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The peculiarities of the organizational and technological designing for the construction liquidation cycle

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Summary. This article presents the peculiarities and methodical principles for designing the technologies and forms of organization of the construction liquidation cycle for typical unified series of residential buildings. The systematic approach for developing the necessary settings and indicators of the structure of a complex technological process for disassembling, destructing and demolishing of structural elements and buildings in general is given. The multigraph is created for the closed walk model of correlation of the parameters of the organizational and technological solutions of the construction liquidation cycle.

Key words: construction liquidation cycle, systematic approach, modularity principle, process models for disassembling, destruction and demolition of constructions, the classification of destructive effects, the creation of a multigraph model

INTRODUCTION

Development of the theory and practice of construction processes, elaboration of new technologies and forms of organization of construction liquidation cycle for typical unified series of residential buildings using modern technical means and equipment is a major focus of research in the field of complex reconstruction of the blocks (housing estates) with obsolete and distressed residential housing. [2, 4, 6, 8,12]

Housing stock in its technical condition does not meet modern demands of the scientific and technical support at different stages of the construction site life cycle established by the state construction standards, rules and regulations [4, 5, 7, 9, 12].

As a theoretical basis for substantiation of residential block complex reconstruction and consideration of the structure and parameters of the construction liquidation cycle, forming, modeling and designing may serve the systemic methodology, implemented in systems engineering construction in the section of organizational technological design [7, 19, 20, 24] .

REVIEW OF RECENT RESEARCH AND PAPERS

Contemporary scientific and technological level of economic development, on one hand dictates new, as a rule, increased requirements for scientific and technical maintenance and support of construction sites [11, 13, 18, 25, 26], on the other hand it opens up new possibilities for their improvement and renovation. At the current stage of the “construction and reconstruction” operation, the project of the liquidation stage of the “home-system” lifecycle meets the following requirements: consistency, security, flexibility, efficient use of resources, quality and efficiency [7, 19, 20, 24, 21].

The performed review of the recent research and papers, which started the conceptually-theoretical substantiation for this problem solutions [15, 19, 20, 21, 26] showed that the main objective of the work on the normalization of the construction liquidation cycle of the object (CLCO) is to develop a conceptual approach, methodological principles and bases for organizational and technological design of construction and liquidation cycle, formation of the tools, allowing to model the design and selection processes for rationally-based organizational and technological solutions in the liquidation functional system (LFS), scientific and technical groundwork and engineering support of the final stage of the life cycle of the certain buildings, housing estates of the “obsolete housing” [1, 3, 10].

OBJECTIVE

To create the methodological principles for normalization the organizational and technological design of the construction liquidation cycle.

KEY RESEARCH FINDINGS

The application of the principles of systemic concept of set-theoretical modeling of the organizational and technological solutions of the liquidation process cycle (OTSL) provides the possibility to consider the concept of “set” to represent actually the systems $\{LFS\} \subseteq \{CLCO\}$ as an aggregate of the elements of the object division, and the object in general within the prevailing concepts of the Set Theory.

Thus the system $\{LFS\} \cup \{CLCO\}$ can be represented as an aggregate of paired relations, defined as a product of sets $S_p = \{N, V(N), Q, \rho(N)\}$, where N and V(N) are respectively a plurality of elements and internal connections between them; Q – set of operators (interconditionality) of conjugation elements and, accordingly, a plurality of active, passive and neutral contacts; ρ(N) – a plurality of system components and parameters.

The primary purpose of LFS is conceptual and methodological support of functions for decommissioning and liquidation of buildings and constructions as ones physically and morally expired, as well as those in the condition of reconstruction, major repairs or emergency unsafe to operate, and other force majeure natural and man-made situations.

It includes designing of methods and means to remove each particular object (object area), manufacture of the special equipment and technical devices, development of special technologies, dismantling, disassembling, destruction and demolition of elements and structures, buildings and constructions, the subsequent processing of construction waste and the use of secondary resources and constructional recultivation of disturbed soils of the area.

The backbone factor (of the objective function) of LFS is the outcome – provision of safe and effective removal of building sites according to project parameters.

Structural analysis of the composition and content of the disassembling (dismantling) process, destruction, demolition and recycling of the material elements allowed to identify the following components of construction technologies:

- **construction** - part of the overall design solution, the building or its part, having the specific structure and composition of the elements which it is created with,

- **material of construction**, which is aimed by the sequence of destructive effects for its processing, changing the shape, characteristics and position in space for separation, dismemberment and construction demolition,

-**technological process destructive (dismembering) effects**, its composition, sequence of actions, their modes and parameters,

- **technical means** (machines, machinery, equipment and tools), by which the technological process of destructive effect is implemented.

