildings and structures in housing and utility sector, industrial and transportation construction.

It can be used as Urban Agenda for Sustainable Development of Regions. For researchers, university students, municipal administration, managers of business structures.

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## **SECTION II**

### **INNOVATIVE TECHNOLOGIES, NEW MATERIALS IN MODERN CONSTRUCTION AND TRANSPORTATION**

#### **2.1. PROSPECTS OF MASTERING OF UNDERGROUND SPACE BY ERECTION OF MULTISTORY UNDERGROUND APARTMENTS OF MULTIFUNCTION COMPLEXES**

**Pshynko Alexander, Radkevych Anatoliy, Netesa Andrey**

One of basic tendencies in modern building on territory of Ukraine is the active mastering of underground space. Erection of multi-purpose complexes, underground parts of building of the publicly-dwelling setting, and also multilevel underground parking is widespread. The specific of modern building of underground parts of building is a variety of technologies of erection, difficult hydrogeological terms, closeness of surrounding building, density of underground communications and other factors [1]. With development and starting-up new normative documents [2-4] erection of multilevel underground parts of building is especially actual in the conditions of close-settled building of large cities.

Planning of underground storage, technical facilities, and also parking pursues a few aims:

1. Filling of building is in a level, having unfavorable for traditional destiny of apartments - dwellings, office and public, - terms: difficult relief, dense nearby building, et cetera

2. Observance of distance from building to the so-called yellow line - line of limitation of zone of possible obstructions dwellings, public and another building and building, located along the main streets of the permanent functioning, on that evacuation of population of city is executed in a special period and a transport providing of implementation of rescue and urgent under abnormal condition-restoration works is supported;

3. Economy on the technical equipment of building, and also on power expenses during exploitation of underground floors of building. From favourable

temperatures exploitation of underground floors results in diminishing of expenses on heating and conditioning of apartments because of diminishing of heat loss.

4. Because of increase of number of underground floors is a device of considerable on an area apartments (for example underground motor-car stands) without the increase of building height, and also with maintenance of equipping with modern amenities at the level of earth. Thus kept possibility entrance to building of operative cars of rescue and another services, attendant technique et cetera

Thus there is a row of defects at the process of erection of underground elements of building :

1. For most traditional technologies of erection of building and building the device of additional underground floors results in the increase of terms of building, cost and expenses of energy resources;

2. Increase of amount of technique, tension of building process, to the accumulation of large number of technique, workers and materials in the conditions of site area;

3. Necessity geodesic and another monitoring of surrounding building with the purpose of non-admission of the unfavorable affecting load carrying structures of building and building;

4. Plenty (topically for large cities) of underground communications and subsoil waters, and also necessity of realization of measures on their transfer (to protecting from them);

5. Potential dangerous factors from implementation of works below of level of earth;

6. Often is the forced necessity of the use of small building technique for underground space, in spite of her subzero efficiency.

7. Complication of implementation of works, related to the necessity of serve of materials and realization of building and installation works at simultaneous erection underground and above-ground parts of building.

There are a few methods of device of underground floors of building and building. Every technology has the dignities and defects.

Classic building under cover of different kind by non-load-bearing constructions. In spite of variety of methods of strengthening of walls of foundation pit, there is general principle - during development of soil or to beginning of development the slopes of foundation pit become stronger so that to prevent the possible bringing down of soil and/or alongside standing building into foundation pit. Thus the constructions of strengthening of walls of foundation pit can be taken off after implementation of works (strengthening by cross-bars), remain on all term of exploitation of building (fastening of wall or slope through anchors), or be the non-load-bearing constructions of future underground floors of building («wall in soil» with of fixing of soil different ways.

One of variants of device of non-load-bearing construction of foundation pit is technology of «jet-grouting» (stream geotechnology). Basic idea [6] consists in an imitation by means of technical equipments of natural processes, carried out направлено and with a frequent acceleration, with the purpose of change of descriptions of soils, creations on their basis of materials with necessary properties and forming from the indicated materials of underground constructions set form and sizes. A stream geotechnology allows to carry out processes reverse in relation to natural: from artificially, chemically constrained dispersible soils to form a technogenic mountain breed (soil-concrete) for the use of her as building material.