A subsystem – **"construction"** includes parts of the constructs that can be distinguished on a structural basis (blocks, sections, etc.) as well as organizational basis (tiers, bays, sites, zones, etc.). Their components are individual separate constructive structural elements, nodes and details, fasteners, items, deliverable assemblies, parts of the carcass, elements of walls, floors etc.

The set of parameters and characteristics that define "construction" in symbols of the mapping theory is denoted:

$$\{K\}=\{K_1, K_2, ..., K_n\}. \quad (1)$$

Each of the quantitative parameters and qualitative indicators should comply with the relevant requirements of the project:

$$K_{i\,min} < K_i < K_{i\,max}. \quad (2)$$

Subsystem – **"materials"** includes types of building materials used to create the decommissioned constructions and their elements are the certain characteristics, mutable and immutable during the constructional technological process of the liquidation cycle (CTPL). The totality of the physical and mechanical, weight, geometry and other characteristics and parameters is denoted:

$$\{Q\} = \{Q_1, Q_2, ..., Q_n\}. \quad (3)$$

In addition, each of the material used to create the "construction" is characterized by a set of parameters:

$$Q_{i\,min} < Q_i < Q_{i\,max}. \quad (4)$$

For disassembling, destruction and demolition of the "construction", the building or its parts, depending on their parameters, complexity, configuration, position in space the appropriate subsystem is to be formed – **"technological process"**, having a particular sequence and composition of its constituent simple processes and operations (private flows). The totality of parameters that characterize the "process", is denoted:

$$\{P\} = \{P_1, P_2, ..., P_n\}. \quad (5)$$

The structure of the complex technological process (designated flow) is determined by the structure of decommissioning and liquidation of the "construction." The subsystem "technological process" includes a possible set of private flows, as a result of which at least one of the characteristics of the raw material is muted, this creates the possibility to disengage parts, assemblies, the building or its constructions parts.

Subsystem – "**technical means"** of different types and kinds of destructive effects consists of groups of similar or different types of machines, devices which implement one or more components of the technology process.

Elements are performed by certain brands of machines and mechanisms, types and kinds of technical devices of destructive effect, units and teams of workers to accomplish elements of technological processes that are part of the set of works and forming a complex-mechanized process for object flow CLCO. For brevity, we call it "executor". The totality of parameters related to "executor", is denoted:

$$\{M\}= \{M_1, M_2, ..., M_n\}. \quad (6)$$

Each of the parameters related with the presence of the required number of workers, machinery, equipment, technical devices, the possibility of bringing them to work on the given object, their condition, may have appropriate restrictions:

$$M_{i\,min} < M_i < M_{i\,max}. \quad (7)$$

Thus, the construction technology and organization of CLCO reflects the essence of the relationship of "construction", "material", "process", "technical means". The links between and inside these elements cause the model of the technology structure of construction-liquidation cycle of the object (S_m), defined by the mapping:

$$m_T : K \times P \times M \times Q \rightarrow S_m. \quad (8)$$

The stronger are the organizational and technological connections and there is better matching of one element to another, the higher are the performance indicators of the construction process CLCO:

$$\{E = \{E_1,. E_2, ..., E_n\}. \quad (9)$$

With that the performance indicators have designed values:

$$E_{i\,min} < E_i < E_{i\,ma}. \quad (10)$$

The designed values include: the duration, the cost of machine time and workers' labor to carry out CTPL, cost indicators, quality parameters.

For the construction liquidation cycle, the main feature of operation is that the connection between S_m and specified elements in many cases is complicated, indeterminate and sometimes don't exist. This creates a multifactorial source data, variability of solutions.

Implementation of the CTPL became associated with the implementation of construction works for disassembling (dismantling), destruction, demolition, transportation of wastes and their disposal on a specific construction site. This relationship is expressed by a group of parameters and factors that we call peculiarities and conditions of works execution (technical, technological, geo-ecological, regional, etc.). The totality of these "conditions and peculiarities" is denoted:

$$\{R\}=\{R_1, R_2, ..., R_n\}, \quad (11)$$

which also has a fluctuation range of each parameter:

$$R_{i\,min} < R_i < R_{i\,max.}. \quad (12)$$

The progress of any process, including CTPL, is inseparable from the movement in the space (space-structural arrangement of the building) and the time. The time factor allows to take into account the dynamics of the entire construction-liquidation functional system, interrelation of various processes of the liquidation cycle, their interaction with each other and with the environment. The totality of parameters that characterize the time course of CTPL is denoted:

$$\{T\}=\{T_0, T_1, T_2, ..., T_n\}, \quad (13)$$

where: in each parameter has a range of variation of the calculated values:

$$T_{i\,min} < T_i < T_{i\,max}. \quad (14)$$

Consideration of the CTPL technological structure in particular conditions of production of the liquidation cycle on the construction site with reference to a time scale allows the introduction of the concept of organizational and technological structure of the constructional-liquidation technological process (OTSL). The OTSL model can be represented as:

$$m_{OTSL}: \; S_m \times R \times T \rightarrow S_L, \quad (15)$$

or, taking into account the expression (8) the structure of construction technology and organization of the liquidation cycle (S_L) may be represented as:

$$m_{OTSL}: K \times P \times M \times Q \times R \times T \rightarrow S_L, \quad (16)$$

where: К – totality (set) of parameters and characteristics properties that determine the "construction", P – a technological process with parameters characterizing the "process", M – totality (set) of parameters properties relating to the "executor", Q – a set of physic-mechanical, weight, geometric and other characteristics and parameters of the constructions' "material", R – a set of the group of parameters and factors, conditions, features, work (executors), T – set of parameters that characterize the "time" flow for S_L.

The presented model is relevant for understanding the totality of technological and organizational interrelations between the elements of construction technologies of the liquidation cycle, their differences and commonality.

The model of OTSL should be created at the stage of engineering the decommissioning of the object and preparation of construction operations of the liquidation cycle within the project of organization of the construction liquidation cycle (POCL) and work production plan (WPP) of the liquidation cycle, the contents of which should be focused on advanced production technology and design, and drawn up according to the requirements of the National Standards of Ukraine 3008-95 or according to the rules defined [15, 16, 18, 20].

The purpose of the modeling OTSL can be regarded as a preferred or desired result, to achieve which the functioning of the system LFS and CLCO is aimed at. The objective function is served by the parameters variable function for intensity (productivity), the duration, the complexity, the cost of the process of the liquidation cycle of the object and those that affect the achievement of optimality parametric criterion (rational substantiation).

Creation of the target function is executed considering the output LFS parameters of the objects that are subjects to liquidation and controlled variables (adjustable parameters) of the organizational, technological and economic decisions under appropriate restrictions of the internal environment of the building and the external infrastructure environment of the complex reconstruction of the block (housing estates).

The optimality criterion attribute, by which the compliance of the LFS and CLCO with the predetermined result is evaluated at adhere the determined limitations, is performed by the minimax optimality criterion type: the minimum duration of the liquidation cycle of the building by scheduling the permitted maximum of the possible combination of the cycles of the technical and organizational-technological solutions - specialized flows (processes) disassembling (dismantling), destruction and demolition of constructions, buildings and its parts, transportation cycles, recycling and reuse of materials after disassembling and demolition of a building, derelict lands recultivation. Minimizing the duration parameters of the liquidation cycle allows reducing the duration of exposure of dangerous or negative phenomena, as promptly as possible to use cleared sites of the municipal infrastructure for blocks (housing estates) infrastructure reconstruction.

Object flow of the construction liquidation cycle of the building is considered as organizational and technological process of implementation of several specific flows in time and space of basic types and kinds of destructive effects on constructions, connections, elements, the whole building or its elements, and could be presented as a model of the system-oriented multigraph of closed walk cycle of parameters interrelations: class of machines (means of technical devices and equipment); technology (methods, techniques, types and kinds of destructive effects); planning and organizing engineering solutions formation, etc. with the vertices K, O, N, Z, A, F, D, E (Fig.1, Table 1).

Methods of visual visualization of the LFS system structure allows to present it in the form of a closed walk multigraph of the organizational and technological model of interrelations of elements CLCO.

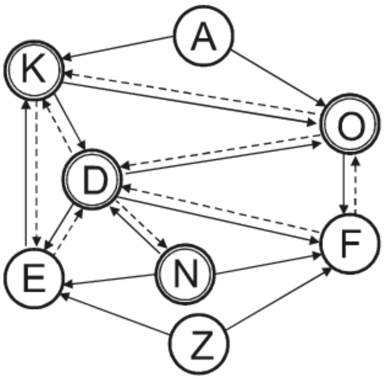

Fig. 1. Closed Walk Multigraph of the System Of Interrelation of Technology and Organization Parameters of Construction-Liquidation Cycle of Residential Buildings and Constructions

It is based on the "process" approach and the principles of typical technological modules (TTM) organizational and technological solutions (OTS)., i.e. using the methods of the workflow, where all technological operations both basic and auxiliary are performed using the organization of sets of mutually complementary combinations of the basic types and kinds of machines (technical devices and equipment, machinery). The linkage of machines and organizational and technological models (OTM) through the organizational and technological scheme of workflows is performed on the main operational parameter -productivity, as well as on the basic functional and other parameters – types and kinds of destructive (dismembering) effects of machines and technical devices considering peculiarities and limitations of the process and versatility of new types of machines – robots, excavators-cranes destroyers with a set of interchangeable attached equipment and computer information controlled process.