Stream cementation («jet-grouting») is based on the use of energy of high-speed stream of liquid for treatment of natural soils with aims:

1. Diminishing of permeability to water and increase of durability of the unrelated sandy soils;
2. Increase of resistance to the change and decline of deformability of clay and пылевато-глинистых soils;
3. Substituting for органогенных and technogenic soils, fixing of that does not allow to attain necessary durability, permeability and longevity.

Depending on the concrete aims of treatment of soils an onecomponent is used, double-base and three-component stream cementations. In addition, such special receptions, as partial previous washing of the processed soils («pre-washing») or their

complete substitution, can be used after hydraulic erosion away and taking away on a surface by cement solution or cement solution with addition of marble powder.

The mode of the previous washing away allows at treatment to promote correlation cement/soil and, consequently, durability of the envisaged soils, that especially topically in clay soils.

Use of cement-sandy solutions for substituting for soils impermissible in a kind the high abrasivity of grains of quartz (quickly wear out and fall out раствороподающие hoses high-pressure).

Last years for the increase of firmness and watertightness of the ground weirs, and also embankments of the different setting, used all more often, the so-called, stream cementation of ламинарии is forming of vertical and sloping panels from the treated soil breadthways a 2,5-4,5 m and in 5-10 sm. thick

Stream cementation is very rarely used super with the diameters of columns of the treated soil a to 5 m.

Durability of soil-cement or material, that turns out as a result of treatment (to stream cementation) of soil depends directly both on the features of soil and from the expense of cement on his fixing.

Onecomponent stream cementation is characterized by washing away, interfusion and fixing of soils exceptionally by the stream of cement solution. At that rate possible achievement of diameter of column of the treated soil within the limits of a 0,4-0,8 m. As a rule, cement solution has a water-to-cement ratio  $W/C=0,8-1,0$ .

Each of methods of fixing of soil can be used thus jointly with another ways. The final choice of method of fixing of soil is executed by the detailed analysis of geological, hydrotechnical and another factors, existent project, and also great number of other features of concrete object of building.

Among dignities of method it is possible to distinguish the following:

1. Fixing of soil allows to erect building and building in a direct closeness from surrounding building;



2. The rational selection of structural decision of cross-bars or anchors is arrive at relative space for the use of effective bulky building technique, including load-lifting mechanisms;

3. Building outside court stipulates possibility of serve of materials and wares on the local grounds of the large-sized assembling and ground of making of wares (for example, armature frameworks), diminishing thus common time of erection of framework due to taking away of labour intensive operations from a basic critical way. Also maybe application of technology of erection of collapsible-monolithic reinforce-concrete framework of building;

4. At the use of the model spacer fastening their dismantling after completion of works of a zero cycle and use is possible on a next object. Especially topically for the by contract organizations specialized on implementation of building and installation works within the limits of close-settled building and difficult hydrogeological terms.

To the lacks of traditional method of erection of building from it is a top to bottom necessary to attribute:

1. Common time, building is megascopic due to successive erection of all floors of building;

2. As in the conditions of close-settled building quite often the spot of building practically coincides with the contour of the taken territory under building, there are complications with placing of basic objects of building general layout - ware-house grounds, grounds of local implementation of works and temporal sanitary-domestic apartments for workers.

Next widespread in the last 20-30 in the developed countries of the world there is a method of erection of building «top-down». At this method the reliable non-load-bearing construction of foundation pit settles down in the beginning. Further she is used as a load carrying structure for all building, and building is conducted simultaneously in two directions is above-ground part in direction from a «top» to bottom, and underground - «from top to bottom». In the conditions of dense surrounding building, difficult hydrogeological terms, and also non-admission of

affecting surrounding objects often it is an only method of erection of multistory building and building.

As the special case of such technology can be examined method of erection of building «from top to bottom», applicable for underground building with the subsequent equipping with modern amenities of territory on a terrene, for example, with creation of recreational zone.

To dignities of this method of erection it is possible to take:

1. Acceleration of process of erection of building due to the parallel increase of framework in both directions. Thus at the far of underground floors the most labour intensive earthmovings can be executed in parallel with basic erection of above-ground part without the necessity of application of good few of machines for development and transporting of soil;

2. Possibility of the use of the already built floors for warehousing of materials and wares, and also for placing of temporal sanitary-domestic apartments for workers - especially topically for the straitened terms of building;

3. Some cost effectiveness is arrived at due to the rational using of non-load-bearing protective construction of underground part of building as bearing. Thus due to the large area of construction and friction of lateral parts at soil, diminishing of loading is arrived at on bearing soil under building - topically at building on weak soils;

4. Non-load-bearing constructions of foundation pit are the reliable protecting from subsoil waters on areas with their near location. But the detailed geological and prospecting is needed and survey works with the purpose of determination of complex of measures on prevention of underflooding of underground part of building of lower-lying by subsoil waters along the whole length of erection of building.