Table 1. Elements of the Organizational-Technological Model of the CLCO Elements Interrelations

Subsystems	Formation Of Subsystems Parameters
K	A set of the recommended machines, mechanized and robotic technical devices
O	The composition of machines, devices equipment, assets and accessories included in the set
N	The planning and organizational structure of the site infrastructural environment (general outlay, site layout, etc.)
Z	Kind, type of object that is a subject to decommissioning and liquidation
A	The constructive solution of the object for liquidation. Materials and interrelations of elements in space
F	External and internal hindrance under N conditions
D	Options for organizational and technological schemes, depending on the kinds of destructive effects
E	Additional conditions that determine the requirements (restrictions) to use K and O

Therefore, the objects of typing and normalization of the organization and technological solutions could be the methods of workflow production, sets of machines (technical devices, equipment of destructive effect and others) to form the organization of private, designated and object flows (Table 2).

Table 2. Basic Organizational and Technological Parameters for CLCO Work-Flow Production

Particular Flow (simple workflow, operation)	Designated Flow (complex integrated processes, types of work)	Object Flow (Complexes of works on dismantling, destruction and liquidation of buildings, structures, utilities, equipment, etc.)
Process Parameters:		
scope of work V_p	Scope of work V_d ;	scope of work V_o (in the given square m^2 or volume m^3);
Duration T_p ;	Duration T_d ;	the liquidation cycle termination T_o;
Intensity $I_p = \frac{V_p}{T_p}$;	intensity $I_d = \frac{V_d}{T_p}$;	intensity I_o ;
labour intensity Q_p machine intensity M_p	labour intensity Q_c; machine intensity M_c	labour intensity Q_o; machine intensity M_o
A Set of Machines for Private Flow:	**A Set of Machines for Designated Flow:**	**A Set of Machines for Object Flow:**
Process Parameters::		
productivity P_p ; number of the basic machines $N_{p.к}$ parameters for machine selection and placement	productivity P_c; number of the basic machines $N_{c.к}$ Parameters for machine selection and placement	productivity $P_{o.}$ of the basic machine in the flow; number of the basic machines $N_{o.к}$ parameters for machine selection and placement

The values of options of the flow intensity parameter (operational productivity) with relevant validity (organizational and technological) solutions, can be controlled in the limiting values, parameters that provide economically expedient term of duration of the liquidation cycle of buildings and structures, and resource use.

Flow-combined (parallel) organization of processes implementation	$\frac{V_i}{T} \leq \varphi \frac{V_{in}}{T}$	Sequential organization of processes implementation

At the same time, the rational use of the total duration of liquidation cycle according to project data, ie processes for disassembling (dismantling), destruction and demolition of buildings and structures are achievable on the basis of organizational and technological criterion of Minimax type: the minimum duration is achieved by the permitted maximum of possible combination of private and designated flows in the object flow of the liquidation cycle of buildings and structures.

Solution finding is to determine the area of joint solutions for all organizational and technological solutions with the methods of sequential finding of options, which meets the criteria for the given problem evaluation at the greatest extent – ensuring the efficient liquidation of building sites according to project data.

CONCLUSIONS

1. The interaction of all participants of investment and construction activities when designing the engineering preparation for decommissioning and liquidation of the object, producing constructional works of the liquidation cycle can be effective if it is based on methodological principles and the foundations of normalization of organizational and technological process and the use of the object unified information model.

2. According to the modular construction of the structure of residential buildings standard series and the principles of normalization of construction processes (objective flows) of the liquidation cycle a complex of models can be developed, that helps to normalize (formalize), typify and unify organizational-technological and resource connections in process modules, problems and solutions of each of the structural levels of the standard series of residential buildings. This can be used the following methods: matrix, aggregate, simulation, modeling of Queuing systems, theory of scheduling, scheduling and more.

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ОСОБЕННОСТИ ОРГАНИЗАЦИОННО-ТЕХНОЛОГИЧЕСКОГО ПРОЕКТИРОВАНИЯ СТРОИТЕЛЬНОГО ЛИКВИДАЦИОННОГО ЦИКЛА

П. Уваров, М. Шпарбер

Аннотация. Рассмотрены особенности и методические принципы проектирования технологии и форм организации строительного ликвидационного цикла типовых унифицированных серий жилых домов. Приведен системный подход формирования необходимых параметров и показателей структуры комплексного технологического процесса разборки, разрушения и сноса конструктивных элементов и зданий в целом. Сформирован мультиграф замкнутой модели взаимосвязей параметров организационно-технологических решений строительного ликвидационного цикла.

Ключевые слова: строительный ликвидационный цикл, системный подход, принцип модульности, модели процессов разборки, разрушения и сноса конструкций, классификация разрушающих воздействий, формирование мультиграфа модели.