Among the lacks of this technology of erection of building and building it is necessary to mark:

1. In the straitened terms of underground floors quite often the most labour intensive works are development of soil, works on the device of monolithic load

carrying structures - it is possible to execute only with the use of small building technique with the subzero productivity;

2. Impossibility of the use of large-sized collapsible elements of frameworks of building for underground floors;

3. Necessity of additional calculations of constructions because of the unmodel loading on all stage of erection of building.

Development of soil in foundation pit at that rate is conducted under cover of ceiling erected on the chart of «top-down» (from above-downward) and supported on intermediate temporally steel or permanent reinforce-concrete supports.

From complication of providing of verticality, reliable interface with ceiling and necessary bearing strength in exploitations, these supports, as a rule, executed temporally by steel, strengthened by the cored re-enforcement and обетонируемыми on the finishing stage of building.

The permanent supports erected in drillholes or hooks-trenches from collapsible reinforce-concrete elements are considerably rarer used, connected on editing. Complication of implementation of reliable knots of docking of elements and knots of interface with ceiling of underground floors, additional expenses on the plant making and transporting the few is attracted.

Worked out [5] fundamentally new technology of erection of monolithic reinforce-concrete boring columns of high exactness of implementation and bearing strength. New technology allows to use the combined method of building, foreseeing parallel erection of underground parts of building on a chart «from above, - downward» and above-ground parts - on a chart «from below - upwards». It is thus succeeded interpreted literally to hang out fully above-ground parts of building together with elevator mines and stair cages above the foundation pits deepened under them.

By the Extremely important technological feature of erection of underground floors of building and building, especially in difficult hydrogeological terms or at dense surrounding building, there is the permanent geodesic monitoring of surrounding objects. He includes measures on diagnosing of the existent state of

objects, to watching the possible change of their state under act of works on erection of the built building, and also prognosis of reliability at the operating modes [3]. Thus Requirement Specification on measures on monitoring, that determines methods, methodology and periodicity of cycles of realization of cycles of supervisions, developed by a designer and executive organization, conforms to the customer and becomes firmly established to beginning of implementation of works. Methods and technical equipments of monitoring must be appointed depending on the level of responsibility of building, their structural features, methods of erection of new objects, geological and hydrogeological terms of area, compactedness of existent building, and also operating requirements to building.

An accounting form is a scientific and technical report that plugs in itself :

1. Monitoring results, that can be presented as imperfect lists, charts of development of settling and heels of building, deformation of terrenes, acts of examination of the state of surface constructions of building, acts of confirmation of observance of technological sequence of protective measures in relation to strengthening of grounds and foundations, documents of representing control of quality of works et cetera;

2. Calculations of constructions, comparison of them with the results of measuring, measures on warning, removal or minimization of negative consequences of noci-influences, prognosis of change of the state of building and surrounding building after completion of building and during subsequent exploitation;

3. Estimation of the actual technical state of monitoring objects.

Thus, in the conditions of modern building there is a necessity of application of rational technology of erection of multifunction complexes of the dwelling-public setting with the developed underground infrastructure. It maybe in case of application of technologies of underground building in the conditions of close-settled building, difficult hydrogeological features of location of ground. Complex research of existent technologies is therefore needed with the selection of dignities and lacks of each of them. In addition, it is important to define and range factors influencing at choice rational technology of erection of underground part of building for a concrete site

area, with the selection of dependences on hydrogeological terms, surrounding building, features of concrete project et cetera. Simple methodology applicable all participants of building must become a result. By passing of algorithm it is necessary to determine a presence or absence of one or another factors, as a result getting the most rational method of implementation of works.

Important direction of researches is remained by the permanent study of front-rank experience of leading world organizations on erection of underground floors of building in difficult hydrogeological terms and at close-settled surrounding building, perfection of existent technologies and development of new. It is necessary to intensify development of normative documentation on underground building, with bringing in of leading project and by contract organizations.

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